Application Note – N°. 904/2025

On-Site sugar content analysis in cereal

Abstract: Breakfast cereals are a common source of nutrients but often contain high sugar levels, raising health concerns. Accurate sucrose measurement is vital for labeling and consumer awareness. This study assesses the ProxiScout™ handheld NIR scanner as a rapid, non-destructive, and cost-effective alternative to traditional HPLC. Results show ProxiScout™ delivers reliable sucrose estimates, supporting its use in quality control.

1. Introduction

Nutrition labels may not always reflect the actual sugar content of commercial products, with studies showing discrepancies of up to 20%. Given the health implications of excessive sugar consumption, there is a need for real-time, accurate methods to assess sugar levels in processed foods.

Traditional sugar analysis techniques, such as HPLC and enzymatic methods, are accurate but expensive and labor-intensive. Near-Infrared (NIR) spectroscopy presents a rapid, non-destructive alternative. This study demonstrates the effectiveness of ProxiScout™ in measuring sucrose levels in breakfast cereals, allowing for efficient on-site testing.

2. Equipment

The ProxiScout™ handheld NIR scanner was used to collect spectral data from breakfast cereal samples. The device enables real-time quality control and screening with minimal training, utilizing diffuse reflectance spectroscopy to capture spectral fingerprints.

- Setup: Scanner on Diffuse reflection mode coupled with the rotator accessory rotating stage for spectral averaging of Heterogeneous samples. (Figure 1).
- Spectral Range: 1350–2550 nm.

Figure 1: ProxiScout™ Scanner coupled with the rotating accessory.

3. Samples and Measurement Conditions

Samples:

- Total Samples: 60 breakfast cereal samples coated with sucrose, manufactured by a leading snack company in Ohio, USA.
- Sample Preparation:
    - Cereals were blended to achieve a homogeneous particle size.
    - Samples were transferred to glass petri dishes and placed on a rotating stage to ensure spectral averaging for reproducible measurements.

Measurement Conditions:

- Scan Time: 5 seconds per sample.
- Resolution: 16 nm at λ = 1,550 nm.
- Spot Size: 10 mm^2.
- Temperature: Room temperature.
- Averaging: Each sample was measured three times, with the results averaged for analysis.

4. Procedure

4.1 Reference Methods

- HPLC was used to determine sucrose levels in the samples.
- The sugars were separated using a stainless steel 7.8 mm ID x 300 mm Aminex® HPX-87C carbohydrate column under isocratic conditions at 80 °C using HPLC grade water with a flow rate of 0.6mL/min for 30 minutes.

4.2 Calibration Model Development

Partial Least Squares (PLS) regression models were developed to establish a linear relationship between spectral data and laboratory-measured sucrose content. The models were optimized using:

- Cross-validation techniques to enhance predictive accuracy.
- Generalized sample calibration, ensuring robustness against variations in sample composition.

4.3 Data Analysis

The PLS model was evaluated using cross-validation, which involved:

- Splitting data into calibration and validation sets.
- Train the model using the calibration set.
- Testing the model on the validation set to assess predictive performance.

The statistical parameters used for evaluation include:

- R^2 (Coefficient of Determination): Measures correlation between predicted and actual values (closer to 1 is better).
- RMSE (Root Mean Square Error): Represents prediction error (lower is better).
- SECV (Standard Error of Cross-Validation): Indicates model reliability (lower values suggest better accuracy).

5. Result

5.1 Model Performance Metrics

Sucrose Content Prediction:

- R^2 = 0.99, indicating excellent correlation with HPLC results.
- SECV = 1.2%, demonstrating high accuracy.
- Performance surpasses previous NIR-based methods and bench-top FT-NIR systems.

