

NC-213 PROGRESS REPORT FOR 2025

Title

Development and Testing of Inline Temperature and Moisture Content Measurement of Feed Mash for Thermal Processing Control

Investigators

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Outputs/Research Updates

The manufacturing of feed is characterized by its high energy and data demands. Inefficiencies in thermal processing can have a direct impact on feed safety, quality, and production costs. As energy costs increase and the demand for biosecure and safe feed rises, feed mills need more precise and timely process information to enable effective control of thermal processing. Operations involving feed mash conditioning and hygienizing are heavily dependent on monitoring and controlling temperature and moisture to achieve pathogen reduction, particularly against *Salmonella spp.*, while also ensuring acceptable feed quality. Moisture content is particularly critical as it directly affects heat and mass transfer, microbial lethality, pellet durability and hardness, and shelf-life after processing. Despite its significance, many feed mills still rely on intermittent sampling and lab methods for moisture measurement, which are labor-intensive and too slow for real-time adjustments to processes. This shortcoming limits the amount of usable data available for monitoring, controlling, and optimizing conditioning operations. Building upon previous research conducted at the Iowa State University Kent Feed Mill and Grain Science Complex, which focused on steam usage and the performance of thermal systems, the current project phase aims to enhance thermal process control by improving measurement and prediction of feed mash moisture. While previous studies quantified steam efficiency and system losses, effectively managing conditioning and hygienizing demands accurate, real-time moisture data before and after thermal treatment of feed mash. Traditional oven-drying or benchtop methods for moisture determination limit the collection of timely data. Inline measurement using near-infrared (NIR) moisture sensing has the potential to deliver rapid, reliable, real-time data. Combined with an ISU-developed energy-balance modelling approach, moisture content of conditioned feed mash could be predicted in real-time. This study seeks to validate predicted moisture content against laboratory oven-drying and benchtop NIR results and assess their accuracy and reliability for commercial feed mills. Knowing moisture content of feed mash in real-time will improve thermal process control and lay the groundwork for future AI-enabled automation in feed manufacturing.

Outcomes/Impacts/Deliverables and updates of studies initiated in 2025

1. *Predict and validate the moisture content of conditioned feed mash using real-time measurements and an ISU-developed energy balance model to support improved control during thermal processing.*

This phase of the research focused on implementing improved moisture measurement and prediction approaches to support thermal process control during feed conditioning in the feed mill tower of the Iowa State University Kent Feed Mill and Grain Science Complex (FMGSC). A bench-top near-infrared (NIR) moisture analyzer was introduced as an initial step toward developing an inline moisture sensing system for feed mash. Moisture data were collected from different feed mash types at two sampling locations: the inlet mash prior to steam conditioning and the conditioned mash after exiting the conditioner. Twenty-four samples were collected. During each sampling event, three subsamples were analyzed for each sample using the NIR instrument. The results were then averaged to mitigate random measurement errors and improve consistency under production conditions. Parallel samples were evaluated using the standard forced-air oven-drying method at 105 °C for 3 hours to provide laboratory reference values for comparative analysis and verification. Simultaneously, the moisture content of the outlet conditioned mash was predicted using the ISU-developed Feed Conditioning Energy Balance Calculator. The inlet moisture readings obtained from the NIR analyzer were used as input with real-time process parameters recorded from the plant automation system. These included product flow rate, inlet and outlet temperatures, steam mass flow rate, and steam quality. Steam enthalpy was determined from the steam table based on the regulated steam pressure. These data points were entered to calculate predicted outlet moisture values and compared against NIR and oven measured moisture content values from samples collected. The findings from this work will produce a structured dataset that links inlet moisture measurement, thermal processing conditions, and predicted conditioned mash moisture.

2. *Identify, install, and validate an inline moisture content sensor for measuring incoming feed mash prior to steam conditioning.*

An inline NIR moisture sensor has been identified and purchased for installation. Sample collection efforts will continue and data generated by the inline NIR moisture sensor will be analyzed and validated against the benchtop NIR and standard oven method. Subsequently, the prediction model will be calibrated against experimental results. Once validated, the model will be incorporated into the plant automation software for real-time inlet moisture measurement and outlet moisture prediction. This will substantially improve process monitoring and control of thermal processing.

Publications

Oral/Poster Presentations (Amofah)

Development and Testing of Inline Temperature and Moisture Content Measurement of Feed Mash for Thermal Processing Control. ABE 6010 Graduate Seminar—Three-Minute Graduate Research Oral Presentation, December 8, 2025. Iowa State University, Ames, IA.

Funding Sources

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