

## ECONOMIC ADULTERATION DETECTION TECHNOLOGY EXECUTIVE SUMMARY

### I. THE CHEMISTRY OF HONEY

#### A. Economic Adulteration is a Continual Challenge

Economic adulteration is the practice of preparing an item for sale by substituting a less valuable substance for a portion of the original product. A highly valued item, such as honey, has always been and will always be susceptible to economic adulteration. Different substances have been used to adulterate honey depending on their availability, cost, similarity to honey and by the ability, or difficulty, to detect them in honey. Every shift to another "honey extender" requires a corresponding shift on the part of those interested in stopping economic adulteration. Preventing economic adulteration requires vigilance, testing, and the development of technology to detect the latest substitute in use.

#### B. Honey is a Complex and Varied Food

The National Honey Board defines honey as the nectar and sweet deposits from plants as gathered, modified and stored in the honey comb by honey bees. Nectar is primarily sugar and water. The chemical conversion from nectar to honey is essentially the enzymatic breakdown of the disaccharide (sucrose) into its component monosaccharides (glucose and fructose). Water is removed, by the bees, through evaporation and a concentrated syrup is formed. Ripe honey is composed primarily of fructose and glucose in an almost even ratio (average ratio of 1.23). Sucrose is also present, but generally in amounts near 1.3 %. Additional chemical components are present including: acids, minerals, enzymes, proteins, amino acids and vitamins. While nectar is a dilute solution of sugars in water, honey may be thought of as a concentrated combination of sugars mixed with a little bit of water and several hundred trace ~~minerals~~ *materials*. The composition of honey varies greatly because honey is a natural product.

#### C. Inexpensive Sweeteners have Similarities to Honey

If honey is adulterated for economic reasons, it is typically with an inexpensive sweetener. Sources of common sweeteners include sugar cane, sugar beets, and corn. The difficulty of detecting inexpensive sweeteners in honey is that the major sugars -- fructose and glucose -- are essentially the same in honey as in the inexpensive sweetener. The challenge is to find some characteristic that distinguishes between honey and the inexpensive sweetener. The ability to detect inexpensive sweeteners in honey is based on a combination of techniques. A combination, or matrix, of techniques are needed to determine the authenticity of the honey because there are a lot of different ways to adulterate honey for economic gain.

## **II. CURRENTLY AVAILABLE TECHNOLOGY**

### **A. SCIRA Detection of Cane or Corn Sugars**

SCIRA stands for Stable Carbon Isotope Ratio Analysis. It is able to detect corn and cane sugars at levels as low as 15%. Fees for this analysis are currently around \$45. An isotope-ratio mass spectrometer is required for this assay. Coastal Science Laboratories has extensive experience with analyzing honey samples.

### **B. ISCIRA Confirmation of the Detection of Cane or Corn Sugars**

The ISCIRA technique, which stands for Internal Standard Stable Carbon Isotope Ratio, is used in conjunction with SCIRA to detect cane and corn sugars in honey. Comparison of results from the two assays ensures accuracy and reduces the limit of detection to about 7%. The test indicates purity for honey if the difference between the SCIRA and the ISCIRA test is not more negative than -1.0 ‰. Fees for this assay are about \$85. For valid data interpretation, the SCIRA assay must also be run; sometimes combined fees of about \$120 are available for both analyses. Coastal Science Laboratories and other laboratories provide this service.

### **C. Carbohydrate Analysis as a General Indicator of Adulteration**

This is a general test that characterizes the sugars in the honey being sampled and compares the results to the composition of pure honey. Alone, the assay can indicate the presence of conventional corn syrup, sucrose or invert sugar. Additional tests are required to confirm the presence of high fructose syrups. It is important to include this assay in the battery of tests that determine authenticity. Fees for analysis are about \$65. Analytical Consulting Services of Columbia, Inc. and Commercial Testing Lab., Inc. are examples of laboratories that provide this analysis.

### **D. TLC as a Screen for Corn and other Starch-based Syrups**

TLC stands for thin layer chromatography. The assay can detect HFCS in honey as well as conventional corn syrup, commercial glucose and high-fructose syrups from other starch sources. It has a limit of detection of about 10%. Fees for this assay are about \$75. Almost all laboratories have the ability to perform this assay. However, few laboratories are known to do so; most laboratories doing honey analyses are currently involved in more sophisticated types of technology. CDS Laboratories does provide this service.

Some scientists are uncomfortable with this assay because: it is subject to the interpretation of the analyst, sometimes it incorrectly indicates economic adulteration, and it is not sensitive to cane sugar. However, the assay is relatively simple, fast, inexpensive and can be done on site. The assay can be used as a screening tool to show HFCS and other starch syrups such as high fructose syrups that come from potato, rice, wheat, cassava.

#### **E. HMF as an Indicator of Inverted Cane and Beet Sugars**

HMF, or hydroxymethylfurfural, is a by-product formed when acid is used to produce invert sugar. HMF is also present in pure honey that has been heated or stored. Analyzing honey for HMF is valuable because it is a parameter of what constitutes "typical" honey. This assay can only be used, to indicate economic adulteration, in conjunction with information from other tests. Analyses are available at a number of laboratories including Analytical Chemical Services of Columbia, Inc. and SGS Control Services, Inc.; fees are about \$45-\$65.

#### **F. CGC Detection of Inverted Cane and Beet Sugars**

CGC stands for capillary gas chromatography. It, along with the HPLC-PAD test described below, was designed to detect invert sugars. Limits of detection approach 5%. Fees for this assay are around \$200. Many laboratories have the CGC equipment but lack the training to run this assay accurately. Access to this technology is available through Analytical Chemical Services of Columbia, Inc.

