Exploring New Methods & Technologies for Wheat End-Use Quality Testing and Benchmarking for the University of Minnesota Breeding Program

George Annor, Grain Biopolymer Lab, Food Science & Nutrition Dept, U of M

Research Questions

The aim of this study, was to explore how new methods and technologies can be used to rapidly screen the hundreds of wheat samples developed by the Wheat Breeding Program at the University of Minnesota. The end use-quality of wheat varieties grown in the years 2015-2016 and 2016-2017 were also screened. In this reporting year, about 800 wheat varieties harvested from the year 2015-2017 have been screened for their protein aggregation kinetics using the Gluten Peak Tester (GPT). The GPT results were used by Dr. James Anderson, a wheat breeder at the Department of Agronomy and Plant Genetics in his breeding program. Screening has also been completed for all 64 wheat samples from different locations in Minnesota for their gluten aggregation kinetics using the GPT and starch pasting properties using the Micro visco Amylograph. About 16 of the samples have been screened for their dough mixing properties using the Farinograph, dough extensibility properties using the Kieffer rig and changes in their gluten secondary structure using the FTIR. Significant differences were observed in the protein functionality of the samples, especially their gluten aggregation kinetics. These differences show that these samples can be differentiated from each other using rapid methods such as the GPT. Work is still ongoing to complete the rest of the proposed analysis to enable correlations of the results to be done in our bid to select key tests that can be used to rapidly screen the hundreds of wheat samples developed by wheat breeders.

Background

In collaboration with the Department of Agronomy and Plant Genetics at the University of Minnesota, the Grain Biopolymer Laboratory in the Department of Food Science and Nutrition at the University of Ghana has been exploring new methods and technologies for the rapid evaluation of the end-use characteristics of new wheat lines under development by the wheat breeding program at the University of Minnesota. This has become necessary because, the use of conventional methods such as the Mixograph and Farinograph for testing dough mixing properties and baking quality tests are laborious and time consuming. Considering the thousands of wheat lines crossed and selected annually by the wheat breeding program, these conventional methods results in significant delays in the release of new varieties. The development of the Gluten Peak Tester (GPT) by Brabender (Brabender, NJ, USA) provides a rapid assessment of the protein quality of wheat based on the aggregation kinetics of gluten. The high throughput of the GPT (about 5min of test time) and the relatively small amounts of samples needed for the analysis (about 10g) makes the GPT a viable equipment for rapid end-use quality testing for wheat breeders. Preliminary experiments conducted in the Grain Biopolymer Lab suggested a good correlation between indices measured by the GPT with those of the Farinograph. However, these preliminary experiments were conducted with a small number of samples and hence a much larger study was needed to validate the correlations previously observed. Haven said that, the GPT has been used by the Grain Biopolymer Lab for screening hundreds of wheat lines being developed by the University of Minnesota wheat breeding program. It was also important to explore new end-use quality testing methods.

The objectives for this project were to:
1. Explore the use of new methods and technologies to assess wheat protein conformation changes, gluten aggregation kinetics, dough mixing and extensibility properties and starch pasting characteristics of new wheat lines being developed by the University of Minnesota wheat breeding program
2. Identify key tests that will be used for routine wheat screening by correlating data from the new tests and methods to quality indices generated from conventional quality approaches
3. Evaluate wheat varieties grown in 2015-2016 for end-use quality
4. Evaluate wheat varieties grown in 2016-2017 for end-use quality

Materials and Methods

Over 800 wheat varieties were milled with the Udy Cyclone Mill and evaluated for protein aggregation kinetics using the GPT. Sixty-four (64) other wheat samples grown in three different locations (St. Paul, Crookston and Morris Minnesota) were used for the study on the exploration of new methods and technologies. The 64 samples were milled by Quadrumat Junior (Brabender, NJ, USA), and the refined flours were assessed for their gluten aggregation kinetics by GlutoPeak Tester, pasting Properties by Micro-Visco-Amylograph dough mixing properties by Farinograph-AT (Brabender 810162, Duisburg, Germany), dough extensibility by Kieffer Rig (Texture Analyzer TA-XT2i, Hamilton, Massachusetts, USA) and protein conformation by Fourier Transformed Infrared Spectroscopy (FTIR) (Bruker Optics Tensor37, Billerica, Massachusetts, USA.

