Guidelines for Storage of High Fructose Corn Syrup

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The Carl Hayden Bee Research Center in Tucson, AZ has been studying the use of high fructose corn syrup (HFCS) as a bee feed. We are offering preliminary recommendations on the storage of HFCS based on our investigations of contaminant formation and surveys of beekeepers' storage practices. We received and tested samples of syrup both from manufacturers as well as from beekeepers that use HFCS in their beekeeping operations. By means of a questionnaire, we obtained information on how beekeepers stored the syrup, how long it was in storage, what type of container was used and to what temperature ranges the storage tank was exposed.

Previous research has shown that the dehydration product, hydroxymethylfurfural (HMF), forms in fructose-based solutions that are exposed to heat, are acidic, have high levels of metal ions and have undergone long-term storage. Honey and HFCS both have high percentages of fructose and therefore are both likely to form HMF under these conditions. Early work by Jachimowicz (1975) found that HMF decreases the longevity of honey bees by 50% when present in concentrations greater than 125 ppm. Furthermore, when water is added to solutions with high HMF content, the toxic rehydration products levulinic acid and formic acid are formed.

In our surveys we have found that beekeepers store HFCS in a variety of conditions. These conditions range from outdoor exposed steel drums to indoor insulated containers. Additionally, some beekeepers use HFCS immediately from the delivery truck, while others may store it for some time. Further, many beekeepers dilute their syrup with water after storage, before feeding to bees.

Dr. LeBlanc performed experiments looking at HMF formation in various container types and under various temperature ranges. The results of his work can be found in a report prepared for the National Honey Board. In summary, Dr. LeBlanc found that the acidity, or pH, of the manufacturers' samples were all within pH 3 to 5 (acidic range on the pH scale), while the sucrose blended syrup was over pH 7 (neutral range on the pH scale). Similar to honey, HFCS is acidic; if acidic liquids are stored in metal containers, metal ions can be released into the liquid and thus contaminate the syrup and encourage HMF formation. Dr. LeBlanc also found that temperatures between 104° and 120°F increased the formation of HMF over time. If the temperatures were over 120°F (49C), the formation of HMF more than doubled, to over 200ppm in 35 days. The sucrose syrup sample subjected to the same temperature range did not form HMF. When temperatures were raised over 150°F, HMF levels reached over 30,000ppm within the same time frame.

We have tested the levels of HMF in HFCS samples from both manufacturers and beekeepers; we found that both had some levels of HMF (See Figs. 1 and 2). In general, most of the manufacturer's samples had less then 20ppm. From the beekeepers samples, we detected a range of 20 to over 120. In general, beekeeper samples had more HMF than the manufacturers.

Depending on the type of container and the temperatures to which that storage container is exposed, HMF levels in your stored syrup could increase quickly. It is best to have your storage tanks insulated and in a controlled environment. In conclusion, do not allow the HFCS to overheat, and use it up quickly if it is stored in an exposed tank.

Factors that promote HMF formation
- Fructose (starting material; sucrose syrup will not form HMF)

Heat
- Time
- Low pH (Acidic conditions)
- Metal Ions (which can stabilize HMF)

What you can do:
- Use syrup up in a timely manner.
- Do not subject the storage container to temperatures in excess of 120°F (get a thermometer or datalogger to - keep track of temperatures).
- Test your old syrup (send it to a lab, there are lists on the Honey Board website). If you are not certain about the syrup, do not use it. If there are high levels of HMF, do not use it. To keep formic acid from forming in the syrup, do not add water to old, stored syrup.