Grant number: 190000002106

Title: Upcycling Brewing Spent Grain Waste into Value Added Commercial Ingredients of Practical Use to the Food and Beverage Industry

Original goals and objectives

Original goals and objectives were to focus on research of scalable procedures and a viable business model for brewers, in partnership with food ingredient manufactures, to better monetize brewing spent grains (BSGs) by creation of new shelf stable intermediate spent grain products (ISGPs), for broad use in the food and beverage industry as a commercial ingredient. Specific aims included the following:

1. Intermediate spent grain products (ISGP) Production Method discovery - JPGR was to research the viability of producing ISGPs Michigan based ingredient manufacturers collaborating with one or more identified Michigan brewers.

2. ISGP Utility Investigation - Once the ISGPs were developed they were to be analyzed for safety, stability, nutrition and practical use in commercial food products at benchtop.

3. Finally, JPGR was to assess the cost structure and business case to allow ISGP commercialization with Michigan breweries in partnership with ingredient manufacturers on a broad industry scale.

Discussion of Results and Work Accomplished

ISGPs were manufactured from BSGs sourced from Saugatuck Brewing Company's Kalamazoo location, and were further processed in a stepwise process to dehydrate the ISGPs to low moisture food ingredients and key microbial and nutrient levels were tested. We were able to manufacture ISGPs that were whole grain style as well as a ground as a flour. The grain style and flour style ISGP behave differently in formulations. They had moisture content of under 5% and a nutrient profile of 2.6% fat, 40% fiber, 21% protein and 36.4% other carbohydrates/ash and moisture.

Focus was dedicated to two drying technologies instead of three as originally planned. This was primarily to allow us to divert costs associated with one of the drying methods to more detailed microbial testing and downstream production scale food processing use of the ISGP. Drying processes investigated were a two-step process used in series. The first was pressing, using equipment typically used for fruit juice extraction for initial extraction and the second was rack oven thermal processing common to commercial bakeries, to get to final shelf stable moisture.

A stepwise procedure used to create the ISGPs is detailed here:

<u>Details of ISGP processing</u>

- Step 1 – gathering BSG at the brewery

BSG was secured at the Saugatuck brewery (formerly Gonzo's Bigg Dogg) 140 S Westnedge Ave, Kalamazoo, MI 49007. It was a 10 BBL brew which had 5% oats, and the remainder barley malt. The recipe called for 685 lb of grains in the grain bill. The BSG was placed in a sanitized stainless steel bin. This process was completed in approximately 20 minutes with 3 people.

- Step 2 – pressing the spent grains to extract initial moisture

The grains were transferred to National Flavors 1206 E. Crosstown Parkway, Kalamazoo, MI to be pressed. At arrival, the BSG temp was still about 130 deg F. It took 1 hour and 3 people to press all grains. Videos of the pressing and the grain dumping are found here:

Pressing: https://youtu.be/ueSStdtPrmE

dumping: https://youtu.be/1XSsHmAotoQ

- Step 3 - Drying

The in process BSG was then transferred to Snackwerks, a production bakery at 180 E. Goodale Ave, Battle Creek Michigan, for thermal drying. The grains were dried using 3 rack ovens. Grains were dried in 30 minute steps. Each rack had a first step of 350 deg F oven, then subsequent 30 minute dry times were at 300 deg F.

In between each 30 minute interval, the grains were mixed in each tray by transporting them to a new tray as seen in the mixing video below.

Video of mixing: https://youtu.be/ X52SpgNfk

Video of drying in the oven: https://youtu.be/U20EnqCfyeE

Thermal processing and cleanup took approximately 5 hours, with 3-4 handlers.

Microbial Analysis

A key question for Project Reynolds was to better understand the potential for microbial growth during the process of converting mash to dried brewers spent grain.

During the mashing and sparging process the grains were exposed to temperatures ranging from 150 to 165 degrees Fahrenheit for three to four hours until collection. At the completion of the mashing process grains were collected for microbial analysis. Additional samples were collected during the process of transport, pressing excess liquid from the grains, and at the conclusion of final drying.

All samples were collected using cleaned and sanitized metal scoops, which were then transferred to pre-sterilized Whirl-Pak® bags and stored on dry ice to minimize additional microbial growth. All samples were stored frozen prior to samples being submitted for chemical and microbial analysis.

