

Molecular Detectives: Is My Honey Pure?

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Purpose:

Honey. It's a sought after natural food product made from honeybees and loved by consumers worldwide, so much so that the global food market share of honey was valued at 8.4 billion USD in 2018. However, there are two major trends impacting the industry today with global repercussions: honeybee population loss, and honey food adulteration. The term "adulterated honey" means any honey to which has been added honeydew, glucose, dextrose, molasses, sugar, sugar syrup, invert sugar, or any other similar product or products, other than the nectar of floral exudations of plants gathered and stored in the comb by honey bees. Honey is among the most adulterated foodstuffs globally, meaning that by the time it reaches the consumer, its raw form has been altered to some extent. With honey ranking high in the global top 10 most adulterated food products due to economically driven motives by fraudsters, it is unsurprising that numerous fake honey scandals have infiltrated news headlines over the years. Reports expose claims of adulterated rice, corn, and sugar cane syrup ingredients being added to pure honey and sold across various regions, including Canada, Europe, the USA, and Australia.

One of the primary techniques to detect honey adulteration is nuclear magnetic resonance (NMR) spectroscopy. NMR is invaluable in honey analysis is its ability to detect the presence of added sugars or syrups. Authentic honey typically consists of a complex mixture of natural sugars, enzymes, amino acids, and other organic compounds. Adulterated honey often contains additional sugars like high-fructose corn syrup or rice syrup, which are cheaper and less desirable. NMR analysis can accurately measure the sugar composition and identify any discrepancies, revealing the presence of adulterants.

References:

Identifying type of sugar adulterants in honey: Combined application of NMR spectroscopy and supervised machine learning classification

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8816647/>

Detection of honey adulteration using benchtop ¹H NMR spectroscopy

<https://pubs.rsc.org/en/content/articlelanding/2023/ay/d2ay01757a>

¹H-NMR Profiling and Chemometric Analysis of Selected Honeys from South Africa, Zambia, and Slovakia

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6017463/>

General Description:

On March 11 2023, the Georgia Tech NMR center had an open lab during the Georgia Tech Science and Engineering day. We had a continuous stream of visitors throughout the day. We feel that it was important and fun to share what we are doing with the broad public, and it was especially nice to present to kids and teenagers. The theme of our open lab was "is my honey pure". We demonstrated that it is easy to use NMR when it comes to the detection of honey alteration through the addition of sucrose-syrup. We tested high quality honey from local bee keepers together with low-cost super-market honey. The good news: we had a limited amount samples but the only fake honey, which we found, was the one, which we faked ourselves. We still recommend that you purchase honey from local beekeepers! A special thanks goes also to

beekeeper Moreen Rebeira-Leisen, who supported our activities by telling our visitors all about bees and beekeeping.

GT Graduate Students Alicia Robang and Andrew Hill explaining how nuclear magnetic resonance (NMR) spectroscopy can be used to detect alterations in honey during the Science and engineering Day at Georgia Tech.



700 MHz NMR spectrometer, named “Rey” after the Star Wars character, was used to test honeys from a local Bee Keeper as well as from supermarkets.



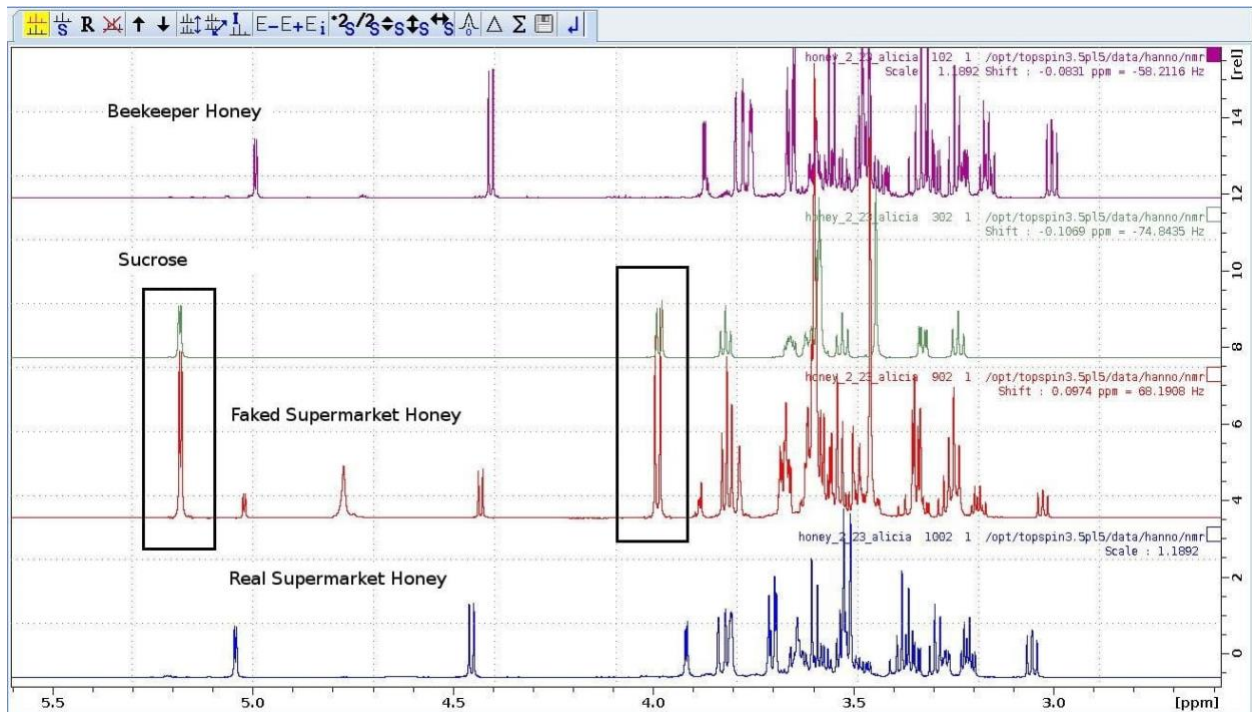
Example of a real hive frame from a local Bee Keeper



Assortment of honey's tested



Example 1D ^1H solution NMR data of different honey's recorded at 700 MHz:



NMR spectra can be used to detect if honey was altered by the addition of sucrose-based syrup.

Experimental Details:

- Measure out ~3 grams honey in a 50 mL falcon tube. In this case, we tested honey from a local bee keeper as well as honey bought from supermarkets.
- Add 10 mL of 1X PBS pH 7.4
- Vortex generously and pH to 4.2
- Take 500 μ L for an NMR sample.
- Spin 10,000 RPM for 10 minutes to remove any insoluble material
- Add 50 μ L of 100% D₂O
- Transfer into 5 mm NMR tube (NORS58008)
- 1D ¹H NMR spectra were recorded at 700 MHz with Bruker pulse sequence `zgpg30` using standard parameters
- Identify the features of different carbohydrates in the sample. Record reference NMR spectra of the carbohydrate references if needed.

The Chemical Composition of Honey

<https://pubs.acs.org/doi/10.1021/ed084p1643>