PRESERVING SUGAR BEETS USING PROPIONIC ACID

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OVERVIEW

This paper reports the results of tests performed in three climatic regions of America; the desert region of southern California, the milder region of Idaho and the 'tundra' of North Dakota. A reduction of sugar loss in stored sugar beets, *Beta vulgaris*, was obtained using a proprietary blend of propionic acid and surfactant. Field tests, conducted in the Imperial Valley in California, indicate that a significant reduction in sugar loss, as well as a possible dehydration advantage, may be accomplished with this treatment. Sugar loss and excessive mold growth, however, did occur in the Idaho test. Excessive mold growth and root rot did occur in the North Dakota test.

Test #1 - Desert region of southern California

OBJECTIVE

The objective of this trial was to determine if propionic acid, a grain preservative distributed by KABO Chemicals, Inc., has a positive effect on the storage of sliced and whole sugar beets. Reducing sugar loss due to biological degradation could prove beneficial to the entire beet sugar industry. Four (4) samples were studied; whole untreated, whole treated, sliced untreated and sliced treated.

PROCEDURE

Testing began on 9 July 1996. Freshly harvested beets were picked off a conveyer belt, by hand, before going to storage sheds. The beets were deposited into a 275 gallon open top Schutz tote bin. The tote had contained an oil based defoamer, KFO 557, and was cleaned thoroughly before any beets were placed into it. Enough beets were gathered to fill 4 tote bins ¾ full. The lids of the plastic lined Schutz tote bins had been removed, hence the beets were exposed to full sunlight and air. After filling, two of the tote bins were dumped onto the ground and 3 individuals proceeded to use beet knifes, obtained from the tare lab, to cut each beet into approximately 4 pieces. The pieces were replaced in the appropriate tote bins. When each container was approximately ½ full of sliced beets 55 gallons of propionic acid and surfactant was poured into the tote. Enough of the solution was used to completely submerge all the sliced beets. The forklift driver then picked up the tote and "shook" it with an up and down motion for 2-3 minutes. In addition, he drove back and forth during this same 2-3 minutes. Vibration was used to make certain that all areas of the beet were in contact with the propionic acid solution and that no air pockets remained. The propionic acid solution was drained from the sliced beet bin into the whole beet bin to provide treatment of that sample. The same procedure of lifting and vibrating to free any air pockets was used on the whole beets. Ambient temperatures ranged from 100 - 115 degrees Fahrenheit during this test period. No attempt was made to protect the beets from direct sunlight. Dehydration of the beets was evident visually and may provide a good reason to continue testing in that climate. Shipping dehydrated versus fresh beets could offer a significant financial reason for long term expanded use of propionic acid. Samples for the tare lab were obtained by removing a 'core' section of beets. Samples were clearly labeled and the tare lab tested percent sugar and percent purity of each sample. Tare lab samples were scheduled for each Monday and Friday beginning on 12 July 1996. Actual tare laboratory test dates varied from this plan because of their work load.

RESULTS

The results of treatment with a propionic acid/surfactant solution indicate that sugar normally lost to bacterial degradation can be significantly reduced when applying propionic acid to the surface of the beet, before storage.

Whole Beets: *Initial percent sugar values were 15.6% and purity was 82.64%.*

<u>% Sugar:</u> Sugar content in the whole untreated beets increased slightly for 6 days to 17.86% sugar. *See chart #1*. This increase was due to the rapid rate of dehydration that occurs in the hot, dry climate of Imperial Valley. The net result is an apparent increase in percent sugar in the beet. For the next 5 days the sugar content decreased, somewhat rapidly, and on day 11 and day 13 reached 8.55% and 9.29% respectively. The terminal average sugar content for whole untreated beets was 13.91%. The percent sugar in whole beets treated with propionic acid increased from 15.6% to 20.16%. This is a significant increase in percent sugar content, with one sample slightly lower than its' previous test. The terminal average sugar was 17.85% for whole beets treated with propionic acid.

<u>% Purity:</u> The purity of whole untreated beets increased only slightly for the first 6 days. *See chart #2*. Then it decreased from a high of 83.91% to a low of 41.22% with a terminal average value of 66.36%. One would expect purity to decrease as microorganisms eat and digest sucrose. The average purity of whole untreated beet was 66.28%, 16.28% percentage points below the starting point. The purity of whole treated beets increased initially, decreased slightly, then increased again. Sampling error may account for the anomalies seen in this testing. The average purity of whole treated beet was 83.46%, or 0.82 percentage points above the starting purity.

