Exploring the Potential of Upcycling Craft Brewers Spent Grain in Winnipeg, MB

By

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A Practicum Document submitted to the Faculty of Graduate Studies of
The University of Manitoba
In fulfillment of the requirements of the degree of

MASTER OF NATURAL RESOURCES MANAGEMENT

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Abstract

Food upcycling is a circular economy method of reducing food waste by adding value to foods that conventionally would have gone to waste. This project explores the potential of upcycling brewers spent grain (BSG) to human food products in Winnipeg, MB to think global and act local, primarily considering The Paris Agreement, The United Nations 17 Sustainable Development Goals, and planetary boundaries. Data was derived from a comprehensive literature review, a website review of 1165 unique Canadian craft breweries, 168 responses to a Canada-wide craft brewer survey, and 12 semi-structured interviews. The data analysis shows that with the current brewer interest, there is sufficient spent grain volumes to upcycle at small scales locally and suggests that large scale/industrial supply is possible with the participation of all local craft breweries. The suggested framework pick-up route would lower spent grain transportation emissions of all local breweries by 25-50%. The final recommendation report concludes that the majority of local spent grain currently goes to animal feed, but Winnipeg does in fact have potential to upcycle BSG locally while minimizing or removing barriers to upcycle for all affected parties, while increasing sustainable operations of local food and beverage companies.

Acknowledgement

I would like to start by thanking the staff at the Natural Resource Institute for accepting my application and allowing me to follow my passion and commitment towards global sustainability. I cannot thank the entire department enough for the opportunities I've had within the program and the doors it's opened for me going forward.

I would like to specifically thank my advisor, Dr. Iain Davidson-Hunt, for being the best mentor, sharing a love of beer, and introducing me to the term "upcycle". You've sincerely changed my outlook on the food industry in the most positive way and I'm eternally grateful. Thank you for your patience and guidance throughout the process as I couldn't have done it without you.

A special thank you to the project partner, Brian Westcott of LOWLIFE Barrel House, for agreeing to work with me and for being the industry expert. I'm beyond grateful that you had interest in the project and faith in me to complete it. I appreciate your support and input, and sincerely hope the deliverables are of real use to yourself and the rest of Winnipeg's craft brewers.

I would also like to thank Dr. Filiz Koksel for her time and input as the food science expert on this project. Above the support you showed during this degree, I'd like to also thank you for the support you gave me in my undergraduate degree. You helped fuel my love of food sciences and I'm beyond happy that I could work with you again to bring food and sustainability together.

I would like to thank every individual participant as the quality of data wouldn't have been the same without any single of you. I'm sincerely grateful that you chose to provide information despite not knowing me at the time. I realize that food and beverage production is extremely busy, even without owning the company, so an extra thank you for taking time out of your busy schedules to contribute to my research. Without you, I wouldn't have been able to produce a framework recommendation for upcycling brewers spent grain in Winnipeg, MB.

Last, but not least, I'd like to thank the friends and family who believed in me and continued to show me support throughout the three years I took to complete the program. I appreciate every single kind word, every ear that listened, and every shoulder. I wouldn't be where I am today without you and I don't know how to thank you enough. An extra special thank you goes to my partner for his support and dedication to my research, especially for facilitating 'quiet time' in a house with young children and dogs. You've all helped me grow into who I am today. Thank you for loving me unconditionally and being the best group of people.

Dedication

I'm dedicating my work and efforts to my two children. I'm doing everything I can to be the absolute best version of myself and mentor to you that I can. But, most of all, I want to make sure there's a beautiful and sustainable world for you to live in even after I'm gone.

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Chapter 1: Introduction

Project Context

Amid a climate, environmental, and biodiversity crisis, a growing human population increases resource demands and causes global concern as to how people will be fed. The overall global situation, represented in *Figure 1.1*, starts with 40% (1 p. 468) of land mass producing 100% of humans' food. Of the total food production, approximately 30% is wasted (2 p. 4), leaving 100% of the worlds 7.87 billion people living off 70% of the food harvested and manufactured. Approximately 10.42% of the earth's population (820 million people) (1 p. 447) are malnourished, leaving 89.58% of people full on 70% of the food produced. Simply put, each 10% of global food production currently feeds 1.007 billion people adequately. Therefore, the 30% of food that currently goes to waste has the potential of nourishing 3.02 billion people. That 30% of "waste" could not only feed those who are currently alive and malnourished but could also nourish the 2050 projected population if we can find ways to rethink "waste" and improve our food systems at all stages. While it might be unrealistic to expect that every single ounce of food produced will make it to someone's stomach, the potential of this colossal waste is certainly worth some effort.

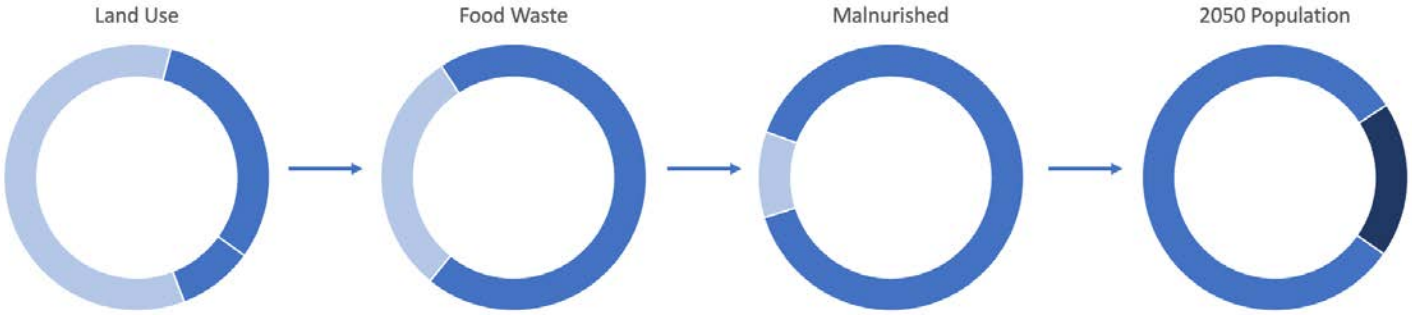

Figure 1.1. Depiction of the projected global population of 2050, highlighting the current number of citizens who are malnourished off modern agricultural production and food waste percentage. Land use is shown as 40% agricultural (23% grazing (lightest blue) and 77% croplands (light blue), while 60% is non-agricultural (dark blue) (1 p. 468). Food waste is shown as approximately 30% of global production wasted (light blue) with 70% consumed (dark blue) (2 p. 4). Malnourishment is shown as 820 million people malnourished globally (light blue), while 7.05 billion are not (dark blue) (1 p. 447). The 2050 global population is shown as a current 7.87 billion (dark blue), with a projected 9.7 billion in 2050 (darkest blue) (3).

Beer is a very popular beverage globally where brewers spent grain (BSG) accounts for approximately 85% of total by-products. Considering that approximately 20kg of wet BSG is produced for every 100L of beer (26.42 gallons) (4 p. 556), the brewing industry produces large quantities of "waste" products that have substantial upcycle potential. According to the Upcycled Food Association, "upcycled foods use ingredients that otherwise would not have gone to human consumption, are procured and produced using verifiable supply chains, and have a positive impact on the environment" (5). With nearly a third of all food wasted, the numbers suggest that addressing global food waste would have substantial benefits for humans and the environment.

While thinking global, this project centers on local initiatives. We first consider planetary boundaries (6 p. 33) to consider solutions that do not contribute to biodiversity loss or expansion of agricultural land use. Second, in meeting the Paris Agreement (7), decarbonization of food systems is needed in which food upcycling provides human food products without emissions associated with the majority of the supply chain as the food is already grown and transported. Third, the proposed upcycling framework focuses on United Nation's (UN) Sustainable Development Goal 12.3 to "halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest" by 2030 (8). The purpose of this project is to assess the overall potential of upcycling brewers spent grain with a case study situated in Winnipeg, MB. As such, global initiatives as used as guiding principles to enact change at the local level, thus contributing to the overall changes needed globally to limit climate change and biodiversity loss.

The project had three primary objectives that were met through seven guiding objectives as listed below. The objectives were met with four overall research stages and resulted in four deliverables: (1) Website Review: Final Report, (2) Survey: Final Report, (3) Interviews: Full Report, and (4) Final Framework Recommendation Report.

1. Define and quantify current waste management strategies for BSG
    i. Quantitatively determine if there is enough BSG in Winnipeg to render upcycling plausible
    ii. Quantify and map what local breweries currently do with their spent grain
2. Understand the opportunities and barriers to upcycling BSG
    i. Document the barriers brewers face in using/moving/storing spent grain
    ii. Determine if/which breweries are interested in BSG upcycling potential
3. Recommend potential upcycling options
    i. Research and identify who the potential users are of BSG as an input in Winnipeg
    ii. Identify and evaluate the intermediate steps required to link BSG with potential users
    iii. Quantify the energy/CO_2 emission differences of currently waste management strategies compared with the final proposed upcycling framework

The website review was intended to provide a general idea of the importance of sustainability and upcycling among the 1165 Canadian craft breweries through 6 key term searches. The terms searched were (1) Upcycle, (2) Circular Economy, (3) Sustainable/Sustainability, (4) Waste, (5) Carbon Footprint, and (6) Spent Grain. The resulting report, provided in Chapter 2, outlines the data analysis and associated conclusions drawn from the first project deliverable.

Among the ten provinces and three territories in Canada, a total of 1165 unique craft breweries were identified, of which 1121 had publicly available email addresses that were used to recruit participants to complete a Canada-wide survey. A total of 168 (14.99%) Canadian craft breweries participated in the survey and the resulting data analysis is provided in Chapter 3 as the Survey Final Report. The survey was intended to obtain data regarding other Canadian craft breweries in which to compare Winnipeg craft breweries to assess upcycling potential in Winnipeg, MB.

The third deliverable, Interviews Final Report, is the result of data analysis from interviews with Winnipeg craft brewers, Manitoba food companies, and North American upcycling companies. The interview stage of the research was intended to generate data specific to Winnipeg, to compare with other breweries/cities to critically assess the potential of upcycling based on both quantitative and qualitative data. Based on the location-specific data, a preliminary framework was developed within the report provided in Chapter 4.

The preliminary framework was meant to be further refined through feedback from a focus group consisting of interview participants, but difficulties in gaining sufficient attendance eventually resulted in event cancellation. In lieu, additional background and market research was conducted to support the framework recommendation with the associated report provided in Chapter 5 as the Final Framework Recommendation Report. The final report summarizes the key findings of the projects research stages, provides additional research, and outlines how all project objectives were met.

Brian Westcott of **LOW**LIFE Barrel House was the project partner and played key roles throughout the project. As there was no financial component to the partnership, his overall role was to act as the industry expert to ensure the resulting framework consisted of quality data and was of real use. To start, upon proposing the project, Brian offered suggestions and made requests towards the project's objectives, primarily concerning emission differences of current waste management strategies with the proposed upcycling framework. Upon agreeing to be the project partner, Brian was tasked with communicating and promoting the research to other local craft brewers to encourage participation, host the in-person focus group, and provide local industry knowledge to facilitate research activities when necessary. Overall, apart from regular communication regarding the project, it was estimated that Brian would commit 10.75-16.50 hours towards project meetings as well as

reviewing and approving documents. Above the project agreements, Brian provided a private brewery tour for the members and a second tour for a student group, resulting in a deeper understanding of the literary data from the background information report (BIR). Throughout project execution, Brian attended all planned meetings, reviewed and approved documents/deliverables as necessary, remained in constant and timely communication, and promptly answered industry and project related questions. The knowledge and support he contributed facilitated acquisition of high-quality data resulting in a detailed and realistic upcycling framework tailored for Winnipeg, MB.

Background Information Report

In the background information report found on page 216, I provide a detailed overview of the environmental effects of food waste on global sustainability, how that relates to the research, and all the background information needed to understand the context of the project objectives. Some of the critical things I learned from reviewing the existing literature focused on the high volumes of 'waste' produced from making beer, the primary global sustainability initiatives of this project, how upcycling adds value to spent grain, and how spent grain adds valuable nutrition in everyday products.

With projections of a growing global population, an estimated 9.7 billion by 2050 (3), questions of resource and food availability come to mind. The most immediate and logical solution to addressing environmental, biodiversity loss, and food supply issues is through food upcycling. Brewers spent grain is an excellent target for upcycling as it's nutritious and bountiful. Approximately 20 kg of wet spent grain is produced per 100 L of beer with a moisture content of close to 80% (4 p. 556). With 23 craft breweries in Manitoba at the time of project planning, the volume of local spent grain supply is suspected to be high. The most common waste management strategies for spent grain are animal feed, composting, and landfill disposal. What the industry calls 'spent grain' isn't spent at all, which renders the current management strategies highly wasteful. BSG typically contains 20% protein but can be as high as 30%, an average of 40% fibre (4), and contains Lysine which is generally a limiting amino acid in other cereals (9). Additionally, when dried, milled, and used at 10% of a flour mixture (10 p. 1267), has high consumer acceptance scores in common flour-based products such as bread, breadsticks, cookies, extruded snacks, and baked snacks.

Since the release of the new food guide, several new "plant-based" products have become available (11 p. 17). "Plant-based protein foods can provide more fibre and less saturated fat than other types of protein foods. This can be beneficial for your heart health" (12). With spent grain being high in protein and fibre, the potential of upcycling BSG locally in depth seemed a worthy endeavor.

The high nutritional value of spent grain, along with documented consumer acceptance and environmental benefits of upcycling food made the subject choice easy but further consideration was needed in developing the project. With the knowledge that flour is a versatile ingredient and used in many food products, further identification of potential food products was essential. The project was planned to incorporate data from as many sources as possible to thoroughly assess local upcycling potential with multiple stages of research as described in the following section. The intent was to acquire as much information as possible and gradually narrow it down to a feasible framework recommendation. The decision to include only breweries within the perimeter of Winnipeg was mainly due to the environmental considerations of transporting spent grain and the short shelf life. In considering the sustainability of operations, Winnipeg has the largest concentration of craft breweries and the largest human population in Manitoba, therefore it seemed reasonable to keep spent grain local to minimize transportation. Objective 7 relates to the greenhouse gas (GHG) emission differences and the project wouldn't have a positive environmental impact if the framework were equally or less sustainable than the current waste management strategies. Food and beverage manufacturing is an expensive industry to get started in and the project timeline wasn't infinite, therefore only the research stage of product development was completed. The hope is that the data provided is complete and convincing enough that we'll see BSG upcycling in Winnipeg in the near future.

Project Methodology

The research design most appropriate for this project is a case study which is "a design … in which the researcher develops an in-depth analysis of a case, often a program, event, activity, process, or one or more individuals. Cases are bounded by time and activity, and researchers collect detailed information using a variety of data collection procedures over a sustained period of time" (13 p. 14). The research was designed to be pragmatic as a real solution to managing brewers spent grain (BSG) was desired. To thoroughly evaluate the issue of managing BSG through upcycling in Winnipeg, MB, the methodology consisted of five planned research methods: (1) Literature review, (2) Website review, (3) Survey, (4) Interviews, and (5) Focus Group. The final recommendation was based on four research methods with the focus group being cancelled during project execution.

