Modeling Pasting Curves of Cornstarches Using Parameter Estimation Techniques

Sulaiman, Rabiha[1,2], Dolan, Kirk D.[1,2] and Steffe, James F.[1,2]
[1]Dept of Biosystems and Agricultural Engineering, [2] Dept of Food Science & Human Nutrition, Michigan State University, East Lansing, MI, USA

Introduction:

Pasting curves are powerful tools to represent starch functional properties. Many researchers have reported the pasting curves of ungelatinized native starches using the RVA, Viscoamylograph, and Brookfield viscometers. However, the rheological data collected from these empirical instruments are of questionable value in pipeline design calculations because the shear rates involved in the mixing process are unknown. In contrast, the mixer viscometry method (fundamental approach) provides known average shear rate and 'true' apparent viscosity value. The pasting curve model, using fundamental values, can be very useful in the food industry, which uses starch as one of its main ingredient. The model can provide quick access in predicting apparent viscosity of starches where it could be used for quality control purpose and process engineering calculation in the food industry. This approach will be helpful in saving cost and time by minimizing experimental work.

Methodology:

This study used the mixer viscometry approach to study the viscosity profile of ungelatinized corn starches (National Starch, NJ) at concentration of 6% (w/w) at different apparent amylose to amylopectin (AM/AP) ratios: waxy (0%AM), Hylon V (50%AM), and a mixture of waxy-Hylon V starch (10, 20, 30, 40%AM). A modified Brookfield viscometer connected to three constant temperature water baths (97ºC, 6ºC, and 61ºC) and controlled by using a system of three solenoid valves with a timer was used. Mixer geometry configurations with 13cc cup and flag impeller were used. Temperature profile was 60ºC to 95ºC to 60ºC with total time of 22min 13sec at constant speed 100rpm. Continuous torque data were collected using LabView program. The apparent viscosity and average shear rate were then calculated based on known mixer constants for the Brookfield flag impeller.

The collected experimental values were then used to predict the pasting curve model. Sequential Maximum A Posterior (MAP) was used. The model consists of 5 independent variables (temperature, time, concentration, time-temperature history, and strain history). The dependent variable was torque. A total of 10 parameters were in the model. Prior information on initial estimate of the parameters was obtained from previous studies. Sensitivity coefficient plot, residual plot, confidence and prediction band were plotted using Matlab

Results:

The experimental results showed that as amylose increased: pasting temperature and peak time increased, while peak viscosity, holding strength and final viscosity decreased. Pasting temperatures ranged from 82-91.2ºC, peak time 67.9-307.7s, peak viscosity 10800 to 5100cP, holding strength 6400-4300cP, and final viscosity 7400-440cP. The predicted model showed a close trend.

Conclusions:

In conclusion, fundamental data collected using a mixer viscometry approach with the modified Brookfield instrument provides a reliable, low cost, and flexible device to study the rheological properties of gelatinizing starch. Sequential estimation was a helpful way of estimating the parameters in the model. Sequential estimation allowed an updating of parameters values as new observations were added. This method gives an idea of the validity of the model since all the parameters in model should came to a constant before all observations were added.