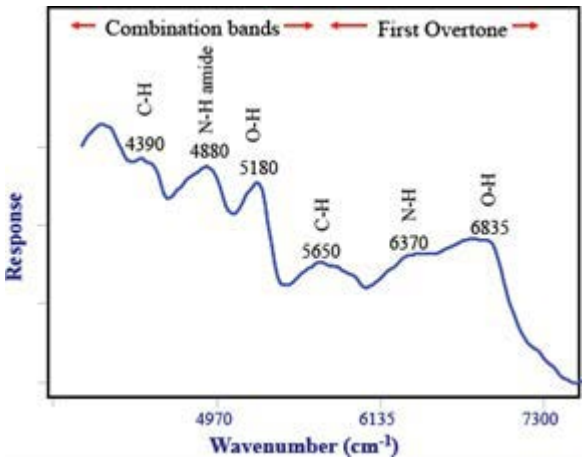

Figure 2: Spectrum obtained from cereal samples taken with ProxiScout™-Module.

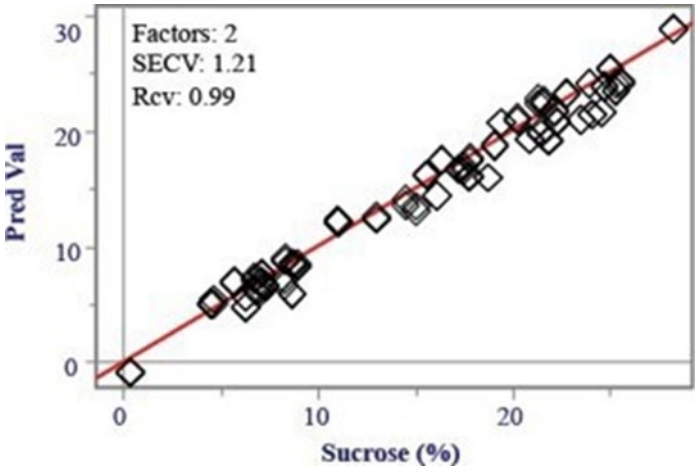

Figure 3: Partial Least Squares Regression (PLSR) plots for sucrose content in breakfast cereals by ProxiScout™-Module.

5.2 Key Observations

- The ProxiScout™ scanner accurately predicted sucrose concentrations in cereals.
- Minimal error compared to traditional HPLC analysis.
- The system enables real-time testing, reducing reliance on costly lab-based methods.
- The sucrose levels in the cereal samples ranged from 0 to 30 g/100 g, covering a wide range of concentrations resembling commercial breakfast cereals with reported averages of 22.5±12.6 g/100 g (Pombo-Rodrigues et al., 2017).
- PLSR Regression Results: SECV for sucrose was 1.2%, with a correlation coefficient (r) of 0.99.
- Comparison with other NIR Methods: ProxiScout™-Module demonstrated superior performance compared to bench-top FT-NIR (SEP = 1.5%) and another handheld analyzer (1.5%).
- NIR Spectra Findings: Characteristic absorption bands at 4390 cm^{-1} (C-H bonds), 4420 cm^{-1} (C-H in carbohydrates), 4880 cm^{-1} (amide absorption in protein), 5180 cm^{-1} (O-H in water), and 5807 cm^{-1} (aliphatic C-H).
- Unique Sucrose Band: Found at ~4800 cm^{-1}, confirming the presence of crystalline sucrose.

6. Conclusion

6.1 Comparison to Standard Methods

- ProxiScout™ results closely matched HLPC measurements, validating its suitability for on-site testing.
- Unlike laboratory methods, ProxiScout™ provides instant results, eliminating ample transfer and preparation delay.

The ProxiScout™ handheld NIR scanner has demonstrated excellent performance in measuring sucrose content in breakfast cereals. Its ability to provide rapid, non-destructive analysis makes it an ideal tool for cereal manufacturers, nutritionists, and regulatory agencies. By integrating real-time testing into production processes, ProxiScout™ enhances quality control and ensures compliance with nutrition labeling requirements.

7. References

[2] Walker, R. W., & Goran, M. I. (2015). Labeling accuracy of added sugars in breakfast cereals and nutrition bars marketed to children. British Journal of Nutrition, 114(8), 1287-1294. https://doi.org/10.1017/S0007114515002822

[3] Te Morenga, L., Mallard, S., & Mann, J. (2012). Dietary sugars and body weight: Systematic review and meta-analyses of randomized controlled trials and cohort studies. BMJ, 346, e7492. https://doi.org/10.1136/bmj.e7492