PROJECT TITLE: Food Grade DDG for Human Consumption - Value Enhancement of a Corn Co Product

PROJECT NUMBER:
REPORTING PERIOD: July 31, 2016
PRINCIPAL INVESTIGATOR: Padu Krishnan
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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 patent was filed on the production process for a wholesome and safe FDDG (Application No. 62/045,057).

Significant progress was made toward an application for GRAS status.

Progress was made in evaluating FDDG as a nutrification ingredient for world supplemental feeding programs.

Collaborated with and Don Endres and Robin Rastani, Novita, Brookings SD.

Collaborated with Cereal Process Technologies. FDDG was compared with Enhance Protein DDG as an ingredient for the baking industry. A research paper was presented at the National Corn Utilization and technology conference, June, 2016.

A Good Manufacturing Practice plan for FDDG was explored in relation to FSMA. Collaboration with Chad Poppe, Compli (Practical Compliance Solutions).

2.) IDENTIFY ANY SIGNIFICANT FINDINGS AND RESULTS OF THE PROJECT TO DATE.

Chinese steam breads containing up to 15% FDDG showed significant increases in protein and dietary fiber content while ensuring acceptability of the product as judged by trained sensory panelists. A significant proportion of wheat flour is consumed as steamed bread in China. Chinese steamed bread is a good vehicle for corn fiber and protein fortification.
Aflatoxins tests employing HPLC and mass spectroscopy revealed no detectable level of aflatoxins in processed and unprocessed DDG. Spiking studies of known aflatoxin standards will be conducted to determine the robustness of FGGD processing.

A high protein DDG (45% protein) and SDSU’s FDDG were compared used in fortifying white sandwich bread to yield nutritionally enhanced white bread.

Inclusion of Chickpea (CP) and FDDG into All Purpose Four Pita formulations (APF), separately and in combinations (70:20:10 & 70:10:20), brought about improvements of the Glycemic Response (GR) when compared to control flour Pita. Sensory evaluation of the pita breads was also performed. The study demonstrated the efficacy of high fiber and high protein ingredients such as chickpeas and food grade distillers’ grains in the development of low glycemic response foods.

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

Access to real-world DDG samples from ethanol facilities has improved since I attended two DDG meetings in St Louis.

Use of Southern Illinois Ethanol Pilot Plants is cost prohibitive. Alternate arrangements are being made with industry partners to generate the same information.

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

No significant deviations from projected budget is expected.

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.)

Three presentations were made at national meetings:

National Corn Utilization and Technology Conference, St. Louis, MO
Distillers’ Grains Technology Meeting St. Louis MO
Institute of Food Technologists Meeting, Chicago, IL.

5000 FDDG cookies will be presented at the Farm Fest, Aug 2, 3 and 4 in Redwood Falls, MN.

Two additional abstracts on Food Grade DDG research have been accepted for the American Association of Cereal Chemists International meeting in October, Savannah, Georgia.
Project 1

PROTEIN AND FIBER FORTIFICATION OF WHITE PAN BREAD USING FOOD-GRADE DISTILLER’S DRIED GRAINS

ASHLEY ADAMSKI and PADU KRISHNAN, Ph.D.

2016

Distiller’s dried grains (DDG) is a coproduct of ethanol production. DDG has been used historically as animal feed. However, in the past decade, ethanol production has dramatically increased causing a surplus of distiller’s grains and saturating the market. The use of DDG, which is high in both protein and fiber, to fortify baked goods is one option to reduce the excess of DDG while enhancing its economic value.

The purpose of this study was first, to evaluate the washing process for DDG to make it food grade, and second to evaluate the effect of incorporation of food-grade DDG from two different sources on the quality of white pan bread (sandwich bread).

Distiller’s dried grains with solubles (DDGS) and a high protein DDG (HP-DDG) were subjected to a washing process to make them food grade. Processing recovery (percent yield), color, and particle size were evaluated during the washing process. Substitutions of 5% and 10% of both DDGS and HP-DDG were used in all-purpose flour (APF). Dough rheology was tested using a Mixolab and a TA.XTPlus Texture Analyzer. Bread was baked using a modified AACC straight dough process. Loaves were then analyzed for color, volume, density, internal crumb structure and texture profile. Sensory acceptance of breads was evaluated using a seven-point hedonic scale.