A literature review was first used to create the BIR, a comprehensive document outlining the environmental effects of food waste, the global sustainability initiatives that have focus within this research, the brewing process and associated waste management strategies of spent grain, and how this research aims to think global and act local through spent grain upcycling. The BIR first defined the project need and potential while offering a range of global data to consider locally. Literature review was also used to provide supporting data in the Final Framework Recommendation Report in adding depth and consideration to participant data. A key benefit of the supporting data is providing research free of emotion and bias, as well as adding depth and secondary data to that obtained. Among the project objectives, literature review was used to help meet objectives 5 and 7.

A document review, through form of a website review, was used to help meet objectives 1, 5 and 6. The Canadian craft brewery website review specifically looked for the number of breweries that mention upcycling or any other spent grain management strategies and provided numerical data and/or relevant information in which to base the Winnipeg recommendations on.

A Canada-wide craft brewer survey was used to concentrate data to Canadian craft breweries as opposed to having only global data to use in the case study. An online survey offers participants convenience and ease to encourage contributions to the research and allows for both quantitative and qualitative data/responses. The survey helped meet objectives 1, 4, 5 and 6. The averages and/or comparative models resulting from the survey were vital to assessing the overall potential of Winnipeg craft breweries and answering the question "Is upcycling BSG possible in a city the size of Winnipeg?"

The final research method executed was semi-structured interviews with Winnipeg craft brewers, Manitoba food companies, and North American upcycling companies. The final research stage expanded on interesting/relevant survey data and generated focused data that refined framework recommendations to the Winnipeg case specifically. The localized information helped meet objectives 1, 2, 3, 4, 5, 6 and 7 through quantitative and qualitative data.

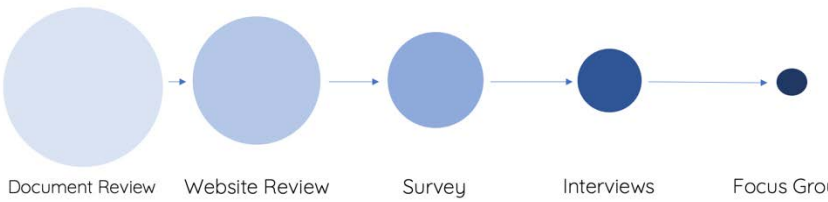

Figure 1.2. Representation of how the research stages increase in detail and focus relative to the case study.

As depicted in *Figure 1.2.*, the research objectives were structured to be increasingly specific to the case study and research methods/participants were chosen accordingly. Generally speaking, the document/literature review provides a variety of ideas and options regarding upcycling BSG in Winnipeg, the website review provides a general notion of what's currently being done in Canada, the survey provides data specific to Canada, and the interviews refine data to be specific to Winnipeg craft brewers and potential customers/consumers.

Key Learnings

As a first-time master's student and project manager, I learned a variety of valuable lessons and developed many skills planning and executing this project. As I'm already an organized individual, my biggest take-away was learning how to effectively manage other people. I started the project with the assumption that people would respond promptly on their own, I realized that no one was as invested in the outcome of this research as me and would therefore require reminders. By mid-project, I was comfortably setting expected due dates and sending 1+ reminder emails to obtain timely responses from individuals.

Another key skill I developed was the ability to effectively plan long-term with tasks I'd never completed before through a work breakdown structure. Outlining the major tasks of the project and breaking them down further, increased my ability to estimate timelines and create an appropriate schedule. Although I got hung up on certain steps (eg. Rescheduling the focus group 3x), the majority of tasks were executed on time and the project flowed as planned.

Despite my early fears, I'm able to work efficiently on my own schedule/timeline; I might argue I work better independently than on someone else's schedule. Having interest in the project outcomes increased my sense of responsibility and kept me focused. I thoroughly enjoyed working from home.

Document Layout

This document is comprised of various chapters detailing all 18 months of planning and execution towards *Exploring the Potential of Upcycling Craft BSG in Winnipeg, MB*. Chapter 1, as you're reading now, introduces the entire project so the reader has a general understanding of the document's purpose. Following the introduction are the project's four deliverables, provided each in an individual chapter. Chapter 2 is comprised of the first deliverable "Website Review Final Report", Chapter 3 holds the second deliverable "Survey Final Report", Chapter 4 is the third deliverable "Interviews Full Report", and Chapter 5 is comprised of the fourth and final deliverable "Final Framework Recommendation Report". Some portions of the BIR, specifically the nutritional profile of brewers spent grain, and previous research/data conclusions are repeated in subsequent deliverables to add depth and context as all deliverables were produced as stand-alone documents that would be detailed and complete on their own. Repeated sections/details are also a natural result of the case study as all research stages were meant to become increasingly specific and build on the previous data set(s).

Following the deliverables, Chapter 6 is a critical reflection of my time at the Natural Resource Institute (NRI). The reflection details the skills I learned and/or developed to complete coursework and throughout the practicum planning/execution, the success (or not) of decisions made throughout the project, how the formal plans executed in real life, what I'd change if I could do this all over again, and how/what I contributed to this body of research. The reflection also includes a section outlining what I learned about myself as an individual during my master's program.

The integrated project plan (IPP) is provided as Appendix 1 on Page 187 for reference, of which the background information report can be found as Appendix A. The integrated project plan compiles all planning documents into a comprehensive report detailing the project charter, scope, schedule, resource plans, relationship, risk, and quality management, budget summary, and how project changes will be managed. The first literature review, as mentioned earlier in this chapter, is provided as the background information report, and provides the necessary background information to understanding the full need and potential of the project's research.

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Chapter 2: Website Review Final Report

Deliverable Synopsis: This deliverable presents the results of a Canada-wide craft brewer website review of 1124 unique brewery websites searching for 6 key terms associated to the project objectives. This review is the first form of Canadian data for the project and contributes to the overall objectives by providing a general idea of the individually stated environmental concern of operations among Canadian craft breweries.

Exploring the Potential of Upcycling Craft BSG in Winnipeg, MB

Canadian Craft Breweries Website Review
Data Report
October 2022

Partially funded by the University of Manitoba Graduate Fellowship (UMGF) and Social Sciences and Humanities Resource Council Grant #435-2020-0923

Marika Boryen (PI), University of Manitoba
in partnership with:

Iain Davidson Hunt, BcD Workshop
Brian Westcott, **LOW**LIFE Barrel House

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An Overview of Canadian Craft Breweries

Canada was home to 1165 unique and independent craft breweries at the time of research planning (Spring/Summer 2022), some of which have multiple brewing/brewpub locations not included in this value. *Figure 1* depicts the volume of craft breweries by province.

Ontario hosts the largest number of craft breweries at 366, representing 31.42% of all Canadian craft breweries. British Columbia hosts 20.34% of Canadian craft breweries with 237 total, Quebec is home to 19.65% with 229 craft breweries, and Alberta has a total of 138 craft breweries representing 11.85% of the total. The remaining 16.74% of Canadian craft breweries are in Nova Scotia, New Brunswick, Saskatchewan, Manitoba, Newfoundland and Labrador, Prince Edward Island, Yukon, Nunavut, and the Northwest Territories.

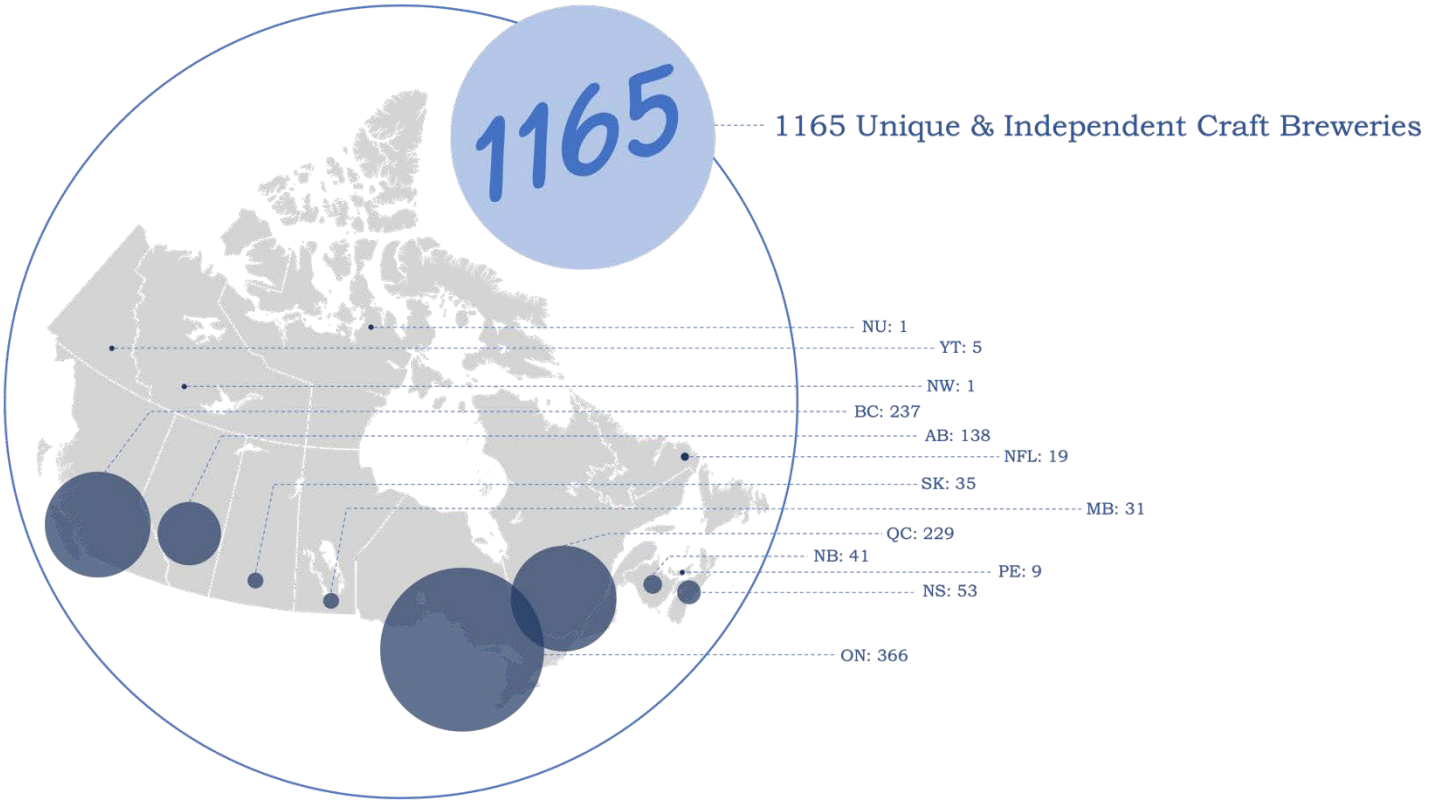

Figure 2.1. Visual of the number of unique and independent craft breweries in Canada by province in Spring/Summer 2022.

In Canada, the number of people per brewery (provincially) ranges from 8.703 to 45,698. The lowest ratio occurs in the Yukon with only 8,703 people per brewery, while the Northwest Territories has the largest ratio. While Manitoba is home to only 31 breweries, there are 45,224 people per brewery, making it the second highest ratio in Canada. With 38,644,920 people living in Canada with 1165 craft breweries, there are on average 33,171 people per brewery.

Table 2.1. Population and craft brewery ratio, by province in Canada (2021).

	BC	AB	SK	MB	ON	QC	NB	NS	PE	NF	YT	NW	NU
Breweries	237	138	35	31	366	229	41	53	9	19	5	1	1
Population (1)	5,273,809	4,502,858	1,188,338	1,401,967	14,996,014	8,650,692	802,862	1,007,360	168,358	523,043	43,518	45,698	40,403
People per Brewery	22,252	32,629	33,952	45,224	40,972	37,775	19,582	19,006	18,706	27,528	8,703	45,698	40,403

Research Methodology and Results

To be considered a "Canadian Craft Brewery", the brewery had to meet a set of inclusion criteria. First off, the brewery had to be in Canada and currently operating/producing beer. The brewery had to be independently owned and have an online presence as either a company website or Facebook page to conduct the website review. Other social media platforms such as Instagram, Twitter, etc. were not included. If the brewery had a website and a Facebook page, the website was used. If the brewery did not have a website, Facebook was used in the review.

Canadian craft breweries were first identified through Canada Beer Map (2). Upon identification, breweries were immediately verified through the company website and/or Facebook. Duplicates/additional locations were not included in the total craft brewery count, nor were breweries that were not independently owned. Additional/missing breweries were identified through a google search to complete the 'Canadian Craft Brewery Masterlist' of open and operating craft breweries.

The website review was done with a google search tool as follows: site:[insert URL] "[insert keyword]". This tool allows a user to specify a domain and search term easily without having to visit each website page in search of information. The specified term must be listed on the webpage's main domain to be recognized in the search, thus mentions on linked websites will not be accounted for. The terms used in this search were "Upcycle", "Circular Economy", "Sustainable", "Sustainability", "Waste", "Carbon Footprint", and "Spent Grain". Quebec websites were searched with French terms as opposed to translating each website. The French terms used were "Recycler", "Économie Circulaire", "Durable", "Durabilité", "Déchets", "Empreinte carbone", and "Drêche".

Further criteria for the terms were identified for the purpose of concentrating on upcycling spent grain. "Upcycle" was only recorded when it was referring to the upcycling of spent grain, and further marked as upcycling to human food products or animal feed. "Waste" was only recorded when it referred to reducing brewery by-product food or water waste, and not in terms of physical equipment or brewpub food waste for example. The term "Spent Grain" was only recorded if it was in reference to what the brewery does with spent grain, but not if it was just mentioning spent grain as a by-product of the brewing process. The remaining terms "Circular Economy", "Sustainability", "Sustainable", and "Carbon Footprint" were recorded with no further specifications. The summarized results of the website review are provided in *Table 2*.

Table 2.2. Overview of Website Review Data for search terms "Upcycle", "Circular Economy", "Sustainable", "Waste", "Carbon Footprint", and "Spent Grain". 0 results marked in white, 1-9 results in lightest blue, 10-19 results in slightly darker blue, 20-29 in medium blue, 30-39 marked with medium-dark blue, 40-49 results marked in dark blue, and 50-59 results marked in blue-black.

	Upcycle	Human Food	Animal Feed	Circular Economy	Sustainability /Sustainable	Waste (Reduce)	Carbon Footprint	Spent Grain	Total
British Columbia	3	1	0	1	37	20	6	34	**102**
Alberta	0	0	0	0	18	5	4	13	**40**
Saskatchewan	0	0	0	0	2	2	0	2	**6**
Manitoba	0	0	0	0	2	2	2	3	**9**
Ontario	1	1	1	5	54	30	16	47	**155**
Quebec	3	0	0	8	33	8	3	12	**67**
New Brunswick	0	0	0	0	0	0	1	2	**3**
Nova Scotia	0	0	0	0	5	4	1	6	**16**
Prince Edward Island	0	0	0	0	1	1	0	2	**4**
Newfoundland & Lab.	0	0	0	0	0	2	0	2	**4**
Yukon	0	0	0	0	2	0	0	0	**3**
Northwest Territories	0	0	0	0	0	0	0	0	**0**
Nunavut	0	0	0	0	0	0	0	0	**0**
	7	**2**	**1**	**14**	**154**	**74**	**33**	**123**	

Search Term: Upcycle

Upcycling can happen in any number of ways in any industry because "Upcycling is taking something that's considered waste and repurposing it. The upcycled item often becomes more functional or beautiful than what it previously was" (3). In the food industry specifically, "Upcycled foods use ingredients that otherwise would not have gone to human consumption, are procured and produced using verifiable supply chains, and have a positive impact on the environment" (4).

