Application Note AN-PAN-1061

Inline detection of wheat flour adulteration by NIR spectroscopy

The adulteration of products in the food industry has always been a major concern since it is an easy way to cut costs [1]. However, this leads to major health risks if allergens or other harmful cutting agents are introduced, as well as changes in food quality and nutritional values.

Detecting food adulteration is often not an easy task since the substitutes mimic the chemical and physical characteristics of the original product. To ensure that the food industry can guarantee high product quality for consumers, it is imperative to identify any contamination in the raw materials and in the final products. This is only possible with precise measurements performed during the manufacturing process.

This Process Application Note details the inline analysis of the presence of potato starch adulterant in a wheat flour manufacturing process with near-infrared (NIR) spectroscopy using a 2060 *The* NIR Analyzer from Metrohm Process Analytics. The 2060 *The* NIR Analyzer offers fast, reagent-free, nondestructive analysis of potato starch with a reflectance probe specifically designed for this application. Results are given quickly, and no chemical reagents are required.

INTRODUCTION

Wheat is one of the key global staple crops. According to Statista, more than 778 million metric tons of wheat were produced worldwide in 2021–2022 [2]. From its grains, wheat flour is produced – the main ingredient in bread, a staple food consumed worldwide. Starch is the key component within bread and influences the shape, crumb consistency, and overall flavor. During the baking process, gelatinization occurs between the starch within the flour and the water added to the dough.

The breakdown process from wheat grains into flour involves several preparative steps that vary depending on the type of flour to be produced (e.g., whole wheat flour, refined flour, etc.). The main process is «milling» which consists of grinding the grains to a flour-like consistency.

Similarly to wheat, potatoes are one of the most produced crops in Europe, America, and Asia [3]. In China specifically, the potato is mainly used as a staple food due to its chemical properties and nutritional value (e.g., superior water absorption and it helps to regulate blood glucose) [3]. Potato flour is chemically similar to wheat flour (i.e., mainly composed of starch) [4] making it an excellent alternative in certain situations. Notably, it is also difficult to discern between potato and wheat flour.

The demand for wheat has always been high due to its variations and uses (e.g., flour, bulgur, durum, etc.). Therefore, many kinds of fraudulent activities have been discovered during the production of wheat flour since other materials such as potato flour can be mixed in to lower production costs and increase production volumes.

Metrohm process NIR analyzers enable the comparison of «real-time» spectral data from the process to a primary method to create a simple, yet indispensable model for critical industrial process requirements.

Regular monitoring at multiple process points assists in the early detection of adulteration trends, allowing for prompt intervention and prevention of widespread contamination. This helps protect consumers and maintain the integrity of the food supply chain. Manufacturers can gain more control over flour production with a 2060 *The* NIR Analyzer (Figure 1), which is capable of monitoring up to five process points with each NIR cabinet.

A probe specifically designed for these applications is used as a «spoon» with purge vents located on the probe tip. After each NIR spectrum is collected (see Figure 2), an air purge exiting through the ports in the probe clears the «spoon» for a new sample.

However, mixing potato flour and wheat flour can be beneficial in some cases. Many people are to some extent intolerant to gluten, a major protein found in wheat. Therefore, depending on the application (e.g., wheat flour manufacturer or staple food production), a rapid and accurate method to determine the specific content of both components is necessary to avoid cross-contamination, adulterations, and/or guarantee product quality.

Samples are typically manually withdrawn from the process (e.g., tank or pipe) during wheat/potato flour blending and then analyzed offline in a laboratory. This delay before the analysis results are available to the operator can cause critical processing decisions to be made without the most current information.

Near-infrared (NIR) spectroscopy is an analytical technique that has been widely used in the food and feed sector [5]. Unlike traditional wet chemical methods, NIR spectroscopy requires neither chemicals nor hardly any sample preparation. Hence, it can even be used by non-chemists. Moreover, this method is fast: results are usually available in less than a minute.

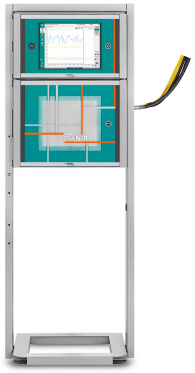

Figure 1. The 2060 The NIR Analyzer with fiber optic cable.