Yields from the washing process were low for both DDGS and HP-DDG, averaging 52.7% and 72%, respectively. Color differences in the crumb of breads containing the two types of DDG. Significant differences were seen between the particle size distributions of the washed DDG samples. Mycotoxins were not detected in either of the washed samples.

Incorporation of food-grade DDG into breads led to smaller, denser loaves with fewer air cells. Loaves with 10% food-grade DDG were found to be significantly more firm than the 5% loaves. Substantial increases in protein content were seen at all levels of DDG inclusion, however statistically significant increases in fiber were noted only in the 10% DDGS loaves. Sensory analysis showed that all bread treatments were acceptable to consumers, and that the only significant difference in acceptability of loaves was noted in the appearance scores.

Project 2

Optimization of extrusion processing parameters for the development of snacks from corn grits, garbanzo flour and distiller’s dried grains developed for food applications

Poonam Singha, Kasiviswanathan Muthukumarappan and Padmanaban Krishnan
Pulse flours, when combined with distillers grains, represent a novel blend as it is gluten-free and high in protein and fiber content. The present study investigated the effects of distiller’s dried grains developed for food applications on the physical and nutritional characteristics of garbanzo flour (GF)-corn grits (CG) based extruded products.

The aim of the experiment was to optimize barrel temperature (100 to 140 °C), screw speed (100 to 200 rpm), moisture content of blend (14 to 20 % d.b.) and levels of distillers grain (0-20 %) based on physical properties of extrudates such as, water absorption index (WAI), water solubility index (WSI), bulk density (BD), radial expansion ratio (RER), textural properties and total dietary fiber using single screw extruder. Percentage of corn grits (60%) was kept constant for all the formulation.

The study was carried out by central composite rotatable design (CCRD) using Response surface methodology (RSM) which generated 27 experimental runs. Mathematical models for various responses were found to fit significantly (P<0.05) for prediction. Optimization of experimental conditions was carried out using numerical optimization technique and the optimum barrel temperature, moisture content, screw speed and distiller’s grain percentage were 125°C, 15.8%, 175 rpm and 20 % respectively with desirability value of 0.907. Experiments were carried out using predicted values and verified using t-test and coefficient of variation percentage.

An extruded snack prepared with distiller’s grain (20 %) and garbanzo flour (20 %) at optimized conditions was found to be acceptable by taste panelists.

Figure 1. Armfield 5 gallon cooker/emulsifier for DDG processing into a food ingredient
Project 3

Low Glycemic for using Food Grade DDG and Chickpea Formulations
Hadeel Al Raayes and Padu Krishnan

Abstract:
The estimated cost of diabetes in the US is $245 Billion (ADA, 2013). Consumption of low-glycemic index (GI) foods, have been shown to improve glucose tolerance. The consumption of these low glycemic response foods (LGR) has increased in recent years. There is a need for more low cost and more diversified range of (Low Glycemic Response (LGR) foods. Taste-friendly chickpea (CP) and newer ingredients such as food grade distillers grain (FDDG) that are known for high fiber and protein content, may be helpful ingredients in new food formulations. Our objective was to compare the Glycemic Response (GR) of combinations of CP and FDDG fortified pita breads in test subjects. Pita breads were made employing the following blends All Purpose Flour (APF,Control), APF:chickpea (90:10 & 80:20), APF:FDDG (90:10 & 80:20), APF:CP:FDDG (70:20:10 & 70:10:20). The experiment design was a single blind, randomized controlled, cross over design with a convenience sample of twelve panelists. Following overnight fasting, subjects consumed each bread type. Blood samples were collected at 30 min intervals. Glycemic response curves were constructed. The Area under the Curve (AUC) was calculated. Control (APF) yielded an IAUC of 86.9 mmol.min/L. Pita bread containing 10% CP yielded an IAUC of 84.23 mmol.min/L while the 20%CP showed IAUC of 67.3 mmol.min/L. FDDG pita breads with 10% FDDG showed IAUC of 56.35 mmol.min/L while the 20% FDDG pita bread showed an IAUC of 48.53 mmol.min/L. Inclusion of CP and FDDG into APF, separately and in combinations (70:20 10 & 70:10: 20), brought about improvements of the GR when compared to control flour Pita. Sensory evaluation of the pita breads was also performed. The study demonstrated the efficacy of high fiber and high protein ingredients such as chickpeas and food grade distillers’ grains in the development of low glycemic response foods.