Figure 2.2. Visual of the number of Canadian craft breweries who mention "Upcycle" on their website/company Facebook page.

In Canada, only 7 craft breweries mention "Upcycle" on their website's main domain or company Facebook page. This means that less than 1% (0.6% to be exact) publicly advertise upcycling activities, but this does not mean that only 0.6% of Canadian craft breweries upcycle grain.

Upcycle was mentioned on brewery websites located in British Columbia, Ontario, and Quebec; all of which have spent grain upcycling companies. British Columbia is home to Susgrainable (5), The Spent Grain Baker (6), and the Kelowna Beer Institute (7). Ontario upcycles spent grain to human food with Spent Goods (8), and Quebec spent grain upcycling includes Boomerang Co-Op (9), Still Good (10), and Saison 2 (11). With the overall increase in environmental sustainability awareness and concern, and the multiple companies upcycling spent grain, it's evident that breweries are not publicly advertising what they do with their spent grain despite industry efforts to increase the sustainability of their operations. This is further obvious with Alberta having no upcycle mentions despite being home to GroundUp (12), coRISE (13), Ceres Solutions (14), and The MASH (15).

Discover Upcycling in Canada

Click on one of these Canadian company's logo to explore their exciting upcycled products or certification for upcycled products!

Search Term: Circular Economy

"In our current economy, we take materials from the Earth, make products from them, and eventually throw them away as waste". Produce-use-dispose is the core of a linear economy. This type of economy is extremely wasteful and hard on our natural environments. To Eliminate waste creation, we look to a circular economy which is "a systems solution framework that tackles global challenges like climate change, biodiversity loss, waste, and pollution" (16).

Circular economies are based on three principals:

1. Eliminate Waste and Pollution
2. Circulate Products and Materials (at their highest value)
3. Regenerate Nature

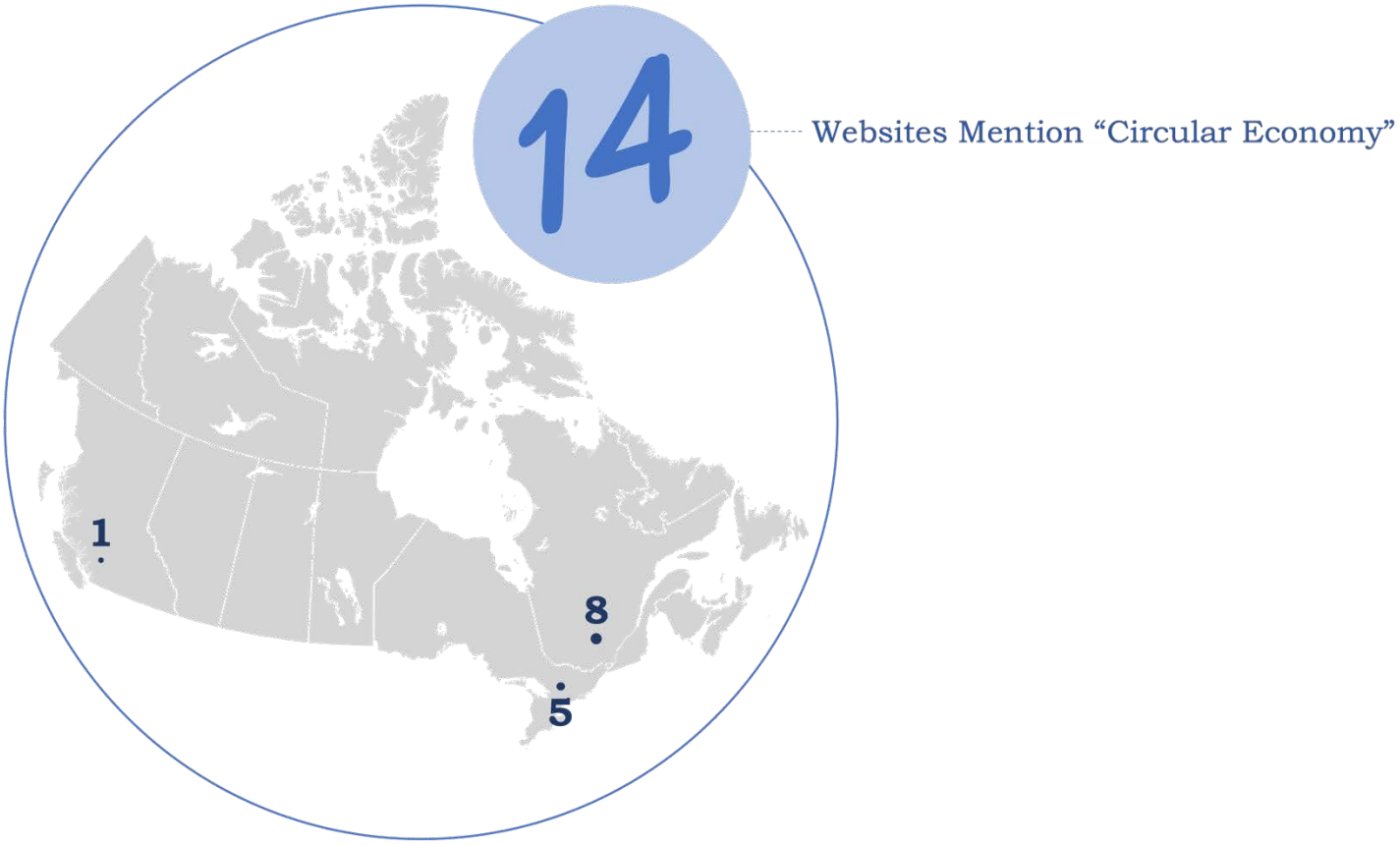

Figure 2.3. Visual of the number of Canadian craft breweries who mention "Circular Economy" on their website/company Facebook page.

The website review found that only 14 of 1165 Canadian craft breweries mentioned "Circular Economy" on their main domain or Facebook page. In any industry, operating as a circular economy revolves around the 10 R's of sustainability: refuse, rethink, reduce, re-use, repair, refurbish, remanufacture, repurpose, recycle, recover (17). Operating with circular economy principals is especially important for beer production because beer holds the 5th largest market share at 11.2% of global beverage production (18). At a popularity of #5 globally, brewers spent grain becomes an important by-product of brewing as it accounts for approximately 85% of brewery 'wastes', which translates to roughly 20kg of wet spent grain for every 100L of beer (19). Spent grain upcycling by brewers most resembles 'repurpose' which is defined as "use discarded product or its parts in a new product with a different function", and upcycling spent grain by food companies is 'reduce' which means to "increase efficiency in product manufacture or use by consuming fewer natural resources and materials". "Repurpose" ranks 8th in most sustainable of the 10 R's, and "Reduce" ranks 3rd (17).

Search Term: Sustainable and/or Sustainability

In 1987, sustainability was defined by the United Nations Brundtland Commission as "meeting the needs of the present without compromising the ability of future generations to meet their own needs" (20). Our surrounding natural environment and ecosystems are the best at operating sustainably; ***nature has NO waste***. As humans, we need to strive to be more like nature through innovative approaches to eliminating waste in all aspects of living.

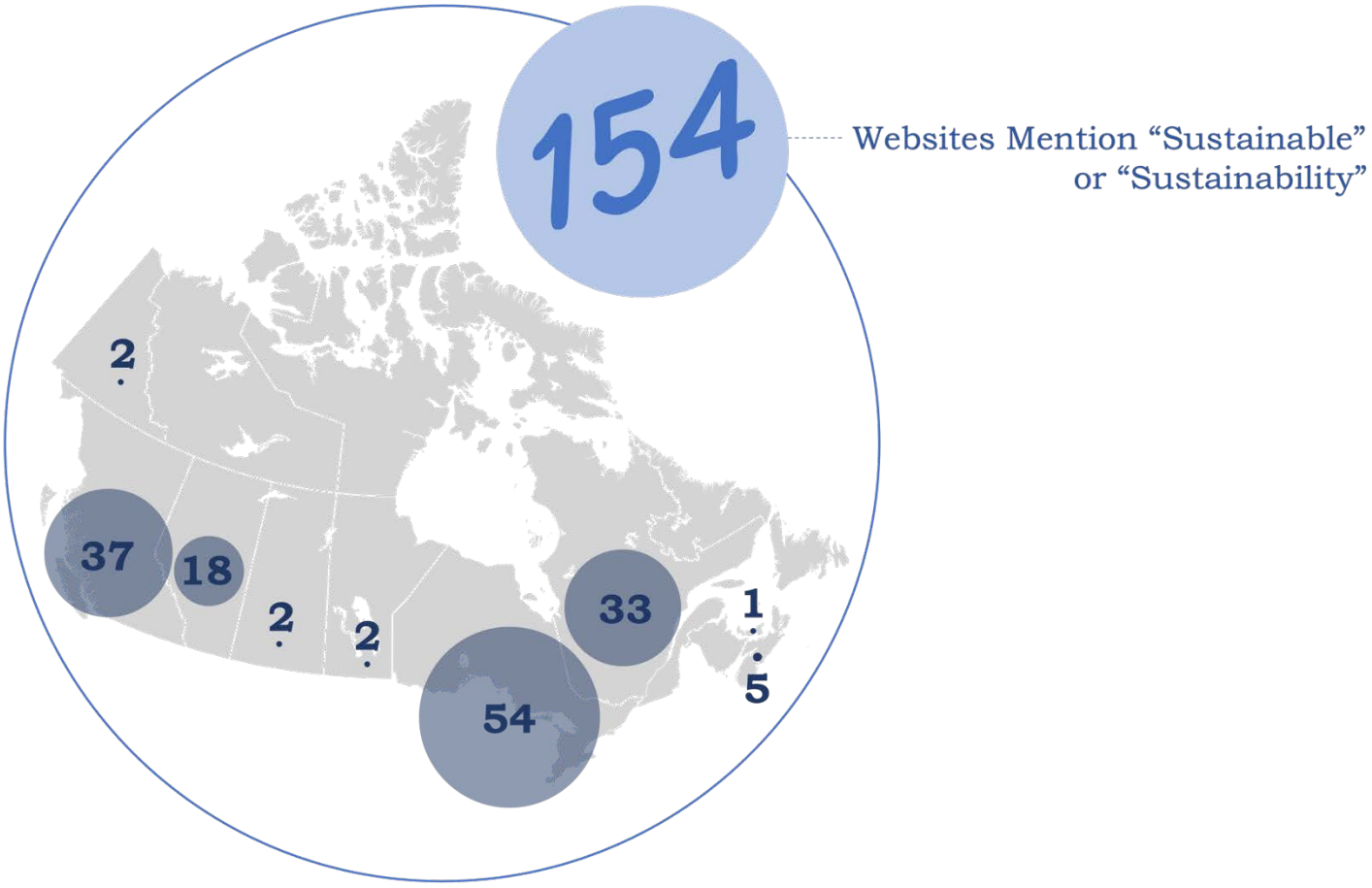

Figure 2.4. Visual of the number of Canadian craft breweries who mention "Sustainable"/"Sustainability" on website/Facebook page.

Living sustainably does not mean that humanity needs to live like wild animals. Sustainable development "requires an integrated approach that takes into consideration environmental concerns along with economic development" (21). The Canadian craft brewery website review found that 154 of a total 1165 breweries mentioned "sustainable" or "sustainability" on their website's main domain or company Facebook page, meaning 13.2% of Canadian craft breweries are making public statements regarding ways 'they are' or 'are going to' operate more sustainably. Sustainability in this review was not only related to food and beverage, but instead an insight as to the percentage of brewers that are thinking about the future effects of their current operations.

The United Nations has 17 Sustainable Development Goals (22), in which upcycling brewers spent grain targets Goal 12: "Ensure sustainable consumption and production patterns". "Unsustainable patterns of consumption and production are root cause of triple planetary crises: climate change, biodiversity loss, pollution". Within this goal, upcycling brewers spent grain is directly related to Target 12.3: "by 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses" (23).

Search Term: Waste

We're not referring to wasting a delicious sip of beer here, we're looking for the total number of Canadian craft brewers who have made public statements regarding waste reduction within their facilities. To reiterate, "Reduce" ranks as the 3rd most sustainable strategy to operating as a circular economy (17), and our target SDG Goal 12.3 is "By 2030, halve per capita global food waste at the retail and consumer levels to reduce food losses along production and supply chains, including post-harvest losses" (23). **2030 is 8 years away** and producing food/beverage for human requires strict safety regulations that aren't approved overnight. To meet these national goals and targets, we need to think global and act local. We're taking matters into our own hands.

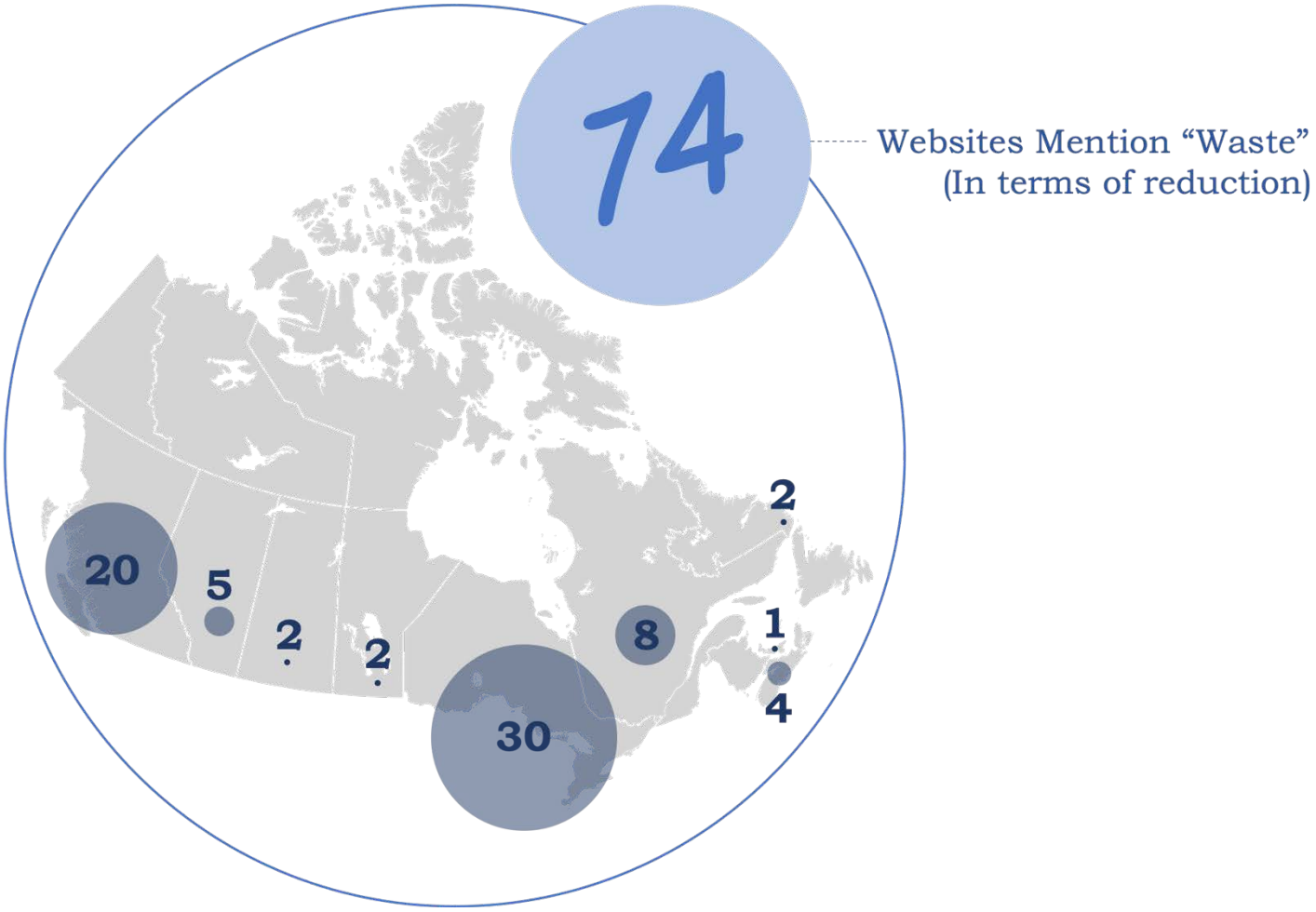

Figure 2.5. Visual of the number of Canadian craft breweries who mention "Waste" on their website/company Facebook page.

