Developing a Rapid Screening Approach for Milk Counterfeiting Risks Using Infrared Spectroscopy Combined With Chemometrics

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Counterfeit milk accounts for up to 14% of food fraud cases globally, severely impacting the economic, consumers health, and manufacturers reputation, particularly in solid-state milk products. While conventional analytical methods are accurate, they are often destructive, expensive, and time-consuming, making it impossible to be developed into a rapid screening method. To address this problem, a rapid screening approach for milk counterfeiting risks was developed using Fourier-Transform Infrared - Attenuated Total Reflectance (FTIR-ATR) spectroscopy combined with advanced chemometrics algorithms. A standard dataset was established by measuring spectra from 50 distinct spots in each container of all 33 commercial milk types. For analyzing, each sample goes through a three-phase framework: Principal Component Analysis (PCA) with k-Nearest Neighbours (kNN) for initial screening in Phase 1; Partial Least Square (PLS) with kNN for further refinement in Phase 2; Artificial Neural Network (ANN) for final classification in Phase 3. An independent dataset was then collected from different batches and containers for external validation; and spiked samples (created from mixing milk types at 8:2 or 7:3 ratio) were also used to evaluate the ability to identify adulteration. Results indicated that nearly 100% classification accuracy across all samples. Afterwards, ANN was used to develop a model to identify infant formulas, implementing the Leave-One-Out (LOO) cross-validation strategy. Lastly, all models are integrated into a web-based platform to provide a real-time analysis tool that can be combined with handheld and portable devices for rapid on-site inspection as well as quality check for manufacturers or retailers.

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