Microbial analysis focused on aerobic plate count (APC) to capture the trend of microbial growth along the process of collecting the grains through to final drying. Barley prior to malting and following malting will have microbial loads between 5 to 8 log (Laitila, Kotaviita, Peltola, Home, & Wilhelmson, 2007). The food industry focuses on reduction of microorganisms that can are harmful to human health such as *Salmonella and L. monocytogenes.* Industry standard for reduction of harmful microorganisms is 5 log.

During the process of collection of grains up until drying the APC ranged from 4.1 to 4.9 log. This is lower than barley and malted barley prior to any processing to produce wort. It is likely that the mashing process contributed to a reduction in microbial count, although this would need to be investigated further. The table below summarizes the APC during the process utilized for Reynolds to collect, press, and dry brewers spent grains.

Process Step	Mash Tun	Before Pressing	After Pressing	Before Drying	After Drying
APC (Log)	4.8	4.6	4.1	4.9	1.6

From the time brewers spent grains were collected there was always a period of hold time before the next step in the process. It is interesting that there was a slight decrease in APC after pressing. This could be explained by the removal of liquid which very likely includes microbes. The longest period between steps was after pressing and before drying. This included transportation of the pressed grains, approximately 60 minutes, and transferring grains onto pans for drying, approximately 30 minutes. This time period could explain the increase in growth between these steps.

From a microbial perspective the process used for Project Reynolds appears to be feasible if time management is employed throughout the process to minimize the chance of microbial growth.

<u>Functionality testing of the ISGPs - Benchtop</u>

Shelf stable ISGPs were tested in various food forms in benchtop food prototyping labs. Original plans were to attempt to develop food products in three formats, but we were able to test in a total of seven formats with the allotted grant resources. The ISGPs were found to have appealing functional, flavor and nutritional contribution to products in a variety of formats, when used at appropriate levels. The finished dried spent grain was utilized either in its whole form or further ground using a small coffee grinder to make flour. Seven product types were researched with multiple formulations so as to research appropriate usage levels of the ISGPs in the formats. Nutritional statements were developed for each. A summary of each prototype is found below and photos of six of the products are in the picture at right.

Granola - The dried unground spent grain is easy to substitute for other grains and particulates in a granola format. The spent grain adds a nice texture that doesn't have a significant impact on flavor. The formula included 29% ISGP.

Dog Treat - Dried unground and ground spent grain were used in the the Dog Treat. The formulation required additional water. Spent grain has a significant impact on product color. The formula included 80% ISGP.

Muffin - The dried unground and ground spent grain added a dark color along with warm brown spice notes in the Muffin. If higher levels of spent grain are added, the muffin becomes too dense and produces an undesirable texture. The formula included 5% ISGP.

Bread - The dried unground and ground spent grain added a dark color and at low percentages allowed for a nice fluffy bread texture. Additional water was required. When too much spent grain was added the product became very dense with an undesirable texture. The formula included 4% ISGP.

Cookies - The dried ground spent grain is easy to substitute for other grain flours in the cookie format at low usage levels. Spent grains produced a darker color. Slight spiced note noticed in the cookie with spent grains. High usage levels makes for a very dense cookie and undesirable texture. The formula included 1.5% ISGP.

Flatbread - The dried ground spent grain is easy to substitute for other grain flours at lower usage levels. The spent grain made the dough slightly less elastic and harder to roll out. After baking, it had similar texture with slight brown color. The formula included 8% ISGP.

Cracker - The dried unground spent grain added a unique texture dimensions to the cracker format. Additional water was required to incorporate into the dough. Spent grains add a nice visual as seen in the photo. The formula included 19% ISGP.