Of the total 1165 craft breweries reviewed, 74 total mentioned "Waste" in terms of reducing brewery wastes, which included ingredients and water associated with producing beer. Some websites mentioned upgrading equipment to more efficient models, some boasted 'zero-waste', and some referred to sending "waste" to farmers as cattle feed or compost to reduce overall landfill volumes. One brewery even referred to reducing food waste by using imperfect fruits (the kind that consumers won't buy) for their sours. It seems that the 6.35% of breweries mentioning waste reduction publicly are in fact finding ways to reduce waste but not necessarily in ways that eliminate "waste" in the first place. Not a single brewery mentioned reducing waste using upcycling spent grain as a strategy. Even if you don't care about the environment, sustainability, or future generations, reducing waste through upcycling could potentially offer brewery's a new source of income which should/could motivate more people to participate and work together for the collective benefits and get the full value from grains.

Search Term: Carbon Footprint

A carbon footprint is "the total amount of greenhouse gases (including carbon dioxide and methane) that are generated by our actions" (24). How does this relate specifically to what this research is exploring? In order to reach the Paris Agreement of limiting global warming to under 2°C by 2050 (preferably 1.5°C), the global average carbon footprint needs to be under 2 tons per person annually. Right now, it's 4 tons. Canadians have an average of 15.6 tons annually per capita (25).

Want to see what your carbon footprint is? Sure, let's see how I compare with the average!

Want to know your ecological footprint? Yes, let's see how many earths my lifestyle needs!

Interesting, but a brewery is not an individual household and has very different energy requirements.

The website review found that only 33 Canadian craft breweries mentioned "Carbon Footprint" on the website's main domain or Facebook page. Of 1165 total websites reviewed, this equals a mere 2.83%. As stated on the Government of Canada's website, "Climate change is one of the most important environmental issues of our time. Climate change is caused by the increase in concentrations of greenhouse gasses (GHGs) in the atmosphere" (26). The national indicator tracks 7 gases that are released by human activity which is important to this research for 2 reasons.

1. Mentioning "Carbon Footprint" on a public website informs us that the brewery is aware of their carbon footprint, aware of the regulations and/or targets relating to greenhouse gas emissions, and actively managing emissions if they've made a statement to do so.
2. The term "Carbon Footprint" was mostly used in relation to the brewery as a stand-alone entity, but a brewery is part of a supply chain that may or may not be sustainable. This means that an upcycling framework needs to consider the environmental accounting of beer production.

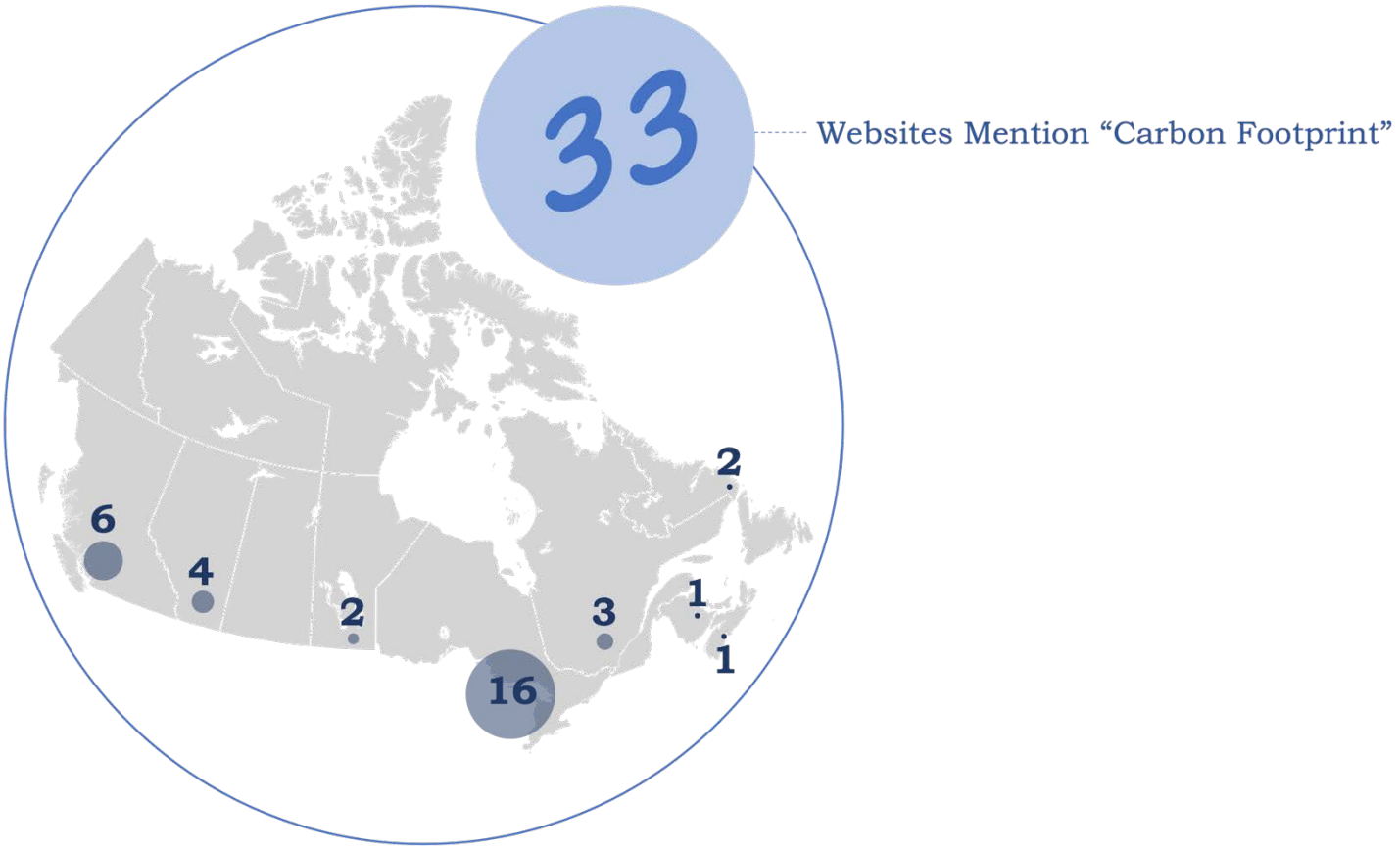

Figure 2.6. Visual of the number of Canadian craft breweries who mention "Carbon Footprint" on their website/company Facebook page.

Search Term: Spent Grain

Last, but not least, the focus of our research; brewers spent grain. 'Spent' is the result of the grains starches having been extracted in the process of making beer, but it is far from lacking nutrients. It's evident from *Figure 7* that BSG is high in protein and fibre, making it an attractive and nutritious human food product. Spent grain has been successfully incorporated into bakery products such as breads, buns, breadsticks, crackers, granola, muffins, pancakes, waffles, brownies, cookies, and pizza doughs while maintaining high consumer acceptance scores. It appears this 'waste' product isn't so useless to humans after all!

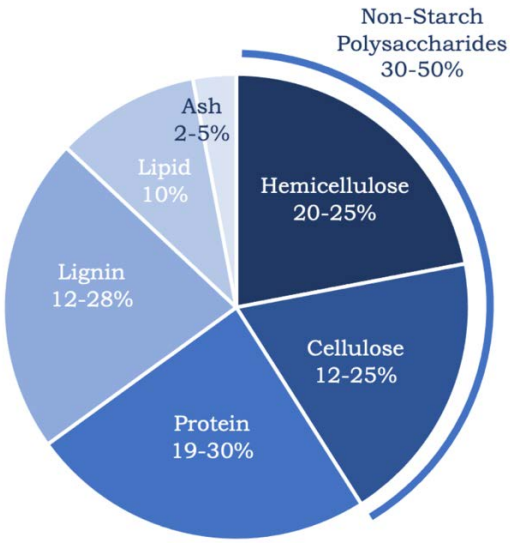

Figure 2.7. Typical BSG (barley) nutritional composition. Graph Replicated from (27 p. 555) , adapted from (29) and (28).

The website review found that 123 Canadian craft breweries mentioned "Spent Grain" on their website's main domain or Facebook page, representing 10.56% of the reviewed websites. Most websites stated sending spent grain to local farmers as animal feed, and some using spent grain in brewpub menu items (which is upcycling but not termed as such). We know that all breweries produce spent grain, but it's not evident from the website review where it all goes in Canada. Brewers spent grain is far too nutritious to be treated as waste and a burden, not to mention it's abundant and available year-round. It's time to become innovative.

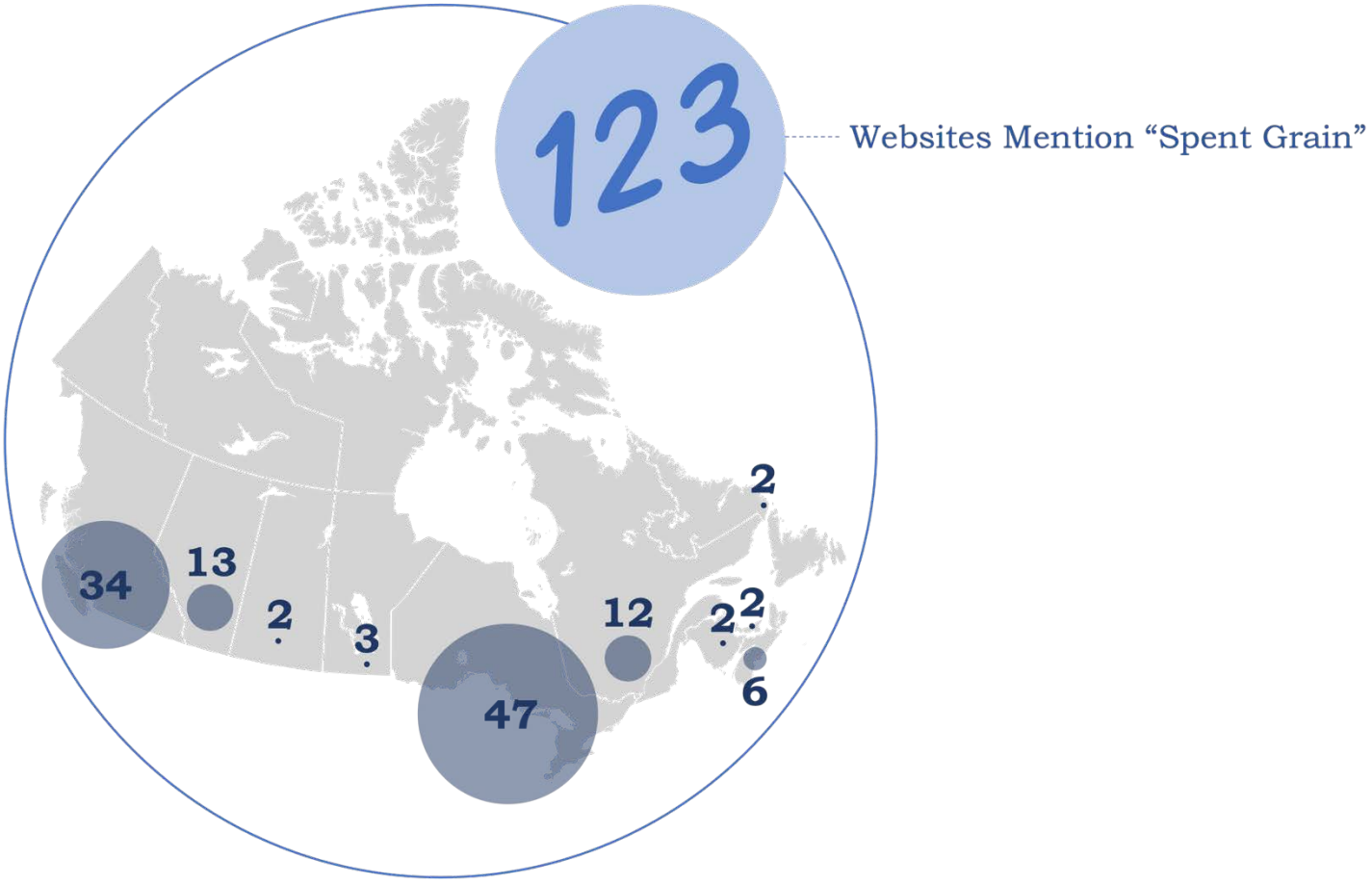

Figure 2.8. Visual of the number of Canadian craft breweries who mention "Spent Grain" on their website/company Facebook page.

Data Conclusions

The website review was intended to generate an overall idea of efforts surrounding global sustainability initiatives at the individual brewery, specifically in reducing food waste through upcycling. As is evident with the number of companies using and profiting from spent grain, this by-product brings together every term from this website review. Let's see how.

The terms chosen and relation to the overall research objectives are as follows:

1. Upcycle: A relatively new term that encompasses many forms of adding value to foods deemed as waste. Chosen primarily to gauge how the brewing industry is maintaining relevant in publicly stating efforts in sustainable operations.
2. Circular Economy: A term that applies to every industry and encompasses upcycling in the food industry. Chosen as a secondary insight to the sustainability of brewing in Canada.
3. Sustainable/Sustainability: Sustainable operations are the target of global climate change initiatives and therefore the center of this research. Chosen to develop an overall understanding to the number of breweries making public claim of increased sustainability.
4. Waste: Chosen as a secondary and additional assessment to "Upcycle" and "Spent Grain" to encompass various terms for a common goal and/or outcome.
5. Carbon Footprint: Chosen as a representation of the industry's awareness of the environmental footprint of brewing with a common term. A secondary term to "Sustainable".
6. Spent Grain: The largest by-product of brewing and focus of this research. Chosen to generate an overall understanding of spent grain's final destination in Canada.