Results

Over 800 new wheat lines grown in the years 2015-2016 and 2016-2017 have been screened for their protein aggregation kinetics using the GPT and results, sent to Dr. James Anderson. These results will be important in taking critical decisions in the breeding program. The evaluation of these samples completes proposed objectives 3 and 4. The GPT of all 64 samples have also been completed and the results shown in Figure 1. The GPT assesses the gluten aggregation kinetics of the samples by measuring the amount of energy needed to aggregate gluten proteins. Typical curves of the GPT have been shown in Figure 1. During the test a uniform gluten network is formed, resulting in a strong increase of the torque curve. Further mixing destroys the network, resulting in a decrease in the torque curve. Important parameters such as peak time (time to reach the maximum torque) and the maximum height of the curve are measured. Strong gluten shows short peak times with high peaks, while weak gluten shows late aggregation peak times with low or no peaks. Samples showed significant variations in their gluten aggregation. In General, Rollag grown in all three locations was the strongest of all the wheat samples. It had the shortest peak times and high maximum peaks. Ent 26 gown in Saint Paul had the longest maximum peak time.This suggest a very weak wheat. The wide variation in the GPT indices shows that this equipment could be adopted to rapidly screen hundreds of wheat samples for their protein quality.

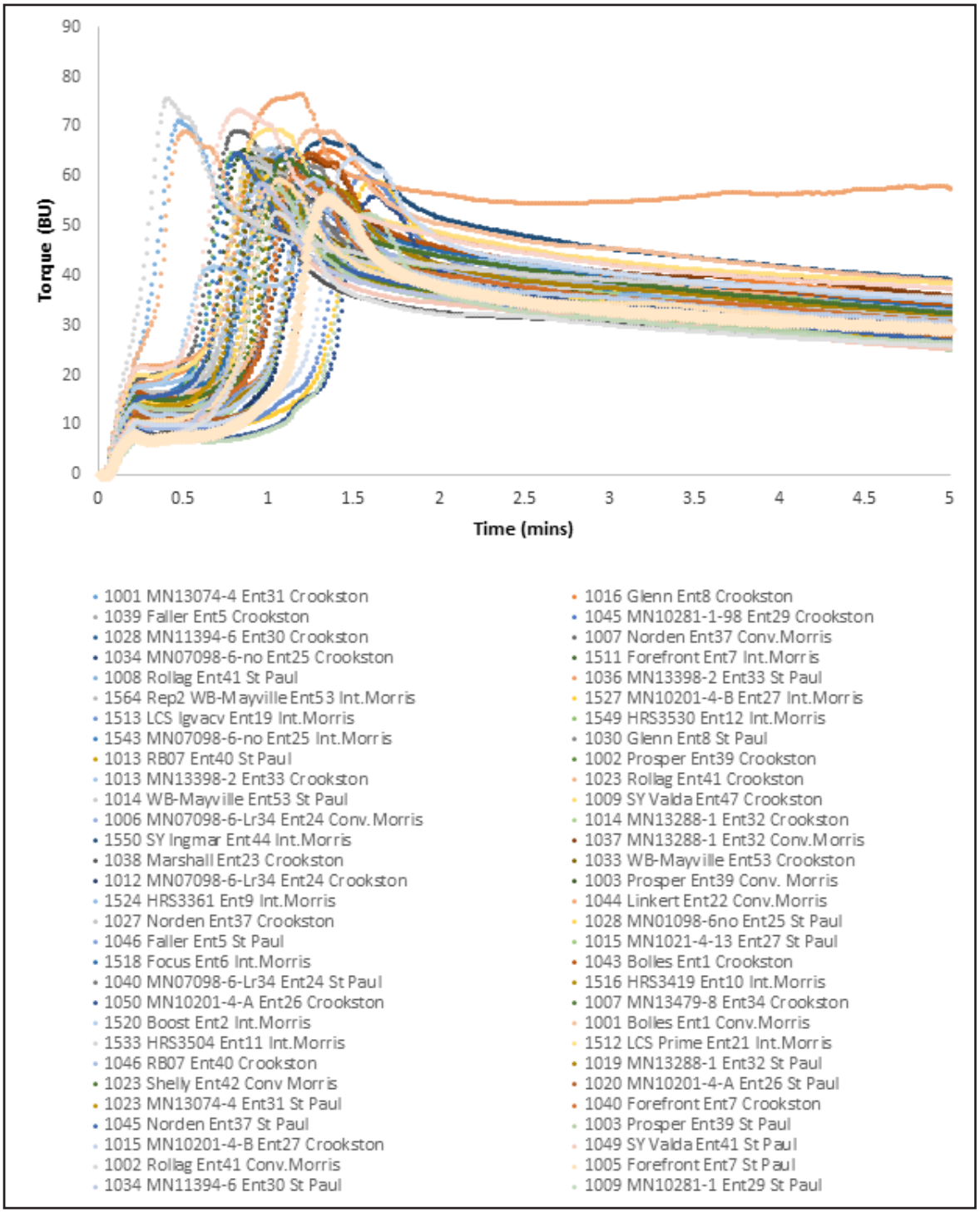

Figure 1. Gluten aggregation kinetics by GlutoPeak results summary graph

The pasting characteristics all 64 samples have also been completed (Figure 2).