<u>Functionality testing of the ISGPs – Production Facility</u>

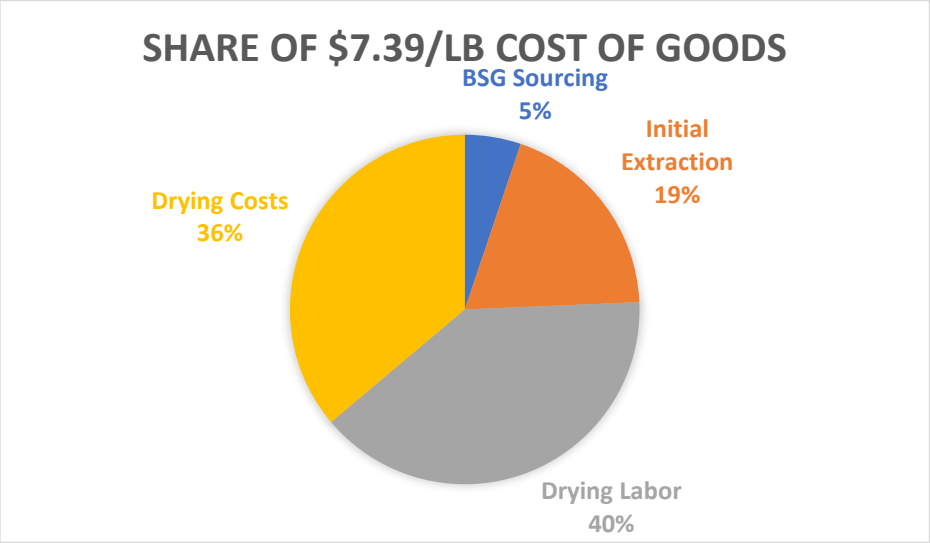
Three of the benchtop prototyped products, the cookie, granola and dog treat were then further assessed as practical commercial ingredients. The cookie formulation was tested in a production scale manufacturing environment to provide a baseline understanding of the ISGPs

in a manufacturing environment. A video of cookie production here: https://youtu.be/PiL5Pxbuvd8

Overall, the formulas performed well on the Snackwerks equipment and should require minimal additional testing in preparation for production runs. Bake time and temperature may need to be adjusted to account for full ovens and any changes to baking efficiency during a full production run. Any desired changes to cookie texture and taste will also need to be updated in the formulas as needed.

Business Case assessment

Based on the observations in the ISGP manufacturing process, a cost model was established to estimate the cost of manufacturing ISGPs and what sort of pricing could be expected as an ingredient business was launched.



Cost modeling demonstrated that ISGPs could be manufactured sourcing BSGs at $0.03/lb from breweries producing ISGPs which had a cost of goods of approximately $7.39/lb at the small scale production investigated. Applying typical industry margins, it would be expected that final ISGP pricing would be $10-$12.50 / lb based on the business model and intermediaries (such as brokers) utilized. The primary cost of goods, representing approximately 3/4 of the total, was the thermal drying process. In total, the 10 BBL grain bill yielded 170 lbs of ISGP. It should be noted that approximately 75% of the total costs of ISGP is the cost of labor and energy to thermally dry the product in the secondary drying process.

Pricing at these levels would put ISGPs squarely in the specialty ingredient market (typical flours sell for a fraction of these prices) and the product would need to be marketed as a “romance” ingredient adding a dimension of excitement to products at low use levels. In addition, product prototyping also demonstrated that ISGPs will need to be used at relatively low percentage of total product as detailed below in order to hold up desired product functionally (texture, flavor and leavening, for example).

Production costs of end products, including standard industry tolling, all ingredient costs (including the ISGPs) and typical packaging materials were calculated based on the learnings

from the production run of cookies. Detailed pricing models for cookies, dog treats, and granola were developed. Production cost of good for 8 oz package of cookies was $2.18, 10 oz package of granola was $2.80 and 6 oz package of dog treats was $2.51. These are estimated cost of product at the dock, ready to ship from a typical bakery contract manufacturing facility.

Period of time of research

Grant supported research spanned from May, 2019 – June 2020.

Communication Activities

This effort was briefly highlighted in the Wall Street Journal on October 7 2019 in their article dedicated to upcycling waste ingredients titled "The Food Industry Looks to Turn Garbage Into Gold." Furthermore, this effort has been communicated with one specific global brewer and a major ingredient supplier as it relates to their interests in the area, and they are potentially planning to launch or invest in synergistic products which may well be a fit to bundle with a product made via the process researched and documented here.

Budget Narrative

This project was conducted consistent with the budget proposed and approved by the State of Michigan. Other sources of funding included a minimum of $15,937.50 worth of in kind work done by JPG Resources which was not reimburses as personnel costs associated with the research effort.