The terms chosen for the website review relate to global sustainability initiatives with both common and new industry words that would indicate understanding of the brewery's overall efforts in operating sustainably. As the overall goal of this research is to "Think Global and Act Local" through upcycling brewers spent grain, spent grain was chosen specifically because it's the largest volume by-product of brewing beer and would thus have the most significant environmental impact if dealt with in a circular fashion. We know from literature and online research that spent grain is an excellent component of a flour mixture and can add nutritional value to many bakery products. As Winnipeg's had a significant increase in craft breweries in the past 5 years, it seems as though the potential for adding value to spent grain is now overdue.

What The Data Tells Us

A brewery's website can tell us many things including its location, mission, products, contact information, and more. This type of information is both public and voluntary, therefore cannot be assumed complete. However, because it is voluntary and public information, it can be used to gain a general understanding of a particular company's values (or commitment to sustainability in this case) based on what is being shared (or not). To further our understanding, the combined analysis of 1165 craft breweries across Canada can provide some insights to the overall industry. Simply put: *Are we loud and proud about sustainable brewing in Canada?*

Let's start at the heart of the research with "Sustainable" and "Sustainability". This term had the highest number of mentions at 154 of a possible 1165. Of all the terms, it's motivating to know that at least 13.22% of Canada's craft breweries are promoting the increased sustainability of their operations. This most likely means that they are following through (or are trying to) on the commitments they've made public, and it most certainly means that this portion of the industry is (or was) considering more sustainable practices. What this doesn't clarify is whether the brewery is sustainable as a complete operation because *more sustainable ≠ sustainable*. Exactly how are they operating more sustainably is not clear as mentions of upcycle, circular economy and carbon footprint were significantly less in comparison and not necessarily associated to the "sustainability" claim.

The search term "Upcycle" yielded interesting results with only 7 mentions total. Of those, 2 referred specifically to upcycling spent grain to human food products, and 1 mentioned upcycling in reference to animal feed. It's apparent that companies on p.6 upcycling spent grain need ingredient sources, but with only 7 upcycle mentions, it's obvious that the Canadian craft breweries providing spent grain are not advertising the partnership. The lack of public connection could potentially be due to explanations such as (but not limited to) legal/business agreements, changing sources of spent grain, a lack of knowledge surrounding upcycling, and/or just not wanting to state business operations publicly. Whatever caused the low value, we know there are 11 companies upcycling spent grain between British Columbia, Alberta, Ontario, and Quebec, therefore mentioned or not; upcycling is happening in Canada.

"Spent Grain" yielded much higher results than "upcycle" despite referring to the same strategy in reducing and/or eliminating brewery waste. The data value represents mentions of spent grain on the brewery's main domain or company Facebook page, excluding mentions of spent grain in reference to describing the brewing process. The review found the final destinations of spent grain to be as follows: local farmers/animal feed (48), human food (33), dog food/treats (17), compost (3), fertilizer (2), fuel (1), and the 'scrub' component of soap bars (1). Technically, each of these uses can be classified as "upcycling" if the final product is of higher value. To clarify, spent grain might be a vital and nutritious component of animal feed that is highly valued/sought after by the farmer, but it can also be a feed that the farmer is willing to take but may not use. While this distinction cannot be determined with this data set, we can still celebrate that spent grain was not advertised as going to a landfill. However, there were 1,042 breweries that did not mention spent grain and we can therefore not assume all spent grain avoids landfills, especially with the difficulty of handling a wet product in Canadian winters.

Upcycling is a circular economy strategy in reducing food waste, yet the website review found that twice as many websites mentioned "Circular Economy" (14) than "Upcycle" (7), but only 2 of the websites that mentioned upcycle also mentioned circular economy. Interestingly, of the 14 circular economy mentions there were only 2 that didn't also mention "Sustainability". It appears that the brewery's mentioning upcycling are not doing so specifically in reference to operating in a circular fashion. While this doesn't conclude the efforts around sustainable operations of Canadian craft brewers, it's a surprisingly low number for an industry that reuses packaging at high volumes.

"Waste" reduction can be done in many ways at a brewery which was evident in the results. 74 websites mentioned reducing waste in ways such as recycling water and materials, efficient equipment, equipment upgrades, using eco-friendly 6-pack rings (E6PR™), offering refillable growlers, not using plastic, and finding other uses for spent grain. As there were a variety of strategies stated, its interesting that "waste" yielded 74 results while "spent grain" yielded 123, making it clear they were only sometimes used in combination. Combined with "circular economy" there was one instance where waste reduction was described as using brewery water as nutrients in the garden, and the website also mentioned "circular economy". Though the combined mention is low, it does not offer concrete evidence that breweries are reducing waste through various/multiple circular economy strategies. Nor does it inform us of the real waste reduction volume among Canadian craft breweries.

There were only 33 mentions of "Carbon Footprint" across all 1165 websites reviewed. In comparison to "spent grain" with 90 more mentions, perhaps the significance of spent grain (environmental, volume, ease of diversion/waste reduction, etc.) demanded more attention. Carbon footprint is an important term in relation to the Paris Agreement targets driving the research, but the website review findings do not provide clarification of industry actions, efforts or solutions.

Overall, we cannot assume that mentioning any of the terms used in this review on a brewery's website provides us with concrete and conclusive data. Alternatively, we cannot assume that breweries who didn't mention these terms are not concerned with sustainability and/or finding ways to upcycle spent grain. The general impression from the website review is *No. Canadian craft breweries are not loud and proud about sustainable brewing* (or upcycling), or at least not online.

Further Research

In determining further research/data needs for this project, it's important to mention the most significant flaw and/or drawback of the website review and the method used to conduct it. As mentioned, the website review was done with a google search tool as follows: site:[insert URL] "[insert keyword]". This is a great tool for efficiently searching through many websites for a specific term without having to read 1665 websites consisting of multiple pages. The drawback of this method is that the search is limited to the domain specified, therefore would not capture the term on a linked domain. This is important in situations where the brewery has a secondary/linked website for (example) sales (merchandise, beer, etc.), or linked documents on different domains for (example) a menu describing items that may contain spent grain. While it's possible that the main domain would include similar information or the same terms, this is not guaranteed and may have affected the data. Nevertheless, the website review was only intended to provide a general impression.

The terms used in the website review were chosen specifically to either directly define and/or relate to spent grain upcycling as described in the previous section. If there was a desire to expand on the website review, the following terms may provide further insight to the Canadian craft brewing industry in Canada: (1) Upcycled, (2) Upcycling, (3) Environment, (4) Environmental, (5) Emissions, (6) Ecological Footprint, and (7) Stewardship.

This project consists of 5 distinct research activities that are intended to generate various types of data and complement each other. They are as follows: (1) website review, (2) literature review, (3) survey, (4) interviews, and (5) focus group. The next stages involve building on the data/insights gained from the website review to build a strong case study for the upcycling potential of brewers spent grain in Winnipeg, MB. The Canada-wide craft brewer survey is structed to generate more in-depth and accurate data relating to upcycling in Canada, and to somewhat verify the insights generated from the website review. The hope is the understand what other breweries are doing with their spent grain and how they're upcycling (if they are). The interviews and focus group will use the survey data as an outline to determine if there is sufficient spent grain supply and industry interest to upcycle locally and will gather specific data relating to the creation of a location-specific framework.

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Chapter 3: Survey Final Report

Deliverable Synopsis: This deliverable presents the results of 168 responses obtained from a Canada-wide craft brewer survey consisting of 23 questions relating to four overall categories: (1) General brewery data, (2) Spent grain, (3) Spent grain upcycling, and (4) Current waste management strategies for spent grain. This research stage contributes to the overall objectives by providing a comparative model for the case study as well as providing country-specific data of current spent grain upcycling in Canada.

Exploring the Potential of Upcycling Craft BSG in Winnipeg, MB

Canadian Craft Breweries Online Survey
Full Data Report
December 2022

Partially funded by the University of Manitoba Graduate Fellowship (UMGF) and Social Sciences and Humanities Resource Council Grant #435-2020-0923

Marika Boryen (PI), University of Manitoba
in partnership with:

Iain Davidson Hunt, BcD Workshop
Brian Westcott, **LOW**LIFE Barrel House

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Report Layout

This report is specific to the Canada-wide craft brewer survey that was conducted as part of a project called 'Exploring the potential of upcycling brewers spent grain in Winnipeg, MB'. The methodology on page 37 describes the survey objectives and distribution methods. The data trends on page 38 outline the response rates and other numbers associated with the survey. Page 39 provides the survey map and how question responses would lead a participant through the survey, while page 40 shows the associated response rates of every question.

The bulk of the report is data analysis and is laid out in a way that allows the reader to understand the individual survey questions (pages 41-61) and leads into the averaged and generalized results that combine survey data (pages 62-63). The data is used as a general comparison to that of participating Winnipeg breweries to help with the framework development. The final section of the report (pages 64-67) provides a list of questions to be answered in the interview and focus group stages of research and make suggestions for further research related to this case study.

The data and analysis provided in this report is specific to this research project and is therefore not intended to be used for any other purpose. The survey is one of six research stages intended to achieve the objectives of the entire project as follows: (1) Background Information Report (Literature Review), (2) Website Review, (3) Canada-wide Survey, (4) Winnipeg/MB Interviews, (5) Focus Group, (6) Additional Literature Review.

Disclaimer

The following is a summary report of a Canada-wide craft brewer survey conducted as a part of a master's practicum project, administered by Marika Boryen of the University of Manitoba. The following report is based on voluntary data provided by 168 craft breweries in Canada. As such, data interpretations are not an accurate representation of the entire Canadian craft brewery population, and instead a representation of the data provided by participants.

Your use of any of this Report is at your sole and absolute risk. None of the authors, contributors, administrators, vandals, or anyone else connected with this project, in any way whatsoever, can be responsible for your use of the information in this summary report. The survey questions were designed to address a specific set of objectives towards the research project "Exploring the potential of upcycling craft brewers spent grain in Winnipeg, MB" and therefore should not be applied to research/data outside of the intended use, or for any other purpose outside this project.

The interpretation of the generalized data is solely that of the principal researcher (Marika Boryen), and is not necessarily to the author's educational institution, employer, organization, committee, or other group or individual. Marika Boryen assumes no responsibility or liability for any errors or omissions in the content of this report. The information contained in this report is provided to you on an "as-is" basis with no guarantees of completeness, accuracy, usefulness, or timeliness and without any warranties for any kind whatsoever.

Methodology

The research is specifically concerned with the development of a spent grain upcycling framework for craft breweries in Winnipeg, Manitoba, Canada. As such, it's of interest to know what's happening in the rest of the country in terms of upcycling. As there is no large-scale spent grain upcycling currently happening in Winnipeg, Canadian craft breweries were chosen as a reference primarily because they share similar laws, ingredient sourcing, and similar equipment availability. In order to have been eligible as a "Canadian Craft Brewery", participants must have met the following inclusion criteria to complete the survey:

1. Must be a Canadian owned and operated brewery with a license from the Government of Canada to produce beer
2. Brewery is independently owned with no controlling shareholders or large beverage alcohol company
3. The brewery is currently operating and producing beer (has not been closed or shut down)
4. Participants must be able to read and respond in English
5. Must be 18 years of age or older
6. Must be the owner/co-owner of the brewery, or an employee/representative who has obtained consent from the owner to participate and provide information
7. Must have access to a computer and internet

The inclusion criteria was described in the initial recruitment process and assessed in the consent form, as well as in the preliminary questions of the online survey.

Participants were identified through detailed Google searches including the search terms "craft brewery" and "brewery", as well as location-specific searches throughout the country. The search identified 1221 craft brewery locations between the 10 provinces and 3 territories. After the removal of duplicate breweries, a total of 1165 Canadian craft breweries remained. Of those, 1121 had publicly available email addresses which were used to recruit participants for the survey.

The overall objectives for the study "Exploring the potential of upcycling brewers spent grain (BSG) in Winnipeg, MB" are as follows: (1) Define and quantify current waste management strategies for BSG in Winnipeg and Canada, (2) To understand the opportunities and barriers to upcycling BSG, and (3) To recommend potential upcycling options for Winnipeg craft brewers. The survey was intended to provide us with a general understanding of upcycling BSG in Canada through four objectives: (1) Understand the most common waste management strategies for spent grain and determine how many breweries upcycle spent grain in Canada, (2) Identify what types of food are most common for incorporating upcycled spent grain, (3) Identify the barriers that Canadian craft breweries face in upcycling their spent grain, and (4) Evaluate the volume of spent grain required to operate a successful upcycling operation. The four survey objectives will be generally assessed through the analysis of 23 voluntary questions. The survey progression and logistics based on question response is outlined on page 39.

The survey was distributed to 1121 recipients on Monday September 26, 2022, with an initial response period of 2 weeks. A survey extension was provided and a second email reminding participants of the survey was sent on Monday October 17, 2022. A final reminder to complete the survey was sent on Thursday October 27, 2022, and the survey was closed on Monday October 31, 2022. A total of 168 brewery representatives participated in the survey.

The survey responses are anonymous and therefore different online platforms was used for the consent forms (Microsoft Forms) than the survey (SurveyMonkey). As the data is anonymous, all data reporting is done as generalized results throughout this report and the final Master's report. Any potentially identifiable data has been omitted from this report to protect participant identities. All survey questions were voluntary apart from the research consent form and eligibility criteria assessment to ensure that the data included is only that of Canadian craft breweries.

Data Trends

In Canada, 1165 individual and unique craft breweries were documented for the purpose of this Canada-wide survey regarding upcycling brewers spent grain. Of the 1165 breweries, 44 did not have public email addresses listed therefore the survey was distributed to a total of 1121 Canadian craft breweries. Over the course of 5 weeks, 168 breweries participated in the survey, representing 14.99% of the invited participants.

Figure 3.1. Overall survey response rate of the 1165 individual Canadian craft breweries as "participated", "did not respond", and "no email".

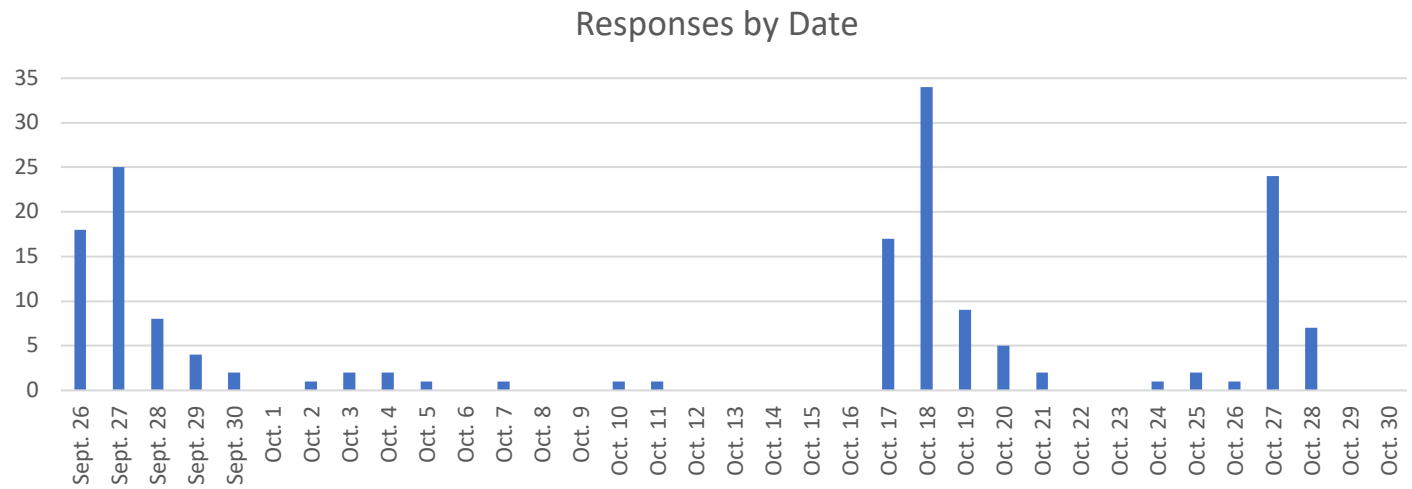

Figure 3.2. Survey response by date.