Sliced Beets: *Initial percent sugar readings were 15.6% and purity was 82.64%.*

<u>% Sugar:</u> Sugar in sliced untreated samples increased from 15.6% initially to a high of 19.47% on day 6. *See chart #3*. Day 11 showed a decrease in sugar down to 14.0% and on day 13 reached a low of 11.18% sugar. The rapid rise in sugar is most likely due to dehydration of the beets, because they were chopped into 4 pieces. The increased surface area allowed more rapid dehydration to take place. Average sugar content in the sliced untreated beet was 15.78%, 0.18 percentage points above the starting value. Percent sugar in sliced treated beets continued to increase throughout the 13 day test period. These samples peaked at 20.5% on day 13. This is in sharp contrast to an untreated sample value of 11.18% sugar on the same day. The average sugar content of sliced treated beet was 18.99%, 3.39 percentage points above the initial value.

<u>% Purity:</u> Change in purity of sliced untreated and sliced treated was not as dramatic as that seen

in whole beets. *See chart #4*. However, the lowest value for sliced untreated was 27.48% and the lowest for sliced treated was 62.02%. The highest readings for sliced untreated and sliced treated were 82.64% purity and 89.36% purity respectively. The average values for sliced untreated and sliced treated were 66.37% and 78.72% respectively. The sliced treated beets maintained higher purity when compared with sliced untreated beets.

CONCLUSION

A solution of propionic acid and surfactant, when used to treat whole or sliced beets, appears to inhibit microbiological activity that causes the degradation of sugar in the beet. Percent sugar in the treated beet, sliced or not, was significantly higher than when the beet was first harvested. The apparent increase in the percent sugar in whole untreated beets during the first days was the result of dehydration. Decreasing water content in the beet was evident because all samples, whole and especially sliced beets, became smaller, dryer and wrinkled on the surface. A marked decrease in sugar content was apparent beginning on day 11 in untreated beets. It is likely that biological degradation of whole untreated beets was the primary factor in reducing the sugar content to 8.55%. The sugar content in the treated beets, whole and sliced, continued to increase as water evaporated. In each sample tested the percent sugar was higher than the initial value of 15.6%. Some samples reached 20% sugar. Untreated beets, however, reached a low of 8.55% sugar. One can surmise that this solution of propionic acid and surfactant was instrumental in preventing infection of the treated beets. Potentially, the increase in apparent percent sugar of treated beets could produce a significant decrease in transportation costs. For an example, a rail car loaded with 85 tons at 15.85% sugar yields 26,945 lbs. of sugar. The same rail car loaded with 19.8% beets yields 33,660 lbs. of sugar. Thus, a net increase of 6,715 lbs. of sugar per rail car can be transported. If a factory requires 75 rail cars per day to operate, or 6375 tons per day slice rate, this equates to approximately 503,625 lbs. per day of "extra" sugar transported, effectively reducing transportation costs.