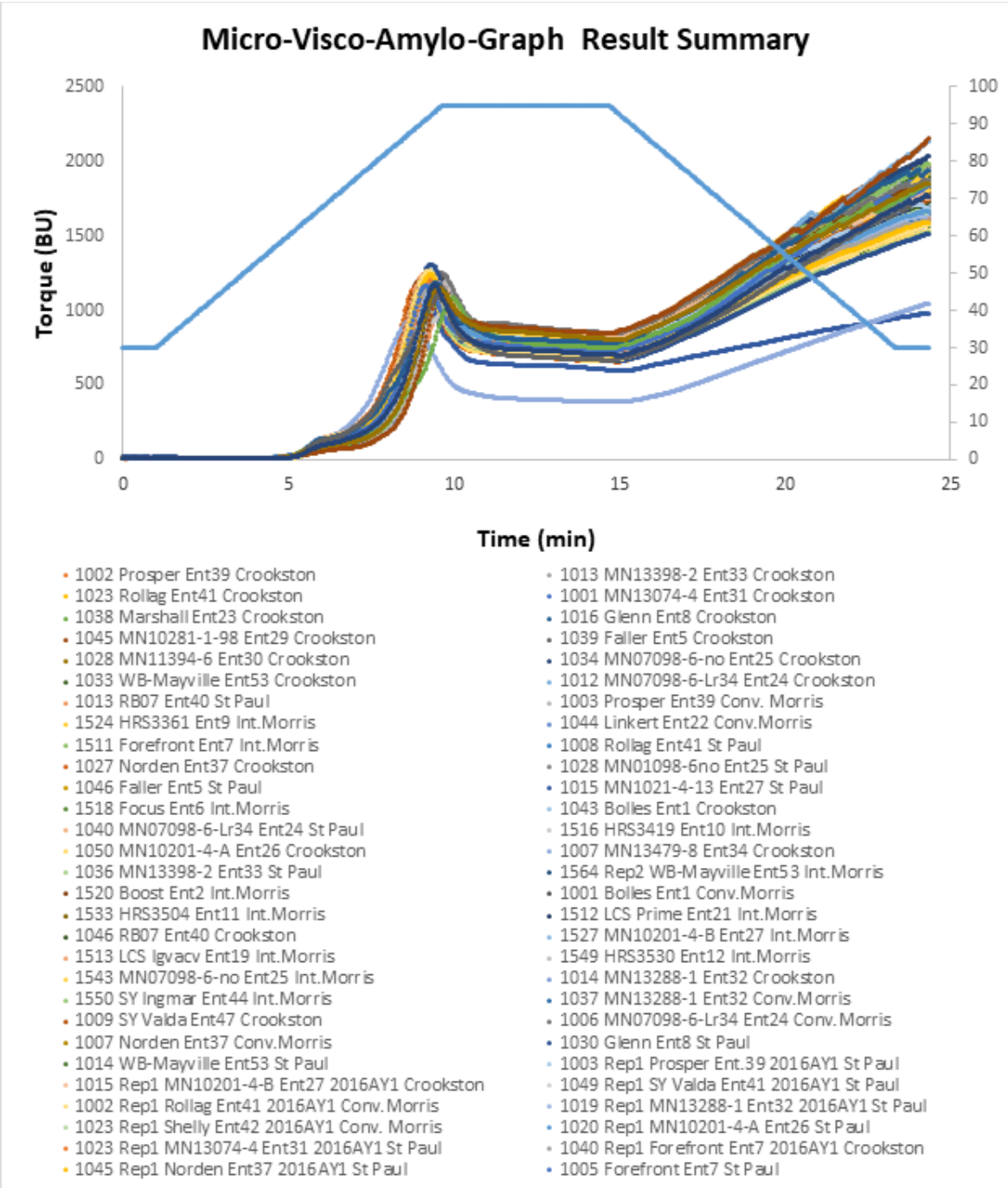

Figure 2. Pasting properties by Micro-Visco-Amylograph results summary

The pasting profiles were determined using the Micro viscoamylograph (MVAG). The MVAG measures the gelatinization properties of the starches by measuring the beginning of gelatinization, gelatinization maximum, and gelatinization temperature, viscosity during holding and viscosity at the end of cooling. The pasting profiles of the samples also showed significant differences in the samples indicating differences in the starch characteristics of the samples. 1015 MN10201-4-13 Ent27 St Paul and 1007 MN13479-8 Ent34 Crookston samples had the lowest pasting profile parameters. The