The survey was distributed on Monday September 26, 2022. A reminder was emailed on Monday October 17, 2022, and a final reminder was sent on Thursday October 27, 2022.

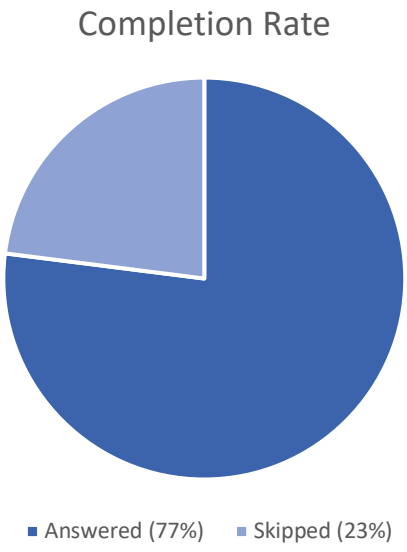

Figure 3.3. Average survey completion rate among the 168 respondents.

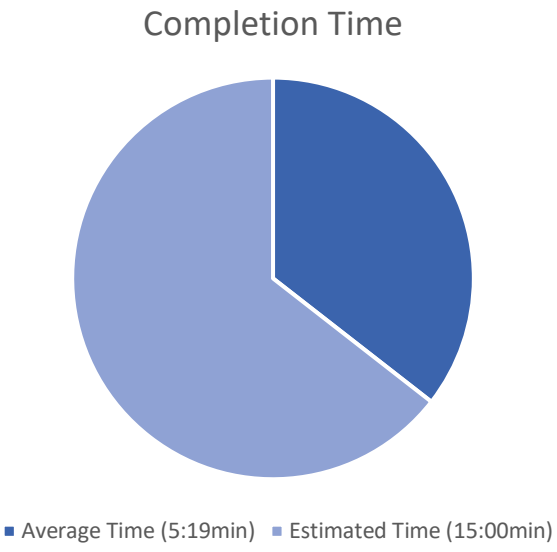

Figure 3.4. Average survey completion time of the 168 respondents was 5m 19s of an estimated 15m.

Question Map

Question Progression

The following map is a visual of the participants progression dependent on the answers provided. The survey was divided in broad sections and answering no to a leading question would skip associated questions and progress to the following section. Participants who skipped answers would automatically go to the next question regardless of the survey logic.

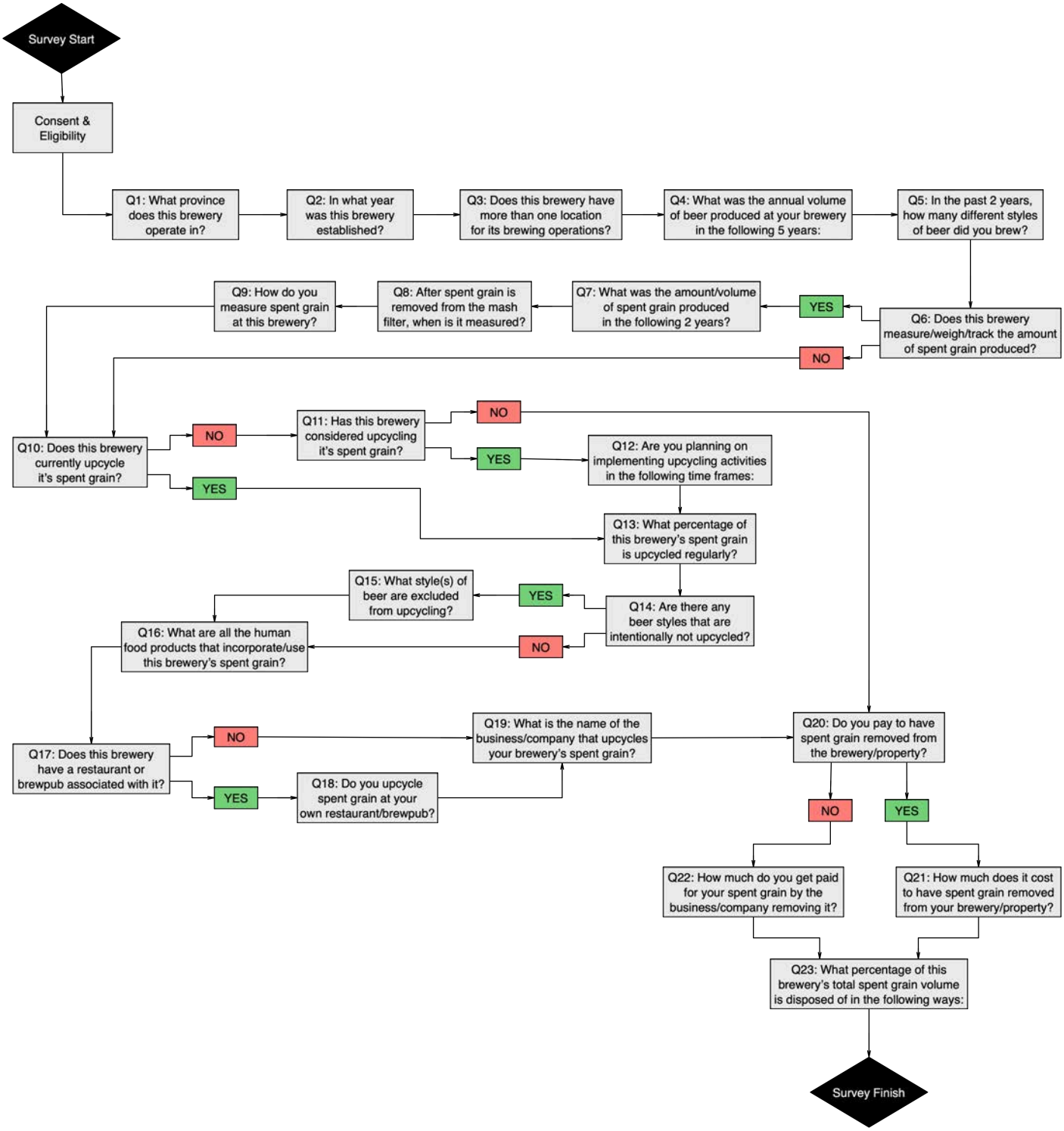

Figure 3.5. Canada-wide craft brewer survey question progression map.

Response Map & Summary

The following map is a summary of the number of participant answers to the respective questions. A total of 168 Canadian craft breweries participated in the survey, thus is the highest possible number of responses per question. Each question box shows the highest number of possible responses, the actual number of responses received, as well as the skipped value.

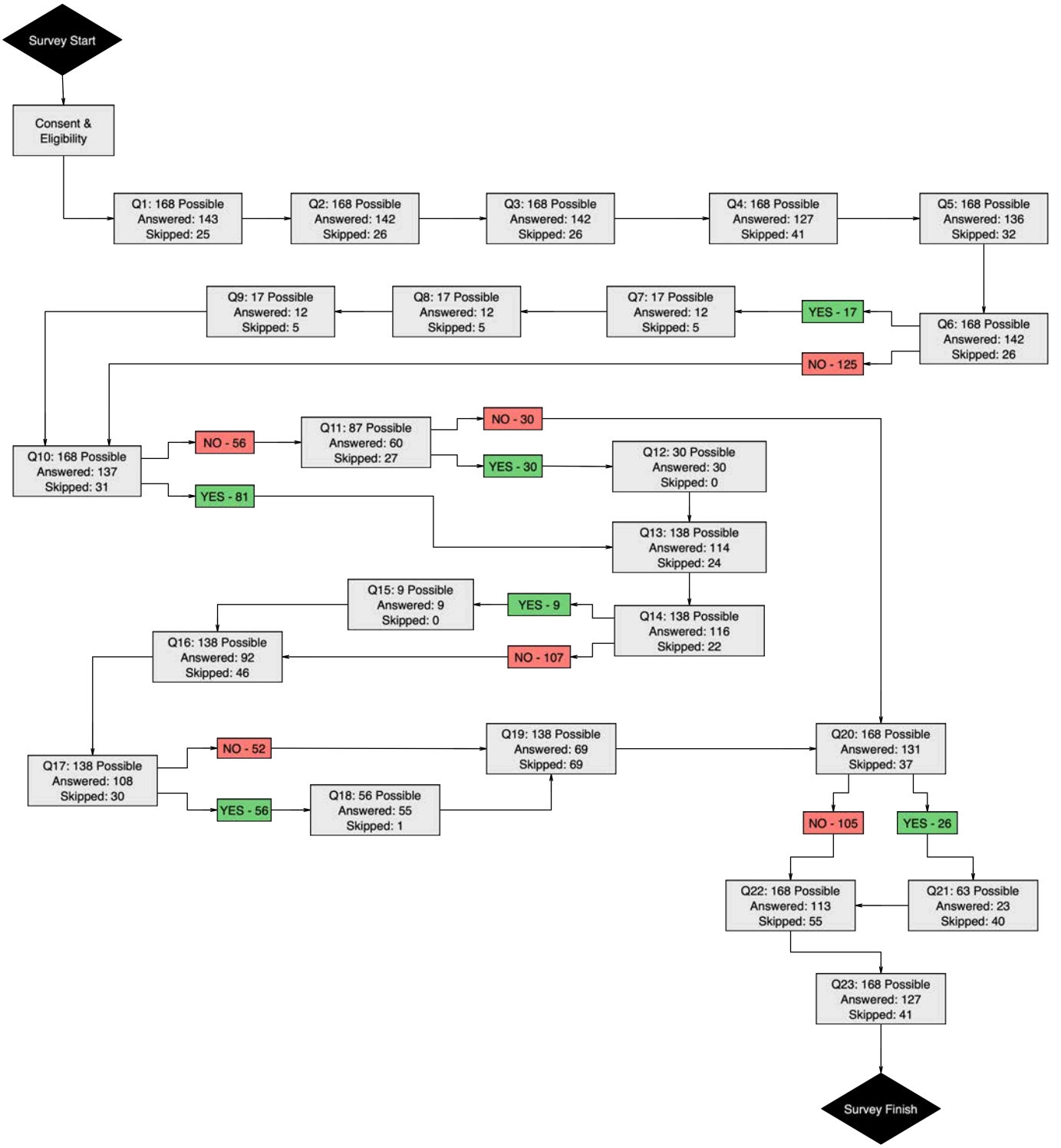

Figure 3.6. Canada-wide craft brewer survey question progression map with response rate.

Survey Data Overview

Survey Section 1: General Brewery Data

The first portion of the Canada-wide craft brewer survey was designed to obtain general information regarding the participating breweries as a general reference and understanding of who the survey participants are while maintaining anonymity. The following five questions were asked of participants:

1. *What province does this brewery operate in?*
2. *In what year was this brewery established?*
3. *Does this brewery have more than one location for its brewing operations?*
4. *What was the annual volume of beer produced at your brewery in the following 5 years (Include the numerical value as well as the unit of measurement. Eg. 300,000 hl):*
5. *In the past 2 years, how many different styles of beer did you brew?*

Table 3.1. Section 1 (Question 1-5) response statistics.

	Answered	Skipped	Total Possible
Question 1	143	25	168
Question 2	142	26	168
Question 3	142	26	168
Question 4	127	41	168
Question 5	136	32	168

The survey was completed by craft breweries from across Canada, as shown in the chart below. Ontario has the highest number of responses with 44 craft breweries (12.3% of the 358 invited), with British Columbia in second with 38 responses (16.4% of the 232 invited). This question provides a snapshot of where the survey responses were collected from among Canadian craft breweries. Based on the responses from question 1 of the survey, while the largest response volume came from Ontario and British Columbia, the highest response rate was from the Northwest Territories, followed by Prince Edward Island, New Brunswick, and Nova Scotia as shown in *Table 3.2.*

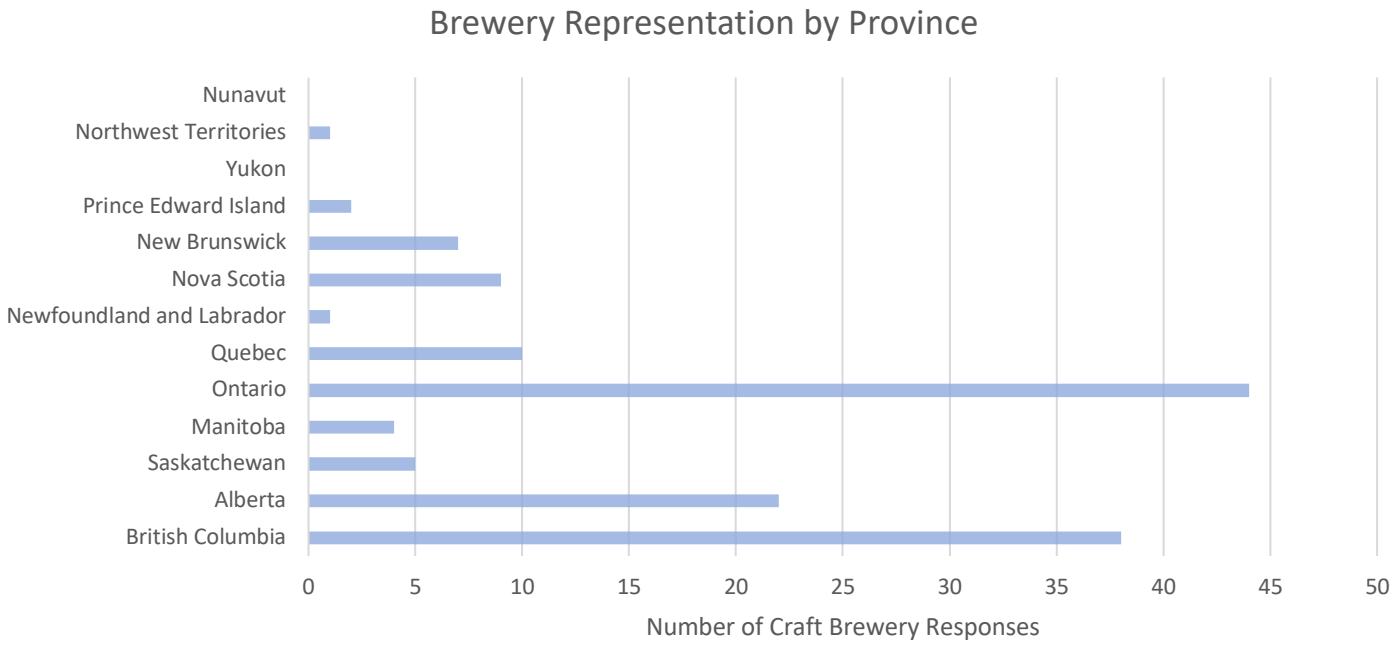

Figure 3.7. Question 1 data chart: brewery representation by province.