Chart #1 - WHOLE BEETS - PERCENT SUGAR

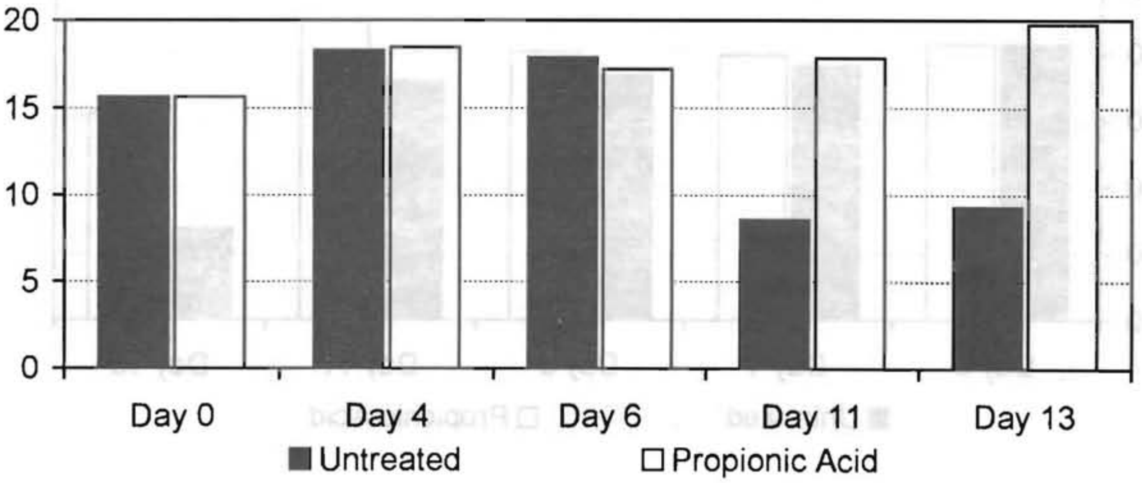


Chart #2 - WHOLE BEETS - PERCENT PURITY

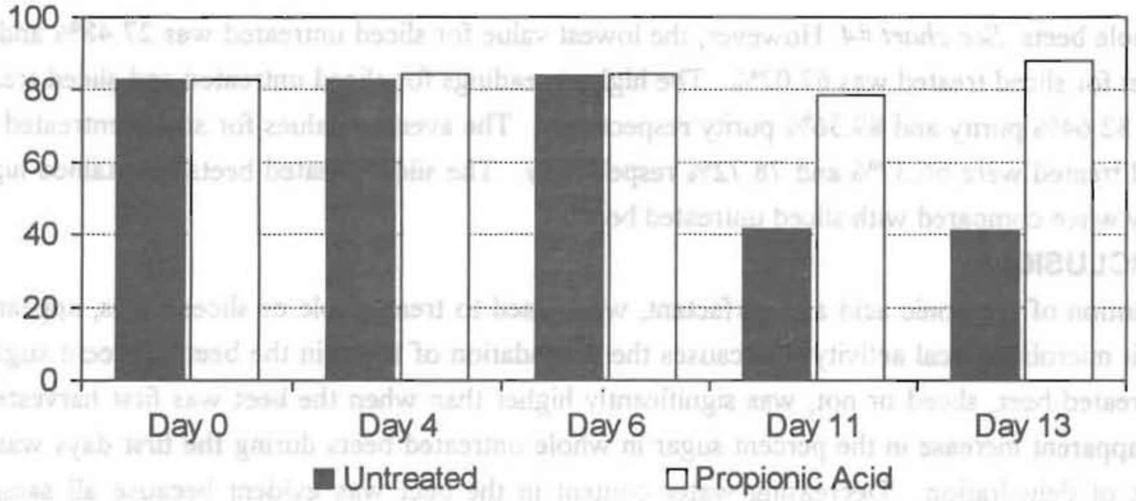


Chart #3 - SLICED BEETS - PERCENT SUGAR

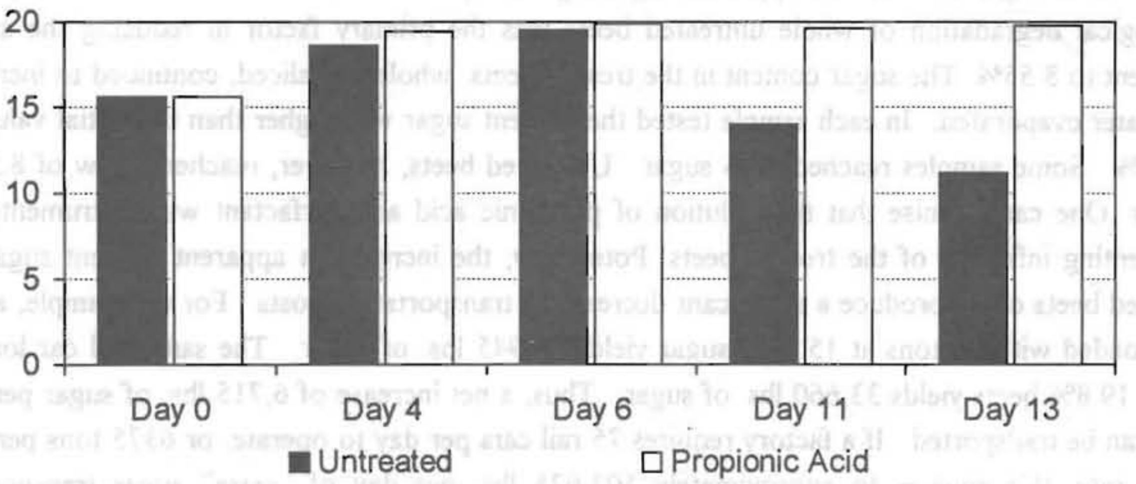
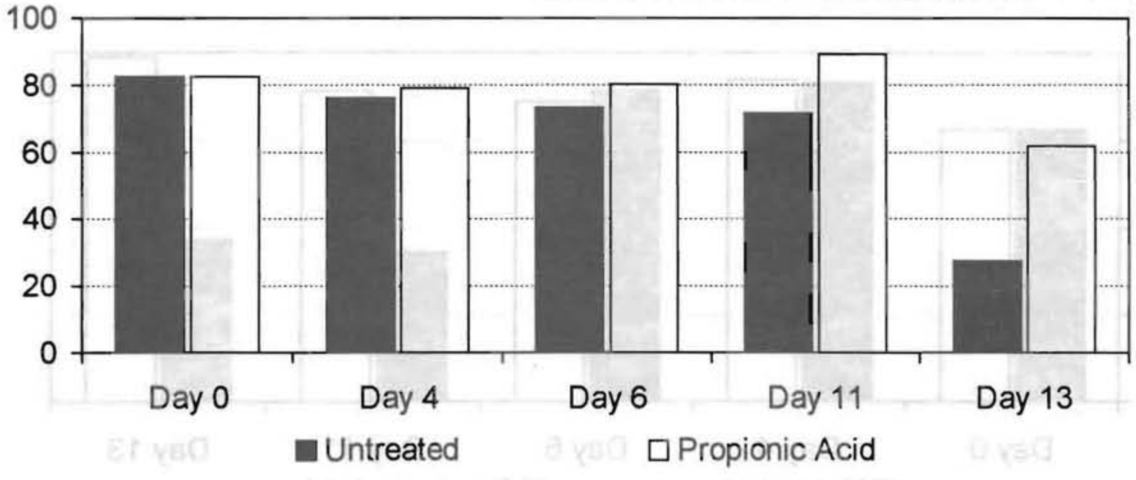