Figure 2. Glycemic response: Blood glucose level in subjects fed test doses of fiber ingredients.
Table 1. Nutritional composition for different pita bread formulations

<table>
<thead>
<tr>
<th>Nutrients</th>
<th>T1 Control</th>
<th>T2 90W-10G</th>
<th>T3 90W-10D</th>
<th>T4 80W-20G</th>
<th>T5 80W-20D</th>
<th>T6 70W-20G-10D</th>
<th>T7 70W-20D-10G</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein</td>
<td>14.78g</td>
<td>16.7f</td>
<td>17.3e</td>
<td>18.06d</td>
<td>18.85b</td>
<td>18.58c</td>
<td>19.57a</td>
</tr>
<tr>
<td></td>
<td>(0.05)</td>
<td>(0.06)</td>
<td>(0.09)</td>
<td>(0.11)</td>
<td>(0.02)</td>
<td>(0.10)</td>
<td>(0.13)</td>
</tr>
<tr>
<td>Fat</td>
<td>0.11f</td>
<td>0.11f</td>
<td>0.12e</td>
<td>0.13d</td>
<td>0.21b</td>
<td>0.16c</td>
<td>0.28a</td>
</tr>
<tr>
<td></td>
<td>(0.00)</td>
<td>(0.00)</td>
<td>(0.00)</td>
<td>(0.00)</td>
<td>(0.00)</td>
<td>(0.00)</td>
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<tr>
<td>Ash</td>
<td>0.59g</td>
<td>0.6f</td>
<td>0.61e</td>
<td>0.62d</td>
<td>0.97b</td>
<td>0.72c</td>
<td>1.06a</td>
</tr>
<tr>
<td></td>
<td>(0.00)</td>
<td>(0.00)</td>
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<td>(0.00)</td>
<td>(0.00)</td>
<td>(0.00)</td>
<td>(0.00)</td>
</tr>
<tr>
<td>Moisture</td>
<td>30.01f</td>
<td>30.11f</td>
<td>30.98e</td>
<td>31.97d</td>
<td>38.64b</td>
<td>34.21c</td>
<td>40.27a</td>
</tr>
<tr>
<td></td>
<td>(0.20)</td>
<td>(0.16)</td>
<td>(0.09)</td>
<td>(0.05)</td>
<td>(0.50)</td>
<td>(0.28)</td>
<td>(0.25)</td>
</tr>
<tr>
<td>TDF</td>
<td>5.21g</td>
<td>7.21f</td>
<td>10.04e</td>
<td>11.74d</td>
<td>15.64b</td>
<td>13.05c</td>
<td>17.44a</td>
</tr>
<tr>
<td></td>
<td>(0.31)</td>
<td>(0.31)</td>
<td>(0.28)</td>
<td>(0.31)</td>
<td>(0.54)</td>
<td>(0.22)</td>
<td>(0.81)</td>
</tr>
<tr>
<td>Kcal/100 g</td>
<td>267.50</td>
<td>263.01</td>
<td>254.14</td>
<td>247.00</td>
<td>212.50</td>
<td>234.00</td>
<td>201.00</td>
</tr>
<tr>
<td>Av (CHO) in</td>
<td>49.23</td>
<td>45.28</td>
<td>40.95</td>
<td>37.48</td>
<td>25.94</td>
<td>33.03</td>
<td>21.38</td>
</tr>
<tr>
<td>100 g</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amt. ser. TA/50 g</td>
<td>101.50</td>
<td>110.42</td>
<td>122.10</td>
<td>133.40</td>
<td>192.75</td>
<td>151.40</td>
<td>234.00</td>
</tr>
</tbody>
</table>