Table 3.2. Survey response rate compared to the number of breweries invited per province/territory.

	BC	AB	SK	MB	ON	QC	NF	NS	NB	PE	YU	NW	NU	Total
Invited	229	132	35	27	358	217	18	51	39	9	4	1	1	1121
Participated	38	22	5	4	44	10	1	9	7	2	0	1	0	143
Response %	16.6%	16.7%	14.3%	14.8%	12.3%	4.6%	5.6%	17.6%	17.9%	22.2%	0%	100%	0%	15.0%

The second survey question data is shown in the chart below and provides a general idea of how old the breweries are that participated in the research. We can see from the chart that 2018 was a popular year to establish a brewery, with most participants (130 of the 142 that answered this question) opening in the last decade (between 2012 and 2022). As upcycling is a relatively new term in the food and beverage industry, it's of interest to analyze the rates of upcycling in relation to the age of the brewery which may provide a linkage between the two.

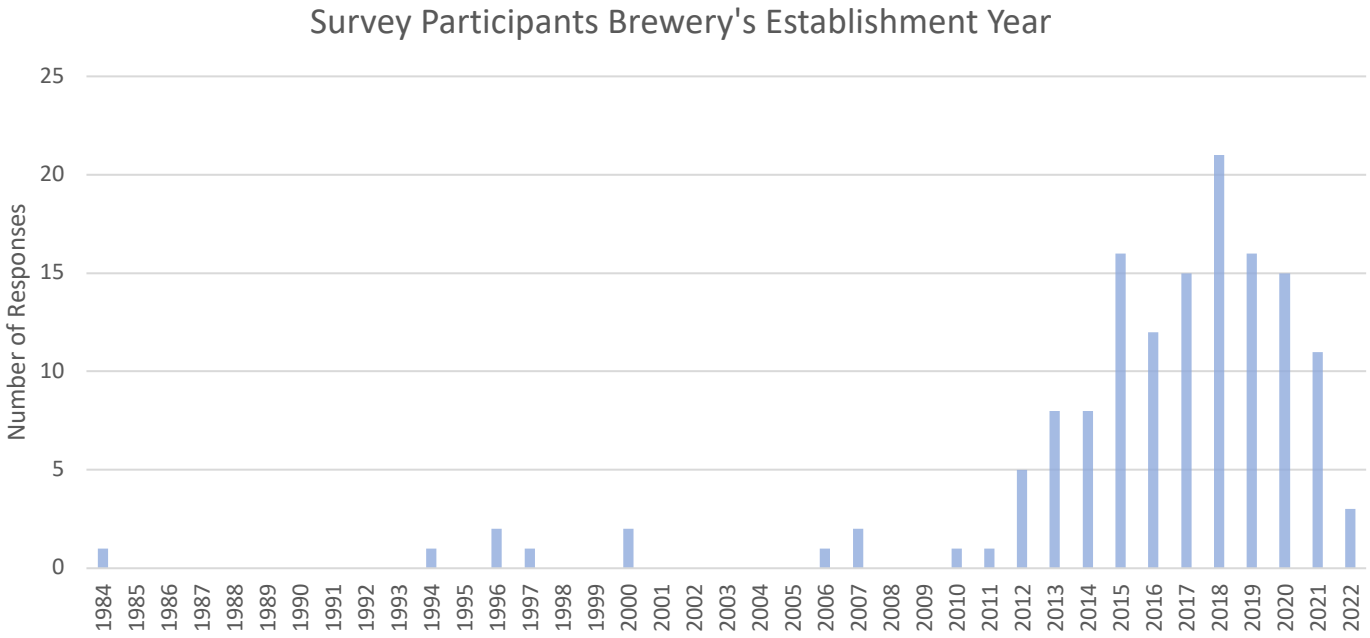

Figure 3.8. Question 2 data chart: Participant brewery's establishment year.

The third question informs us of how many duplicate craft breweries (brand chains) are actual brewing locations as opposed to brewpubs/restaurants under the same name and ownership. During the data collection phase, a total of 1221 craft breweries were documented while only 1165 were unique names. While the associated brewery websites did not always clarify the actual brewery locations, it was of interest to clarify exactly how many craft brewing locations were in Canada, thus the number spent-grain-producing locations. With the survey response rate being 14.99%, the exact number is not revealed, but it did bring the total number of craft brewing locations from 1165 up to 1177, an increase of 12 spent-grain-producing locations.

Figure 3.9. Question 3 data chart: Breweries that have 2+ locations.

The fourth question asked participants to provide their production volumes between 2017-2021. The intent was to (1) obtain a reference of the different sizes of breweries participating in the research, and (2) use this reference as a comparison of the average annual volumes of the participating interviewing Winnipeg breweries in the next phase of research. While there is no universal definition for what a craft brewery is, according to the *Canadian Craft Brewers Association* (CCBA) "No craft brewery in Canada produces more than 400,000 hectolitres of beer, and the vast majority produce less than 5,000 hectolitres" (1). The data chart below shows that none of the participating breweries are producing 400,000 hl of beer annually as the maximum was 125,000 hl in three separate years. We also see that the average volume produced is higher than the 5,000 CCBA value which may hint that the craft brewing industry, as well as individual brewery output, might be growing. Unfortunately, because the survey is not representative of the entire Canadian craft brewer population this cannot be confirmed. However, we know that every 100L of beer produces approximately 20 kg (44.09 lbs) of spent grain (2 p. 556). Looking at 2021, the combined response volume of beer produced was 79,693,400 L which is approximately 35,136,820 lbs of spent grain (representing only 10.9% of craft breweries). The pure popularity of beer suggests there are no supply shortages of spent grain, making upcycling an important industry.

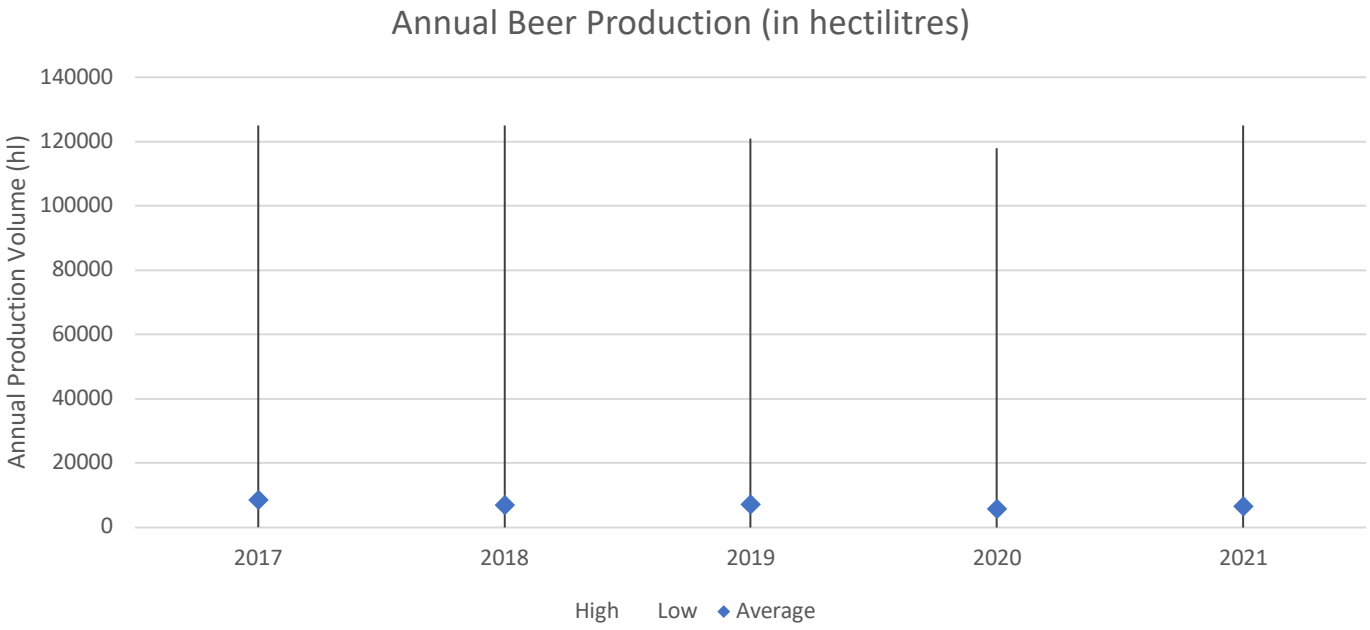

Figure 3.10. Question 4 data chart: Brewery annual beer production (in hectolitres) with the average marked with a blue diamond while the full response range is marked with a black line.

Table 3.3. High, low, and average values from the Question 4 data chart (*Figure 3.10*).

	2017	2018	2019	2020	2021
High	125,000	125,000	121,000	118,000	125,000
Average	8500.46	6992.00	7003.59	5715.37	6426.89
Low	4	5	20	17	18

The fifth and final question assessing the general brewery data asked how many different styles of beer the brewery produced in 2020 and 2021. From the projects background research, it's known that spent grain sensory characteristics (most notably flavour, colour, and texture) change based on beer style and is an important consideration in the final framework development (3 p. 1264). The question 5 data chart makes it obvious that there is a significant difference in the high values of beer styles (70 in 2020 and 170 in 2021), the same value for the minimum (1 style), and a slight increase in the average (17 in 2020 and 20 in 2021). While the assumption with the upward trend is not as straight forward as stating *'On average, breweries brewed more styles in 2021 than in 2020'* especially as the COVID-19 global pandemic was affecting 'business-as-usual' in many ways, it does seem as though craft breweries are in fact brewing a more diversified menu for their customers.

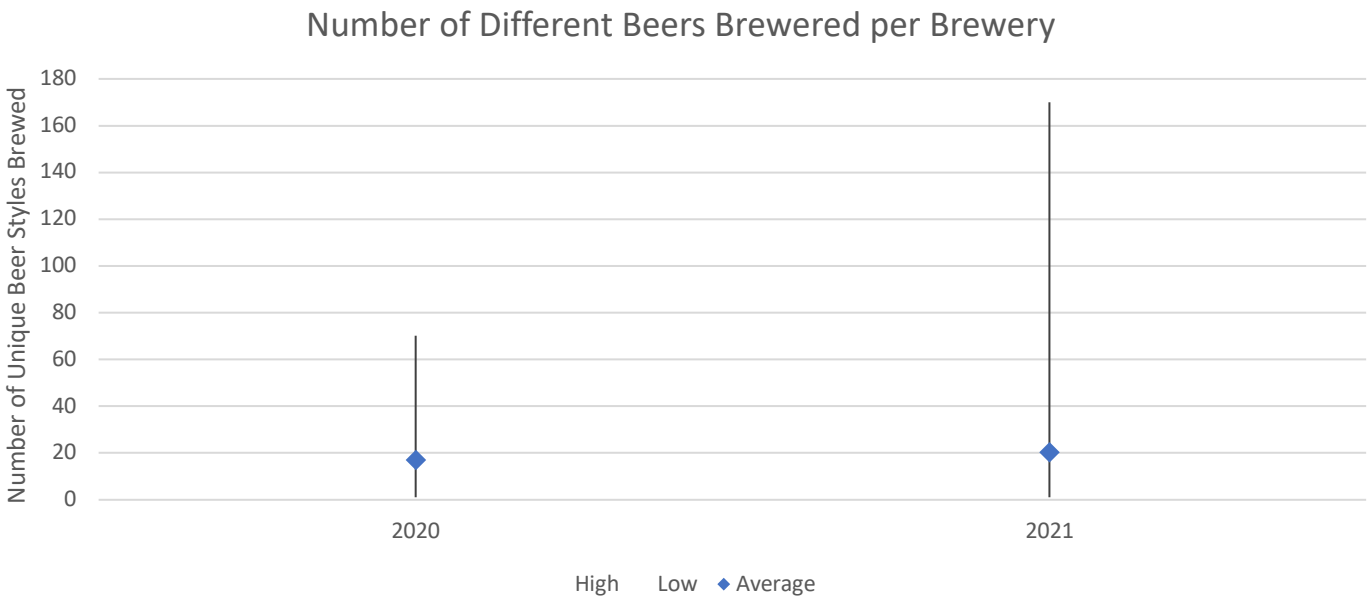

Figure 3.11. Question 5 data chart: Number of different beers brewed per brewery with the average marked with a blue diamond while the full response range is marked with a black line.

Table 3.4. High, low, and average number of beer styles produced in 2020 and 2021 from the Question 5 data chart (*Figure 3.11*).

	2020	2021
High	70	170
Average	17	20
Low	1	1

Section 1 Data Conclusions

Section 1 of the survey paints a picture of what the 'average craft brewery' is within this research, which serves as an overall comparative model for the Winnipeg craft breweries involved in the final upcycling framework development. The data provided by 168 Canadian craft breweries describes the following average brewery:

> *The average Canadian craft brewery has a single location for brewing, is less than 10 years old, and brews 17-20 different beer styles for an average annual production volume of 6,000-7,000 hectolitres.*

A 6,500 hl (650,000 L) average results in 125 hl (12,500 L) of beer every week of the year. This then means an average of 5,511 lbs of spent grain on a weekly basis, per brewery. This further translates to 787 lbs of spent grain per brewery/day of varying characteristics.

In considering an upcycling framework for Winnipeg craft brewers, question 4 & 5 data are of particular interest in how to manage the increasing volume and variety of spent grain, specifically in considering the end uses and markets for the upcycled product(s). If the trend continues upwards, spent grain volumes and variety will require more and more attention in process and supply management. An average of 787 lbs of spent grain per brewery/day becomes a large volume very quickly, especially with the rapid degradation due to high moisture. While further volume and beer style data is needed from Winnipeg craft brewers, the increase in beer styles may play a significant role in the selection of continuous or batch style processing equipment and the final products possible as a result.

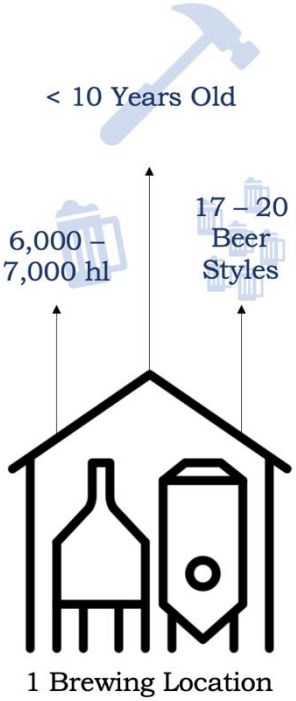

Figure 3.12. Representation of the average Canadian craft brewery as per the overall survey responses of 168 participants.

Survey Section 2: Spent Grain

The second section of the survey was designed to understand if and how Canadian craft breweries measure their spent grain. The following four questions were asked of participants:

6. *Does this brewery measure/weigh/track the amount of spent grain produced?*
7. *What was the amount/volume of spent grain produced in the following 2 years? (Include the numerical value as well as the unit of measurement)*
8. *After spent grain is removed from the mash filter, when is it measured? (Select the best answer)*
9. *How do you measure spent grain at this brewery? Include a brief description of what the weighing/measurement process of BSG is, as well as the measurement units)*

Table 3.5. Section 2 (Question 6-9) response statistics.

