Application Note – N°. 900/2025

Conformity testing in milk powders with ProxiScout™

Abstract: Ensuring the purity of milk powders is essential for food safety, quality control, and regulatory compliance. Adulteration, particularly with substances such as urea, poses significant risks. The ProxiScout™ handheld NIR scanner provides a rapid and cost-effective solution for detecting adulterants in milk powder using spectral fingerprinting and an advanced conformity index algorithm. This study evaluates ProxiScout's ability to detect urea adulteration in milk powders with high accuracy and repeatability.

1. Introduction

Milk powders are widely consumed globally and play a critical role in the dairy industry. However, milk powder adulteration is a prevalent issue, with urea commonly used to falsify protein content Urea (Carbamide – CO $(NH_2)_2$) is a natural constituent of milk and is rich in Nitrogen. In typical milk testing practices, the protein content of milk is estimated by analyzing the nitrogen content. Therefore, to increase the detectable amount of nitrogen in milk, urea is often used as a milk adulterant. This practice allows adulterators to falsely mark their milk as higher quality milk with higher protein content and charge higher prices. Traditional detection methods, such as chemical analysis, require laboratory infrastructure, are time-consuming, and involve destructive sample preparation.

Near-infrared (NIR) spectroscopy presents a rapid, non-destructive alternative, enabling real-time conformity testing by analyzing spectral deviations from pure milk powder samples. This study demonstrates the effectiveness of ProxiScout™ in detecting unknown adulterants in milk powder. This study investigates the effectiveness of ProxiScout™ in determining fat, protein, and lactose content in milk, offering a practical solution for dairy farmers, quality control laboratories, and processing plants.

2. Equipment

The ProxiScout™ handheld NIR scanner was used to collect spectral data from milk powder samples. This device enables on-site purity screening with minimal training, utilizing diffuse reflectance spectroscopy to capture spectral signatures and determine sample conformity instantly.

- Setup: Reflection mode using powder kit.
- Spectral Range: 1350–2550 nm.

3. Chemicals and Materials

Samples:

- Total Samples: 5 commercial milk powder samples.
- Test Groups:
  - Reference samples: Unadulterated milk powder.
  - Adulterated samples: Milk powders mixed with urea at concentrations of 1.25%, 2.5%, and 5%.

3.1 Measurement Conditions

- Scan Time: 3 seconds per sample.
- Temperature: Room temperature.
- Averaging: Each sample was measured four times, with results averaged for analysis.
- Devices Used: Five ProxiScout™ scanners were employed to ensure model consistency across instruments.

3.2 Screening Algorithm

ProxiScout™ utilizes an envelope-based screening algorithm, which compares the test spectrum against reference spectra. An envelope around the mean of the reference spectra is used as an acceptance criterion. If the test spectrum falls fully inside this envelope, then this sample passes this screening algorithm, otherwise, this sample doesn't match the reference samples. The envelope is based on the standard deviation of the reference spectra at every wavelength as shown in Figure 1.

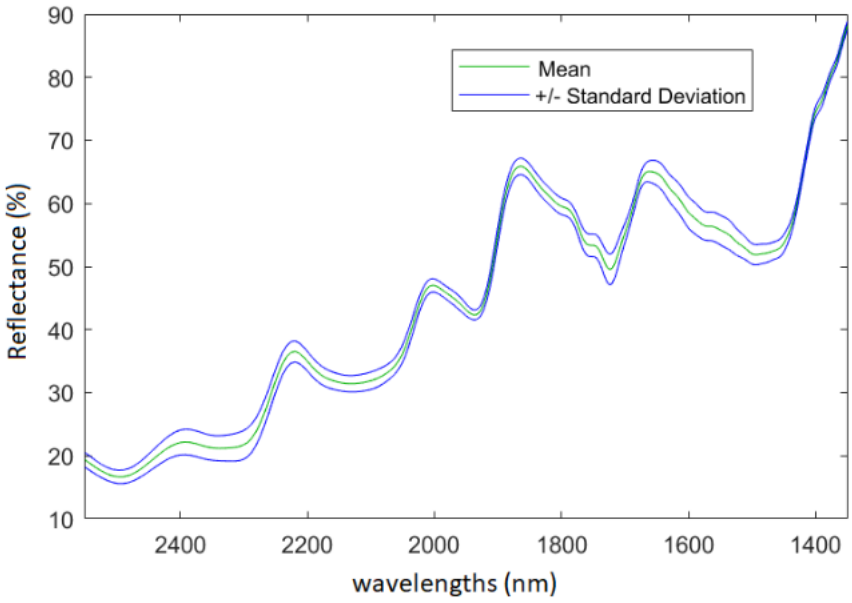

Figure 1: Mean and standard deviation of the unadulterated milk powder samples.