dough mixing properties of 14 of the samples have been completed and the water absorption and dough stability are shown in Figures 3 and 4. Samples showed varied differences in their dough mixing properties, especially their water absorption and dough stability.

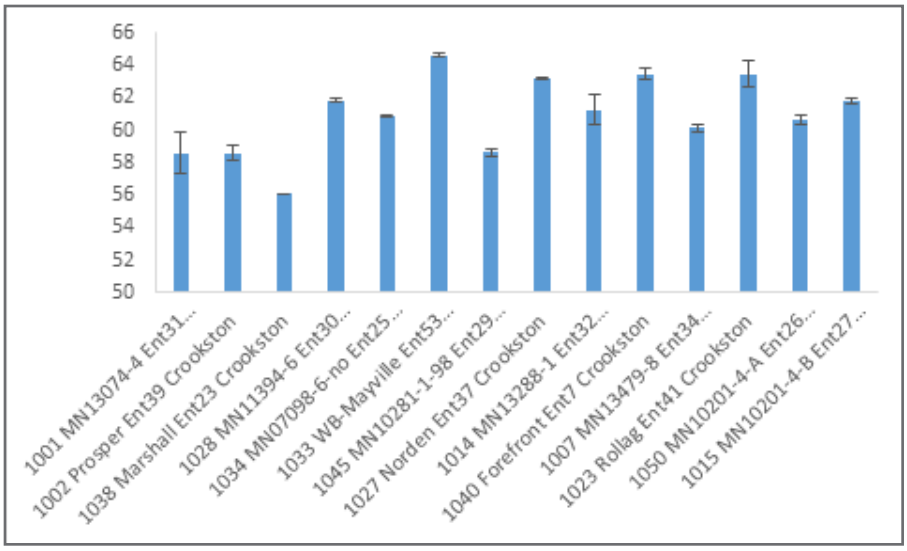

Figure 3: Water absorption (%) of samples

Another property of the samples investigated, was the changes in the secondary structure of their gluten protein during dough mixing. The presence or absence of these secondary structures influence the performance of dough prepared from the samples. Samples showed significant differences in the protein secondary structures (Figure 5)

