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A Dilution-Free Capacitive Sensing Platform for Rapid Detection of Honey Adulteration

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Abstract

Honey adulteration has become increasingly prevalent, and consumers cannot easily verify authenticity without relying on specialized testing laboratories. Such approaches are time consuming and labor intensive, creating barriers to routine quality assurance. To streamline authenticity assessment, this study introduces a capacitive sensor as an alternative to conventional electrochemical impedance spectroscopy. The sensor directly interrogates undiluted honey and adulterated samples, eliminating dilution and other pre-treatment steps. As a result, it shortens assay turnaround, reduces overall cost, and provides a rapid and straightforward means of discriminating genuine honey from adulterated products.

Keywords: Honey adulteration; capacitive sensor; dilution-free analysis; rapid authentication.

INTRODUCTION

Honey is a globally valued natural product, yet its vulnerability to adulteration, particularly through dilution with water or addition of sugar syrups, has raised serious concerns for consumer safety and market integrity. Conventional analytical methods such as chromatography, isotope ratio mass spectrometry, and electrochemical impedance spectroscopy can reliably identify adulteration but remain limited by their high cost, labor requirements, and lack of portability, which restricts their use in rapid field-based quality assurance (Huang et al., 2021). To address these limitations, this study proposes a capacitive sensing platform capable of directly interrogating undiluted honey samples without pre-treatment. The sensor provides results within one second, operates at a fraction of the cost of conventional approaches, and demonstrates the potential of capacitive sensing technologies as a practical alternative for authenticity verification and real-time food quality monitoring.

MATERIALS AND METHODS

Honey was obtained from the National Chiayi University Staff and Student Consumer Cooperative (Chiayi, Taiwan), and syrup from Fengnian Fenghe Co., Ltd. (Tainan, Taiwan). Sample preparation employed an analytical balance (SHIMADZU ATX224R), an ultrasonic bath (Branson Ultrasonics 5510), and a tube mixer (MIXER UZUSIC VTX-3000L) to ensure uniformity and remove air bubbles. During measurements, temperature was maintained at 25 ± 0.2 °C using a heating stirrer (Thermo Scientific SP88857100). Capacitance was measured with a custom sensor equipped with

screen-printed electrodes. Honey was blended with syrup at weight ratios of 25% (H75), 50% (H50), and 75% (H25), with pure honey (H100) and pure syrup (H0) as controls, following procedures adapted from Huang (2021).

RESULTS & DISCUSSION

Figure 1 showed a clear positive correlation between honey content and capacitance, which increased from 2.28 pF to 2.54 pF as the honey proportion rose. Regression analysis yielded an R^2 of 0.9716, indicating excellent data fitting and predictive capability. Although the variation in capacitance values was relatively small, the method consistently distinguished different mixing ratios, demonstrating both stability and effectiveness in detecting adulterated honey.

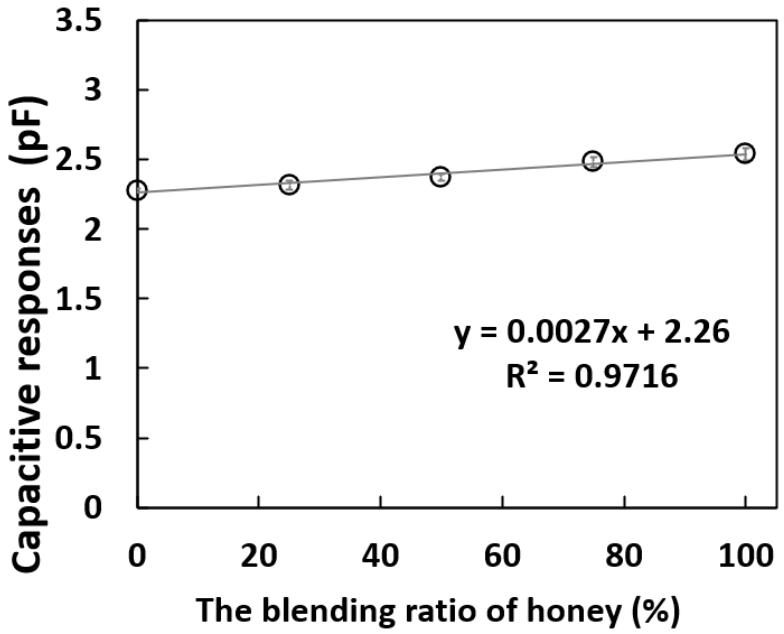

Fig 1. Capacitance of honey adulterated with syrup at 0% (H0), 25% (H25), 50% (H50), 75% (H75), and 100% honey (H100).

CONCLUSIONS

This study presents a dilution-free capacitive sensing approach for rapid honey adulteration detection. Using a simple sensor with replaceable screen-printed electrodes, the method ensures high accuracy, shortens analysis time, and simplifies operation. Its portability and real-time capability highlight strong potential for on-site food quality control.

REFERENCES

Huang et al. 2021. Impedimetric sensing of honey adulterated with high fructose corn syrup. Food Control .130: 108326.