The evaluation metric is the maximum normalized deviation from all wavelengths, called the conformity index. The conformity index (CI) is calculated using:

$$CI = \max[\ (\ test\_spectrum_i - mean_i\ ) / \ std_i\ ]$$

Where:

- Test spectrum = spectral response of the sample.
- Mean = average spectral response of the reference samples.
- Std = standard deviation of reference spectra.

A **CI threshold of 5** was set as the acceptance criterion, meaning any sample with a CI above this value is classified as adulterated.

4. Result

4.1 Model Performance Metrics

3 milk powder samples adulterated with different concentrations of Urea are tested with 4 scanners, beside an unadulterated sample. All adulterated samples were detectable across all 4 ProxiScout™ scanners as shown in Figure 2.

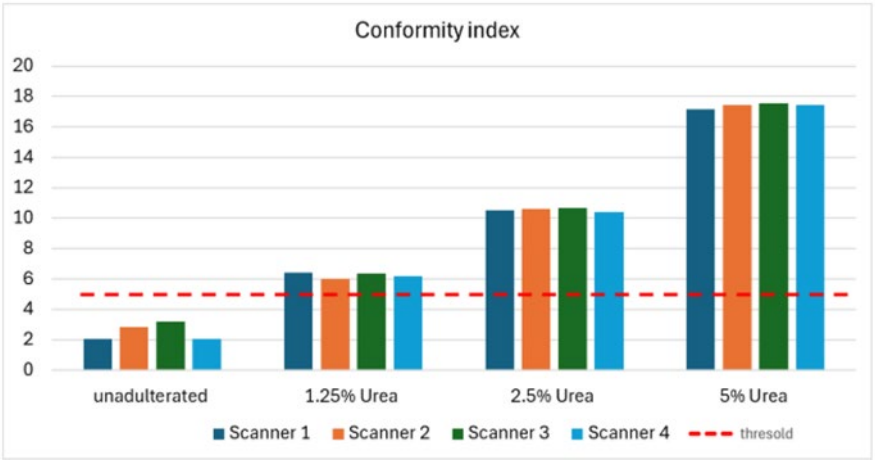

Figure 2: conformity index of urea adulterated milk powder samples.

- All adulterated samples **(1.25%, 2.5%, and 5% urea)** were detected across all four test scanners.
- CI values exceeded the set threshold of 5 for adulterated samples, confirming the screening method's robustness.
- Unadulterated samples consistently remained within the acceptance envelope, ensuring high specificity.

5. Conclusion

5.1 Comparison to Standard Methods

- ProxiScout™ provided results in seconds, compared to hours required for chemical analysis.
- Unlike traditional methods, ProxiScout™ offers real-time, non-destructive analysis with no reagent costs.

The ProxiScout™ handheld NIR scanner, in combination with the Conformity App, provides an effective, rapid, and user-friendly solution for detecting urea-adulterated milk powders. Its ease of deployment, coupled with minimal training requirements, makes it an ideal tool for quality control labs, regulatory agencies, and dairy manufacturers. This technology significantly enhances food safety by enabling real-time decision-making and batch conformity verification.

6. References

[1] International Committee for Animal Recording (ICAR). (n.d.). Milk analysis guidelines. ICAR. https://www.icar.org/Guidelines/12-Milk-Analysis.pdf

[2] Sharma, S., & Bhargava, A. (2023). A comprehensive analysis and detection methodology using near-infrared (NIR) spectroscopy to unveil the deceptive practice of milk adulteration. Proceedings, 59(1), 196. MDPI. https://doi.org/10.3390/proceedings2023059196

[3] Ellis, D. I., Muhamadali, H., Haughey, S. A., Elliott, C. T., & Goodacre, R. (2016). Point-and-shoot: Rapid quantitative detection methods for on-site food fraud analysis – Moving out of the laboratory and into the food supply chain. Food Safety and Risk, 2, 4. https://foodsafetyandrisk.biomedcentral.com/articles/10.1186/s40550-016-0045-3