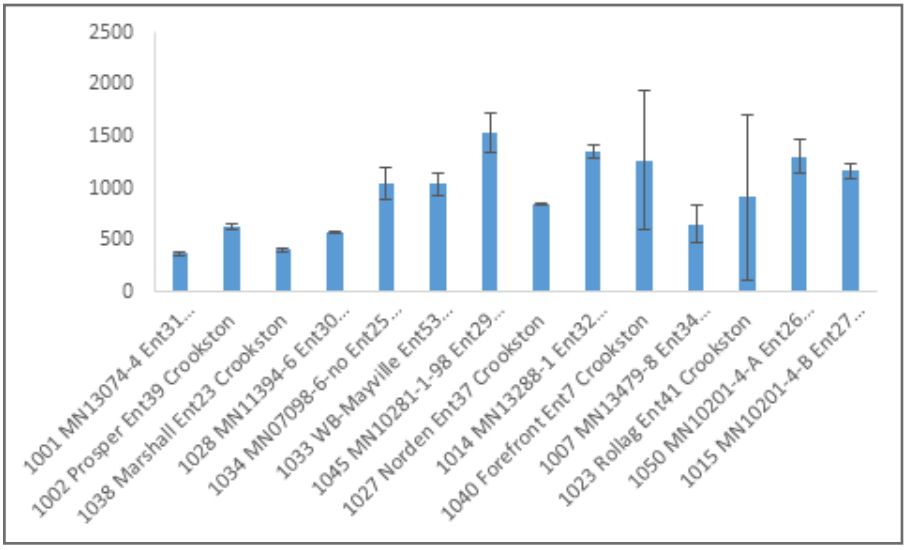

Figure 4: Dough stability (s) of samples

Summary

Work is still ongoing to achieve the project's aim of identifying key and rapid tests to screen wheat samples for wheat breeders. Results from the GPT and MVAG which are all complete indicates that, the protein aggregation kinetics as well as the pasting properties of starches in wheat can be used as indices for end-use quality screening. We are yet to complete all tests on the dough mixing properties and the protein solubility and hydrophobicity of the samples.

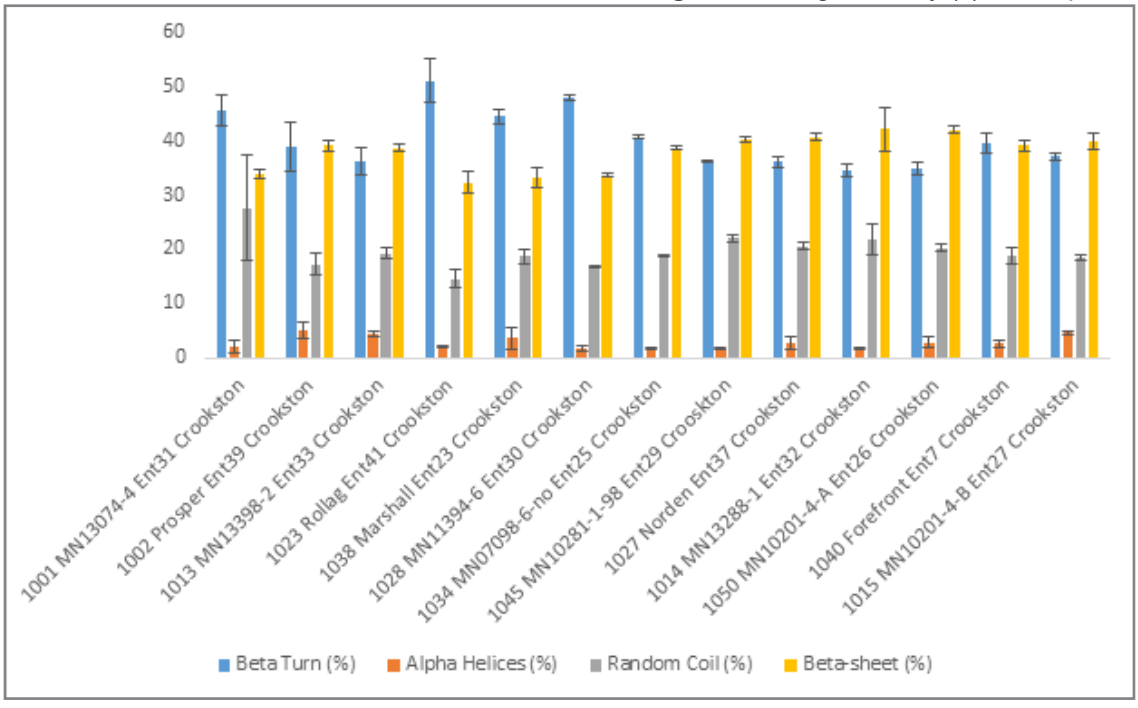

Figure 5: Dough protein secondary structures