Chart #4 - SLICED BEETS - PERCENT PURITY



Test #2 - Milder climate of Idaho

OBJECIVE

The objective of this trial was to determine if propionic acid has a positive effect on the long term storage of sugar beets in the relatively milder climate of Idaho. Reducing sugar loss due to biological degradation could prove beneficial to the entire beet sugar industry. Three (3) piles of 5 tons of beets each were studied. Two of the piles were treated and one was untreated, a control pile, with propionic acid. Visual observations as well as laboratory analyses were to be conducted.

PROCEDURE

On November 11, 1996, three (3) loads of beets at five (5) tons each were obtained from an existing factory pile. Two (2) of the loads were treated with a solution of propionic acid and surfactant. The solution was applied to the beets using a high pressure sprayer. Approximately 10 gallons of propionic acid were applied to each treated pile. Pile #1 was treated with a solution of approximately 25% propionic acid. Pile #2 was treated with a solution of approximately 45% propionic acid. There was a control pile for comparison. The treated piles were sprayed, as opposed to submerged,. KABO feels that spraying beets is a more realistic application technique should the product prove to be an effective beet preservative in this climate. The three piles were allowed to sit, on the north side of an existing factory pile, for 2 ½ months. The test piles were somewhat protected from direct sunlight, although not covered. No further treatment was applied to the three test piles.

RESULTS

On January 29, 1997 all three piles were inspected and photographed. The first and most apparent observation was that the control pile looked just like the factory pile. It was covered with snow. Conversely, the two treated piles were not covered with snow. From a distance, one could see the beets in the piles. Bacterial and mold growth generated enough heat to melt the snow. When the piles were examined, the untreated beets were found to be frozen, had good turgidity and appeared healthy. When sliced in half, the control group had a healthy yellowish color, showed little sign of internal rot and looked very much like the large factory pile. On the other hand, the treated beets were covered excessively with mold. On examination of the treated piles, every beet inspected was enveloped in mold. When these beets were sliced in half, they showed signs of rot up to 2 inches deep from their outer skin. Many of the beets had excessive internal rot and had become very soft. The were in a state of continuing decay.

CONCLUSION

Propionic acid failed to control mold growth in this environment. The sugar content dropped from 16.32% sugar in the control pile to 2.57% sugar and 5.97% sugar in the two treated piles. *See chart #5.* Percent purity was 80.28% in the control pile and decreased to 43.12% and 62.56% in the two treated piles. *See chart #6.* In this test, propionic acid failed to control mold growth and root rot. Further testing would be desirable to determine whether or not the concentration of propionic acid might have been strong enough to burn the beets.