#### **G. HPLC-PAD Detection of Inverted Cane and Beet Sugars and HFCS**

HPLC stands for high performance liquid chromatography. PAD stands for pulsed amperometric detection. It, along with the CGC test described above, was designed to detect invert sugars. The HPLC-PAD analysis has also been used to identify HFCS that has been added to honey. Limits of detection approach 10%. Fees for this assay are around \$500. Few laboratories have the PAD system or the training to run this assay accurately. Access to this technology is only available through Reading Scientific Services Ltd.

#### **H. Bound Galactose as a Screen for Beet Sugars**

*bound* → This technique was developed in an effort to identify beet sugars in honey. Beet sugars contain 10 times more galactose than does honey. But honey also contains small amounts of galactose, hence, this assay is useful only as a screening technique. However, it is not commonly used. No commercial laboratory is currently offering this analysis among its services. The necessary equipment and training are within the grasp of competent laboratories; fastidious technique is necessary for reproducibility. Fees for this analysis would depend on the start-up costs. Routine analysis should be reasonably inexpensive; no highly technical or expensive equipment is required.

#### **I. SNIF-NMR Determination of Beet Sugars**

SNIF-NMR stands for site-specific natural isotope fractionation nuclear magnetic resonance. This is a technique that has been in use in the wine and juice industries and has begun to be adapted for honey. Eurofins Laboratories, Inc. developed the method and has gathered extensive data on some authentic natural products. The technique has been advertised as able to detect beet sugars in honey; however, the data on honey is limited, particularly for honey from North America. Limits of detection are reported as approaching 10%. Fees for this assay vary from \$375 to \$595. This

technology is available through Eurofins Laboratories, Inc. and Reading Scientific Services Ltd. Although this technique has potential utility, it is still under development.

### **III. USING CURRENT TECHNOLOGY**

Given enough time, money, equipment and trained personnel, the authenticity of a sample of honey can be stated with great assurance. The difficulty lays in the complexity and sophistication of the assays, in that multiple assays are often necessary, and that scientific consultation is often needed to interpret the results. No single laboratory can conduct the diverse number of assays that are available to judge authenticity. The relatively low sample volume in the honey industry discourages analytical laboratories from investing in specialized techniques or equipment. When no analytical technique is available (e.g., when the inexpensive sweetener is present at low levels), a statistical analysis of a considerable number of samples can indicate adulterated honey; this is costly. The challenge is to find an economical way to analyze honey and a practical way to interpret the results.

The effective use of analytical technology is dependent upon the ability to understand the range and limitations of that technology. All analytical techniques have limits to their accuracy; within the confines of those limits, scientists are confident in the results. The difficulty is in the interpretation of the test results. As it stands, to use analytical technology, the businessman must have insight into the detection technology or retain someone that does. Analytical accuracy can be increased by improved technology or through the use of statistical principles. A chemist that is familiar with statistics can design sampling and testing schemes that ensure accuracy in determining the authenticity of honey. In all instances multiple tests, also known as a matrix of tests, are required to determine the authenticity of honey with accuracy. A variety of strategies can be developed depending upon the circumstances.

### **IV. HONEY INDUSTRY RESEARCH AND PROGRAM NEEDS**

Current research relating to the detection of inexpensive sugars in honey is very limited. A number of research projects would benefit the honey industry. For example, the most recently developed technologies need further investigation and verification. All detection technologies could use additional data on samples of pure honey from around the world. The detection of low levels of all adulterants (i.e., less than 10%) is a goal to be considered. An expanded collection of authentic honey from national and international sources would be of value. More research is needed on the basic nature of beet sugars. A more dependable inexpensive screen for invert sugars is desirable. The range and average of HMF levels in current world supplies of honey should be determined. Improvements in accuracy are always important as are reductions in costs.

Scientific research could be stimulated through the identification of industry needs, and the provision of encouragement and funds. Programs can also be developed that stimulate research without the expense of funding research directly. As equally important as research is the ability to put the technology to practical use. The industry would benefit if they had easier access to scientific and technical support for data analysis and interpretation. Industry education to increase the awareness of the advantages and limits of technology would be useful. The industry may need to be encouraged to use screening techniques as an indicator of adulteration with the use of additional analyses to confirm the results. But perhaps most important of all would be the development of a laboratory dedicated to the needs of the honey industry. The laboratory would operate specifically to analyze samples and interpret results. Additionally, the laboratory could research selected subjects. Industry programs, such as the Honey Industry Quality Assurance Program, the National Honey Board and other ad hoc coalitions can serve as vehicles to set goals, marshal resources and discourage economic adulteration in the honey industry.

## **V. CONCLUSIONS**

More than one test is necessary, to determine the purity of honey, primarily because no one test can detect all inexpensive sweeteners. A matrix of tests is also needed to ensure accuracy and to corroborate test results. The technology is available to detect all inexpensive sweeteners but the cost is considerable. Additionally, a technical specialist is often necessary to interpret the results.

The practical utility of the available technology is limited by: the need for multiple tests, the sophisticated nature of the technology, the difficulty in interpreting the data, and the associated expense. Very little scientific research is being conducted on this topic. The honey industry may wish to motivate scientific investigation or fund research to advance industry goals. A laboratory dedicated to honey industry issues is a cost-effective approach to addressing the need for analytical services for the honey industry. The laboratory could serve as a central facility primarily for sample handling, analytical testing (when practical), and data analysis and interpretation; a limited research program would enhance the program for testing services.