PROJECT TITLE: Recovery and Use of Value-Added Corn Functional Ingredients
PROJECT NUMBER:
REPORTING PERIOD: July 31, 2020
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1.) PROJECT ACTIVITIES COMPLETED DURING THE REPORTING PERIOD. (Describe project progress specific to goals, objectives, and deliverables identified in the project workplan.)

A national survey of ethanol plants was conducted to determine the current level of interest in value addition from corn fractions from the ethanol plants. Current thinking about readiness of ethanol plants for alternate value added production will be assessed. This survey was distributed electronically through ACE and to date we have received a 33% response rate. Results of the survey are currently being analyzed and will summarized for the next report.

https://app.smartsheet.com/b/form/1ca3b06f66a843409c8ebe0b50314b25

Optimal techniques to produce food grade DDG and recovery of bioactive moieties (Total phenolic Content, Total Carotenoid, etc.) from wash streams were studied. Varied solvent systems and varied extraction protocols were evaluated relative to a common starting material (DDG, DDGS).

An Automated Total Dietary Fiber Analyzer was acquired through federal funding. This instrument will be used to characterize high-fiber food products including FDDG-fortified food products.
2.) IDENTIFY ANY SIGNIFICANT FINDINGS AND RESULTS OF THE PROJECT TO DATE.

Selected findings:
The closed loop extraction capability afforded by the solvent extraction apparatus allowed for mass balance studies since there was virtually no effluent that was discarded. All washings were
collected, pooled and evaporated down to determine what was lost in the “oil fraction” and what was retained in the “residue fraction”. The latter was similar to the food grade DDG (FDDG) that PI Krishnan has been using in food product innovation projects. The processing protocols simulated scaled-up techniques to determine if quality traits in FDDG can be retained when Ethanol is the solvent of choice and when multiple kilograms quantities of starting materials are used in the system. The fate of bioactive moieties such as phenolic compounds and Total Carotenoids is important to know in order to recover them for economic value.

Hexane extraction does the best job of recovering Total Carotenoids Content in Food grade DDG residue compared to Ethanol treatments.

Ethanol extraction does the best job at recovering Total Carotenoids Content in DDG oil fractions compared to Hexane treatments.

ACE Sequential washing with Ethanol provided high recovery of Total Phenolic Content (72.56%) in the residue fraction intended to be used as a Food Grade DDG.

3.) CHALLENGES ENCOUNTERED. (Describe any challenges that you encountered related to project progress specific to goals, objectives, and deliverables identified in the project workplan.)

Owing to severe restrictions in access to research labs and equipment (imposed by COVID 19), it was difficult to maintain productivity in the early stages of the epidemic. Graduate Research Assistant Brady Bury was able to make up for lost time to complete his research. Much of the findings in this report will come from preliminary information from his research.

4.) FINANCIAL INFORMATION (Describe any budget challenges and provide specific reasons for deviations from the projected project spending.)

No budget challenges were encountered.

5.) EDUCATION AND OUTREACH ACTIVITIES. (Describe any conferences, workshops, field days, etc attended, number of contacts at each event, and/or publications developed to disseminate project results.)

A journal article on efficacy and use of a food grade DDG developed in our lab, was published in April. This article defined the food quality standards of enhanced DDG. Different levels of DDG substitution in were explored in wheat-based foods (Chinese Steamed Bread). A lay statement and draft article was prepared for NewsWise(see Appendix).

Appendix

News release about adding DDG to Chinese steamed bread

**SDSU food scientist increases protein, fiber in steamed bread**

A corn-based product can help increase the amount of protein and fiber people consume, according to South Dakota State University professor Padu Krishnan. The food scientist is fortifying breads and other baked goods with dried distillers grain, a coproduct of the corn ethanol industry.

His latest project in the Department of Dairy and Food Science is incorporating DDG into steamed bread. The dumpling-like product accounts for 60% of the wheat flour consumed in northern China and 20 to 30% in southern China, according to semanticscholar.org. Steamed bread is also popular in Asian countries, such as the Philippines.

“We need to consume 35 to 50 grams of protein and fiber a day, but we consume only 10 to 20 grams,” he explained. Products enriched with DDG can help improve that.

Krishnan worked with visiting scientist Xianona “Ivy” Li from the College of Food Science at Shenyang Agricultural University to determine how much DDG can be integrated into steamed bread while maintaining the characteristics consumers want. Study results are in the November 2019 issue of Food Science and Nutrition, an open-access, peer-reviewed journal.

The research was supported by the Minnesota Corn Research and Promotion Council, the China Scholarship Council and U.S. Department of Agriculture Hatch Act funding through the South Dakota Agricultural Experiment Station.

Dried distillers grain is sold as livestock feed for slightly more than $100 a ton. “If it can be used in food or industrial applications, we can increase its value tenfold,” Krishnan said.

**Making food-grade DDG**

“Adding DDG to wheat flour improves its nutritional value,” Krishnan said. The food-grade DDG, developed at SDSU, contains 30 to 40% protein and fiber.

Krishnan obtains distillers grain from an ethanol processing plant. “When it comes out of the plant, it is cooked, sterilized and piping hot,” he said. However, the mixture is 60 to 70% moisture and is not shelf-stable. The food scientist then “processes and refines it so it is wholesome and fit for human consumption.”

**Adjusting the formulation**

Steamed bread is made of flour, water and yeast with little or no sugar nor fat, Krishnan said. The internal texture is chewy with a glossy outer skin, much like the steamed dumplings served with chicken in American cuisine.

The researchers used flour that had 10, 15, 20 and 25% DDG and made six loaves with each formulation. Steaming uses a lower temperature, thereby reducing nutrient loss as opposed to conventional baked bread, Krishnan said.

The researchers found that up to 15% DDG can be incorporated into the flour without damaging the dough functionality nor the texture and taste of the bread. However, higher DDG levels increase the hardness and adhesiveness of the bread.

“The DDG affected the dough’s gluten network, decreasing its endurance to mixing,” Krishnan explained. “At 15%, the bread was chewy and the dough maintained its elasticity.”

Although DDG tends to darken the bread’s color, this is not a concern among Asian consumers. Li told Krishnan that Asians add colors, like purple, green, brown and yellow because they prefer dark colors in their bread.
“It’s important to work with a food scientist, such as Ivy, who is familiar with the Asian cultural standards,” Krishnan said. The fortified steamed bread “has to meet consumers’ eating quality standards.”

Figure 1. Control Steamed Bread and DDG fortified Steamed Bread (10%, 15%, 20% & 25% FDDG).

Figure 2. Raw DDG (left) and Processed food grade DDG (center and right) showing color improvements from selected washing.