Chart #5 - PERCENT SUGAR

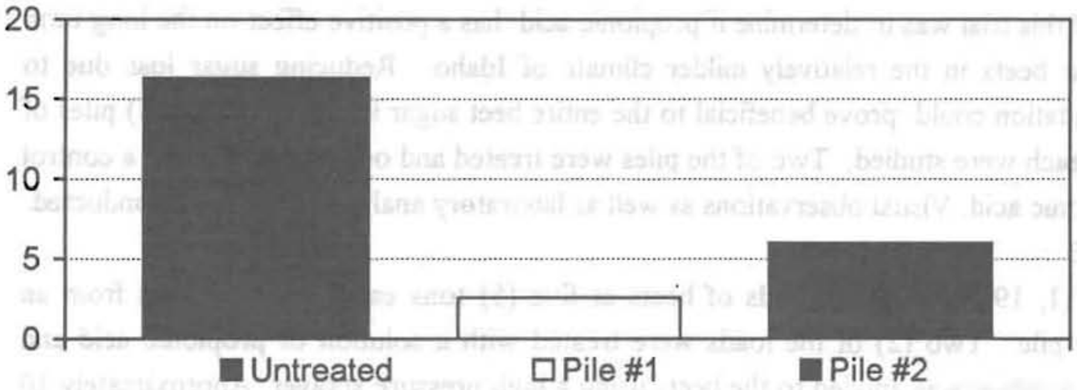
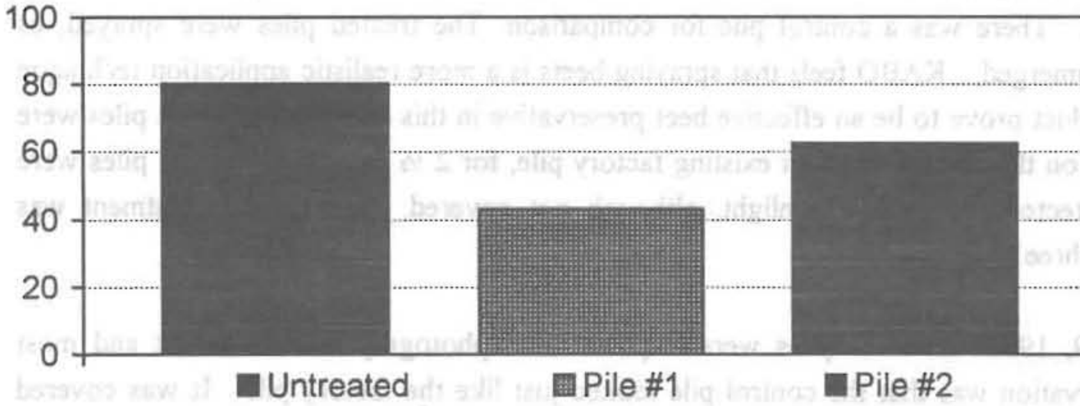


Chart #6 - PERCENT PURITY



<u>Test #3 - Laboratory Test in North Dakota</u>

OBJECIVE

The objective of this trial was to determine if propionic acid has a positive effect on long term storage of sugar beets in a controlled laboratory setting. A reduction of sugar loss due to biological degradation could prove beneficial to the entire beet sugar industry.

PROCEDURE

Sugar beets were sprayed, as opposed to being submerged, with a solution of propionic acid and surfactant. They were the stored in a controlled environment of ~95% humidity and ~38% Fahrenheit for the duration of this test. The beets remained in storage for a period of time ranging from 4 weeks up to 4 months. They were observed visually for mold growth and root rot. An index was used to determine the relative condition of the root. A root rot index was used, grading the beets on a scale of 0 to 10. Zero indicates the root is very healthy and has no rot. A reading of 10 indicates root rot has completely destroyed the beet. Samples were not submitted to laboratory analysis for percent sugar and percent purity.

RESULTS

The beets were inspected, visually, during this test. Untreated beets had an average range of 2-3 on the root rot index. Treated beets had an average range of 5-6 on the root rot index. Propionic acid failed to control mold growth and root rot in this environment.

KABO would like to thank; Holly Sugar Corporation, The Amalgamated Sugar Company and American Crystal Sugar Corporation for their interest, cooperation and participation during these tests. The authors appreciate this opportunity to demonstrate KABO Chemicals, Inc., commitment to the sugar beet industry. Additionally, KABO Chemicals, Inc., feel that the most applicable area for this product might be pellets. Propionic acid is currently used as a grain preservative for cattle and poultry feeds. Pellets are similar to these grains in moisture content. There could be substantial advantages in fuel savings should this prove an effective application. Testing in this area should be conducted.