TDF: Total Dietary Fibers, Kcal: Kilocalories, g: grams, Amt.: Amount, ser.: served, TA: to achieve, Av: available, CHO: Carbohydrates W=wheat flour, D=food grade DDGS, G=garbanzo/chickpea flour

Sensory Report Conclusion:

Recently, new efforts have been systematically undertaken to replace part of the wheat flour by other types of flours in order to improve its nutritional and sensorial properties. In this study, the researcher has used chickpea flour and food grade DDGS as substitutes to determine the effect of adding different levels of chickpea and food grade DDGS on the sensory properties of pita bread.

Darkness in color of bread was increased as DDGS increased which also negatively influenced the color scores. Our results showed that addition of chickpea with food grade DDGS showed substantial improvement in the color of the bread. Beany odor and flavor was increased as the percentage of chickpea increased which showed adverse effects on the taste and aroma scores. Quality and acceptability of legume products is influenced by beany odor and flavor which can be reduced by the addition of food grade DDGS. Color of the baked product is of paramount importance in the initial acceptability by consumers.
Texture results showed no significant differences across all treatments. Therefore, it can be concluded that it is feasible to produce bread with acceptable internal crumb texture using chickpea flour and food grade DDGS substituted in wheat flour. Also, the overall acceptability of bread was found greater with combination of food grade DDGS and chickpea flour. The findings in this research can be useful for both researchers and industry to understand the impact of DDGS and chickpea flour on the nutritional and sensorial qualities of bread. It should be noted that addition of excessive amounts of DDGS and chickpea can adversely affect the color and aroma & taste of bread.

Table 2. Sensory scores for pita bread using a trained panel.

<table>
<thead>
<tr>
<th>Treatment (T)</th>
<th>Ingredients</th>
<th>Color (µ ± SD)</th>
<th>Aroma (µ ± SD)</th>
<th>Taste (µ ± SD)</th>
<th>Texture (µ ± SD)</th>
<th>Overall (µ ± SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1 (Control)</td>
<td>100%W</td>
<td>3.82 B±0.98</td>
<td>4.14 A±0.65</td>
<td>4.12 A±0.81</td>
<td>4.00 A±1.09</td>
<td>4.30 A±0.96</td>
</tr>
<tr>
<td>T2</td>
<td>90%W10%G</td>
<td>4.13A</td>
<td>3.66 B</td>
<td>3.46 B</td>
<td>4.08 A</td>
<td>3.96B</td>
</tr>
<tr>
<td>T3</td>
<td>90%W10%D</td>
<td>3.60 c</td>
<td>4.04AB</td>
<td>4.10 A</td>
<td>4.06 A</td>
<td>3.54C</td>
</tr>
<tr>
<td>T4</td>
<td>80%W-20%G</td>
<td>4.14 A+0.85</td>
<td>3.68 B+0.98</td>
<td>3.42 B+1.16</td>
<td>4.12 A+0.77</td>
<td>3.50 C+0.92</td>
</tr>
<tr>
<td>T5</td>
<td>80%W-20%D</td>
<td>3.52 c+1.20</td>
<td>4.21 A+0.63</td>
<td>4.07 A+0.72</td>
<td>4.18 A+0.71</td>
<td>3.78 BC+1.02</td>
</tr>
<tr>
<td>T6</td>
<td>70%W-20%G 10%D</td>
<td>4.00 A+0.86</td>
<td>4.04 AB+0.86</td>
<td>4.07 A+0.77</td>
<td>3.88 A+1.08</td>
<td>4.29 A+0.66</td>
</tr>
<tr>
<td>T7</td>
<td>70%W-20%D-10%G</td>
<td>4.10 A+0.79</td>
<td>4.03 AB+0.69</td>
<td>3.96 A+1.00</td>
<td>3.98 A+1.09</td>
<td>4.26 A+0.68</td>
</tr>
</tbody>
</table>

Dislike extremely = 1
Like extremely = 5