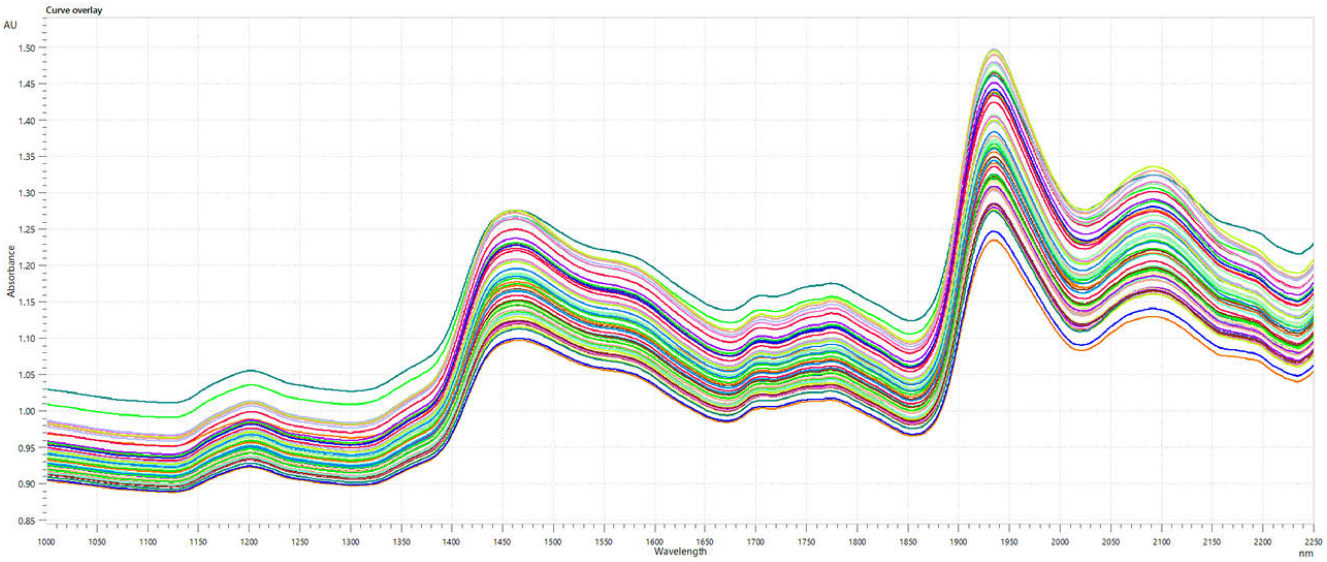

Figure 2. Raw near-infrared spectra collected during wheat flour blending as measured by the 2060 The NIR Analyzer from Metrohm Process Analytics.

APPLICATION

The spectra shown in Figure 2 cover all concentrations from 0 to 100% for each type of flour (wheat and potato). It is not possible to assign a spectrum to a type of flour merely by visual inspection. Therefore, advanced mathematics (chemometrics) are used.
The wavelength range used is 1100–2000 nm which corresponds to the region where the compounds of interest give a response, in the present case: starch, water (moisture), protein, sugar, and fat. Inline analysis is possible using a micro interactance reflectance probe with purge on collection tip directly in a feeder/hopper or in a blender.

Table 1. Parameters to monitor inline during the wheat flour blending process.

Analyte	Concentration (%)	Precision
Wheat flour content	0–100%	2.5%
Potato flour content	0–100%	2.5%

REMARKS

An appropriate range of samples covering the process variability should be analyzed by both methods (primary and NIRS) to build an accurate NIRS model. Correlations are made to process specifications. The correct NIRS probe must be placed in-situ in a manner that provides sufficient sample contact with the probe tip window. Correct probe design and proper placement in process equipment is of high importance.

The use of NIR spectroscopy for the inline detection of wheat flour adulteration offers a fast, nondestructive, and reagent-free solution to ensure product quality and safety in the food industry. Adulteration of wheat flour with substances like potato starch can pose health risks and compromise nutritional values.
Traditional methods of detecting such adulteration often involve manual sampling and offline analysis, leading to delays and processing decisions based on potentially outdated information. However, NIR spectroscopy, exemplified by the 2060 *The* NIR Analyzer from Metrohm Process Analytics, enables real-time monitoring of the manufacturing process, providing quick and accurate results. By implementing NIR spectroscopy, manufacturers can make informed decisions, prevent cross-contamination, and uphold product integrity to meet consumer demands for authentic and safe food products.

RELATED DOCUMENTS

AN-NIR-040 Protein content in dietary supplements and near-infrared spectroscopy (NIRS)
AN-NIR-110 Quality control of sugarcane juice
AN-RS-009 Identification and checking of fatty acids in functional foods and cosmetics

BENEFITS FOR NIRS IN PROCESS

- **Optimize product quality and increase profit** with faster response times to process variations
- **Greater and faster return on investment** by using real-time data for process optimization (e.g., optimal wheat/potato ratio)
- No chemicals and reagents required, greatly **reducing operational costs and improving safety**

REFERENCES

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CONFIGURATION

2060 The NIR Analyzer

The 2060 *The* NIR Analyzer is the next generation of process spectroscopy instruments from Metrohm Process Analytics. With its unique and proven design from the inside out, it delivers accurate results every *10 seconds*. It can provide non-destructive analysis of liquids and solids directly in the process line or in a reaction vessel by using fiber optics and contact probes. It has been designed to connect up to five (5) probes and/or flow-cells. All five channels can be configured independently from each other using our versatile embedded proprietary software.

As part of the 2060 Platform, the 2060 *The* NIR Analyzer has a modular concept and it is available in three other versions: the 2060 *The* NIR-R Analyzer, 2060 *The* NIR-Ex Analyzer, and 2060 *The* NIR-REx Analyzer.