Biorefinery concept development based on wheat flour milling

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Background

Wheat is the second largest agricultural commodity in the United States with a net production of 61.7 million tons in 1995 (2.1 billion bushels). Of that production, about half is exported; and of the balance, 85% is dry-milled within the U.S. to produce 19.6 million tons of flour for human food consumption. The remaining 6.5 million tons are low-value byproducts, which are disposed as animal feed, for the most part. These byproducts, collectively referred to as mill feed, contain the bran, germ, and a portion of the endosperm which contains a significant amount of starch not recovered in the milling process.

Mill feed is a combination of cellular structures and components left from the wheat kernel after the flour removal; and it contains about 80% carbohydrate, 13% protein, 2% fat, and 5% mineral matter. Mill feed is not a single homogeneous stream but a collection of several streams from the process of making flour. In addition, mill feed composition varies depending on the variety of wheat being processed into flour. Mill feed production varies slightly depending on mill operation and variety of wheat processed. Flour extraction ranges from 73 to 77% resulting in an average mill feed production of about 25% by weight of the wheat introduced to the mill. Considering that the wheat kernel contains 83% endosperm (the starchy source of white flour), it is apparent that the mill feed contains, in addition to the bran, a significant portion of the starchy endosperm. A rough calculation suggests that mill feed is composed of up to 35% starch that originated from the endosperm.

Wheat Milling Byproducts Used for Chemical Production

We are developing an innovative process for the recovery of a starch-rich product from mill feed, the low-value byproduct of wheat flour milling; enzymatic processing of the starch to glucose; and the subsequent processes for conversion of that glucose into a value-added product by either a catalytic or fermentation process. We have completed the development of the starch recovery step with enzymatic processing and the assessment of its economic viability. The processes to use the glucose product as feedstock for catalytic processing and fermentation processing have been tested in the laboratory. Catalytic processing of the glucose from the extracted starch for polyol production is based on catalytic hydrogenation and hydrogenolysis to glycols and other low-molecular weight polyol products. Alternatively, fermentation of the extracted starch-derived glucose also provides a pathway to value-added chemical products via a platform chemical, lactic acid.

In either pathway to value-added products (catalytic or fermentation), use of the residual mill feed will be an important consideration. If the residual material has value as a premium animal feed, it will reduce the actual cost of the extracted starch. By extracting the starch from the mill feed, the food value of the remaining material may actually be increased by concentrating the protein content. The improved value of this starch-extracted mill feed for animal feeding needs to be validated in animal feeding tests.

Technical Results

The results to be presented were generated as part of a Cooperative Research and Development Agreement (CARDA) among Pacific Northwest National Laboratory[1], Pendleton Flour Mills and the

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Mennel Milling Company and including subcontractor ProForma Systems. The presentation will include results form all the processing areas addressed. Starch extraction and glucose generation from wheat milling byproducts will be presented with laboratory and scaled-up processing results. Results of fermentation of the glucose product to lactic acid in shaker flask tests will be presented, documenting the minimal requirements for nutrient addition. Stirred batch reactor tests of catalytic hydrogenation of the glucose product to sorbitol will be presented with a discussion of contaminant effects on the catalyst.

Initial economic modeling results of some the processing steps will also be presented. Based on a positive conclusion of the results from economic analyses of the process configurations, a process for piloting can be identified. The pilot plant facility will be designed and built or arrangements made for toll utilization of existing processing facilities as a future goal of this development effort.