	Answered	Skipped	Total Possible
Question 6	142	26	168
Question 7	12	5	17
Question 8	12	5	17
Question 9	12	5	17

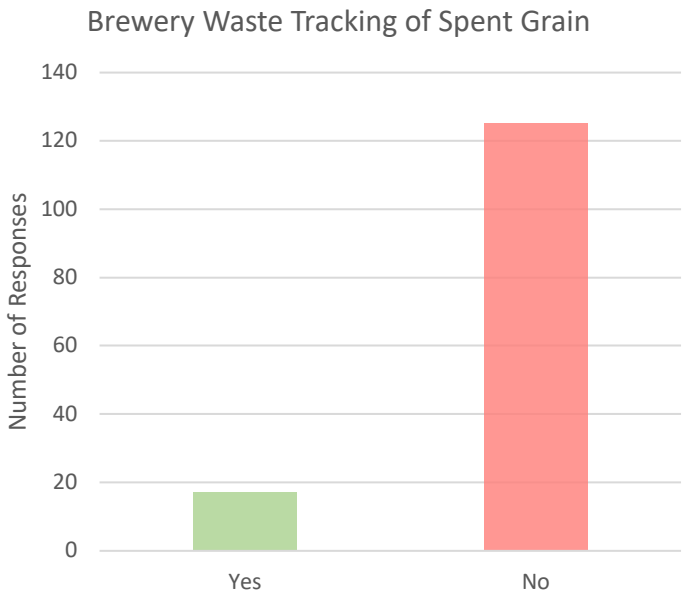

Figure 3.13. Question 6 data chart: does brewery track spent grain volume.

The sixth survey question asked participants if they track the amount of spent grain they produce. Every participant was asked this question in an effort to determine if it's a standard industry practice to track 'brewery output'. Among the 142 participants who answered the question, only 12% measure, weigh, or track their spent grain. The overwhelming number of breweries that don't do this tells us that it's not a standard industry practice therefore we should not expect the Winnipeg craft breweries to have exact spent grain volumes available, meaning that the framework will likely be based on the literature value of 44.09 lbs of spent grain per 100 L of beer brewed. This question was the prerequisite for questions 7-9, therefore only the 17 who measure their spent grain participated in the rest of section 2.

The following question asked participants to disclose the amount of spent grain produced and measured in 2020 and 2021. The data chart from the survey responses indicate that the highest measured volume was 4,850,170 lbs in both years. The lowest recorded volume in 2020 was 5,838 lbs and 3,100 lbs in 2021, with the average measured volumes being 606,041 lbs in 2020 and 515,765 lbs in 2021. While the data is only based on 12 responses, these averages are double the amount calculated from the average production volume found in section 1. 6500 hectolitres of beer are equal to approximately 286,585 lbs of spent grain annually, or 787 lbs/day. An average of 606,041 lbs of spent grain (2020) results from a production volume of roughly 13,745 hectolitres of beer (based on the literature conversion value of 44.09 lbs spent grain per 100 L of beer). The median values have a significantly different volume than the data average, as shown in *Table 6*. In 2020, the median volume was 36,927 lbs of spent grain, corresponding to a production volume of 837 hectolitres of beer, and in 2021 the median of 28,088 corresponds to 637 hectolitres of beer. Neither the average nor the median values indicate if measurement tracking is typically done at a certain sized brewery as the values correspond to a large range of production volumes. For the framework development, this means that spent grain measurement can be done at any and all the involved breweries.

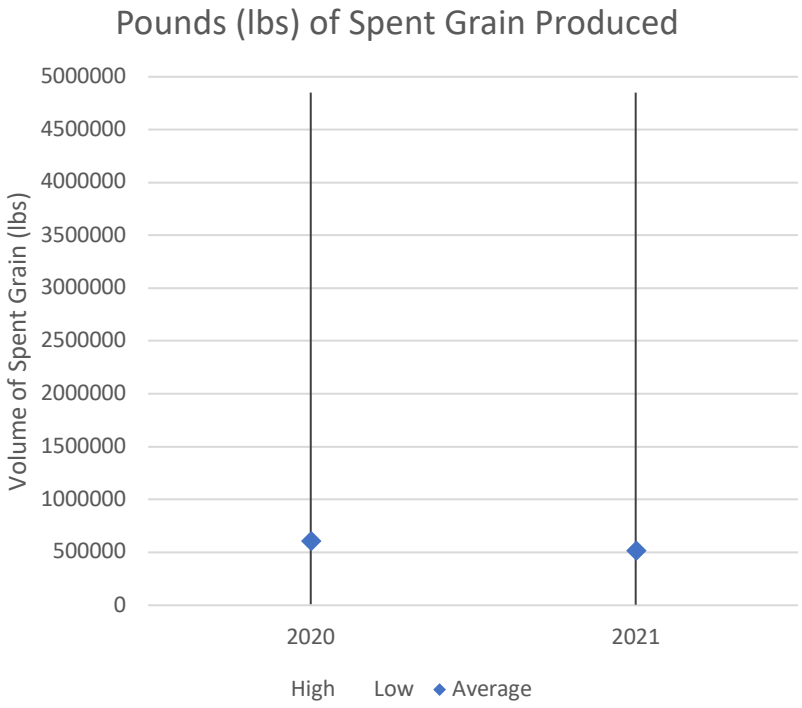

Figure 3.14. Question 7 data chart: Pounds (lbs) of spent grain produced with the average marked with a blue diamond and the full response range marked with a black line.

Table 3.6. Survey data for question 7 Data Chart with calculated average and median shown among the highest and lowest response.

2020	2021
5838	7506
18,200	19,800
857,598	948,164
0	13,640
4,850.170	4,850,170
35,274	36,376
0	3,100
165,347	178,574
14,771	17,527
8,500	8,500
38,581	44,092
66,138	61,729
(Average) 606,041	515,765
(High) 4,850,170	4,850,170
(Low) 5,838	3,100
(Median) 36,927	28,088

Table 3.7. High, low, and average measured pounds (lbs) of spent grain in 2020 and 2021 from the Question 7 data chart (*Table 3.6*).

	2020	2021
High	4,850,170	4,850,170
Average	606,041	515,765
Median	36,927	28,088
Low	5,838	3,100

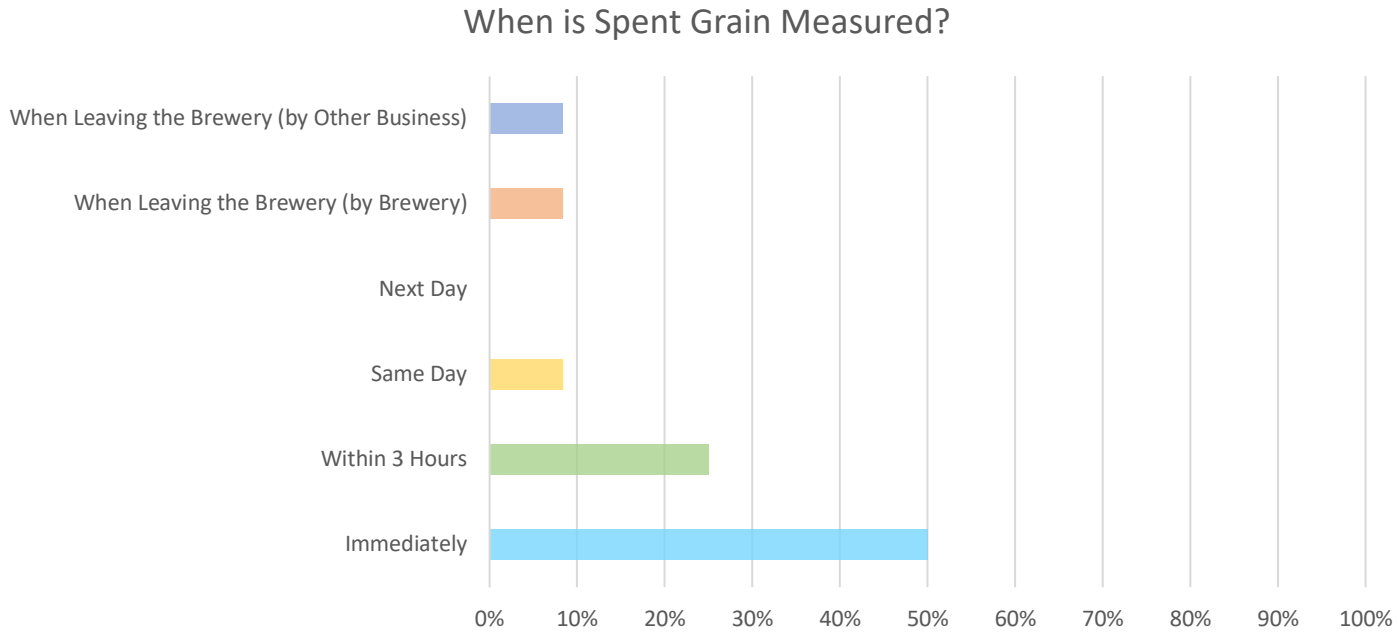

Figure 3.15. Question 8 data chart: Time range at which spent grain is measured post removal from mash tun.

Question 8 provided a selection of answers to the question of *'When is spent grain measured?'* Of the 12 responses, 50% (6 participants) indicated that it is measured immediately after being removed from the mash tun. 25% (3 participants) answered 'within 3 hours', and the remaining 3 participants specified that they measure on the same day, 'when leaving the brewery (by brewery)', and 'when leaving the brewery (by other business)'. If the responses to question 8 had been associated to the volumes provided in question 7, there would have been a slight indication of the spent grain moisture content, therefore pertaining to the consistency and accuracy among volume measurements. While this is not the case with the survey, consistency and accuracy of measurements will be important in the final framework development, especially if there is a financial transaction involved. Another insight provided with this data is whether or not the corresponding breweries have equipment or systems for tracking spent grain. It's clear that one brewery, who's spent grain is measured by the company removing it, does not have the equipment to measure their spent grain but uses the removal company as a system for tracking, while the remaining 11 breweries have equipment and/or systems for tracking. The third hint we've obtained from this question is the relative importance/urgency placed on the actual measurement. It's assumed that tracking the volume of spent grain is done for a reason (financial, storage space, reporting, etc.), the timing of measurement could be for a different reason (convenience, staff availability, etc.). For the development of the framework, it's of use to know that the timing of measurement appears to not be urgent and can be planned according to convenience.

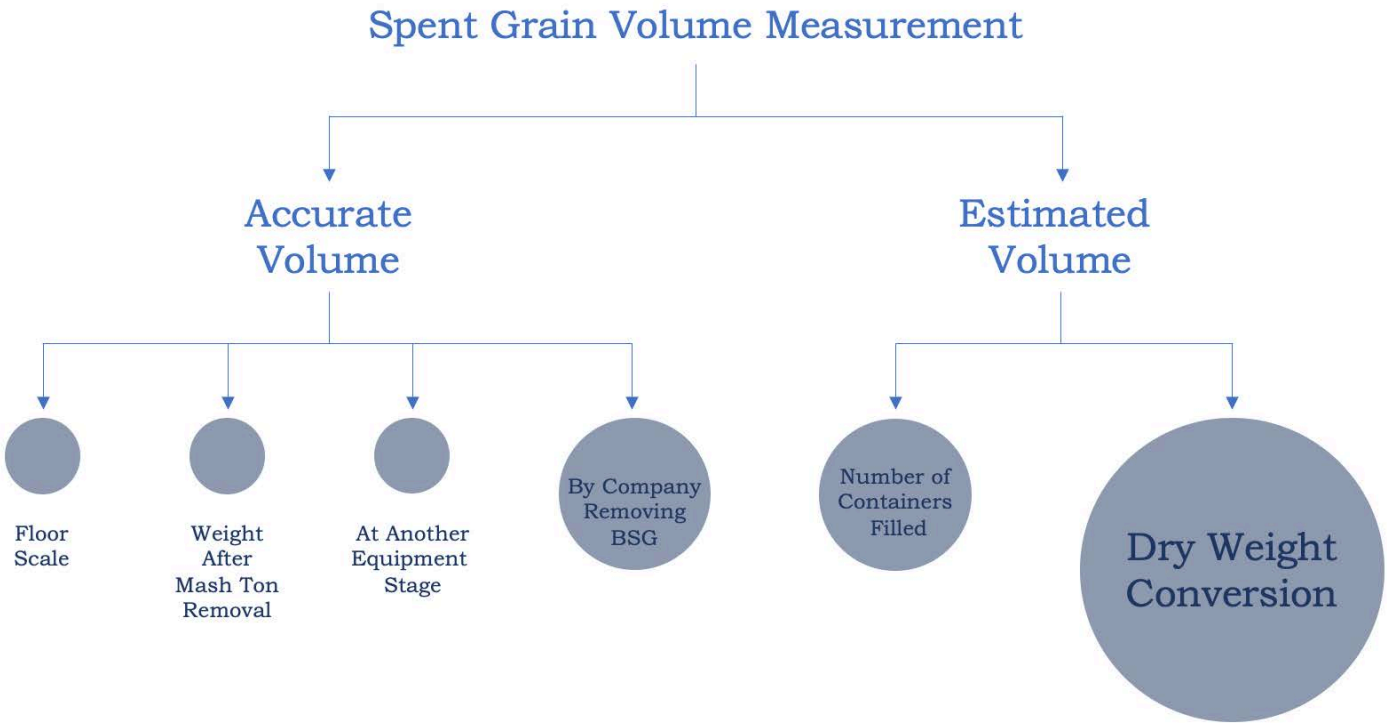

Figure 3.16. Question 9 data chart: Graphed data representing spent grain measurement type with the circle size representing the number of similar responses.

Question 9 addresses questions of consistency and accuracy of spent grain measurement techniques, as well as the associated *'How?'* of tracking. The measurement techniques were grouped into two overarching categories, accurate and estimated, and were further defined within the grouping. It's clear that most spent grain measurement is done with a dry weight conversion of the batch ingredients. A second weight estimate is done by counting the number of containers/totes filled and multiplying by a weight. The accurate volumes seem to be less common and are done by (1) the company removing the spent grain, (2) at the beginning of a different equipment stage, (3) weighing after removal from the mash tun, and (4) with a floor scale. The popularity of estimated weights indicates that accuracy is not of high importance with spent grain measurement.

Section 2 Data Conclusions

The questions in section two address brewers spent grain in terms of measurement and/or tracking in some form. This is an important consideration in the final framework development when considering spent grain as a valuable food ingredient. The responses obtained from the four questions generally indicate that measurement of spent grain is not a priority of craft breweries. The first indication is that of 142 responses, only 12 breweries measure their spent grain. Of the 12 that do, the responses tell us the following:

Among all sizes of craft breweries in Canada, only a small portion track their spent grain, usually with a dry ingredient conversion and usually immediately after emptying the mash tun.

The above generalization might have been expected as the preliminary research and literature review found that spent grain is typically viewed as a burden of a waste product due to multiple factors. With upcycling being a relatively new term and concept for 'food waste' it is then also expected that (1) craft breweries are not yet all familiar with the potential of their production's by-product, and (2) establishing a process for upcycling spent grain is not something that happens overnight and not every brewery has the same opportunity to make that decision.

The generalized data from this section leads to the conclusion that the measurement of spent grain can be measured/tracked in whatever way is most convenient and efficient for this exact framework, meaning the level of importance can be decided on. The data received hints at the fact that the accuracy of the actual measurement is not of high importance but it's likely that the decision of accuracy will therefore be based on the framework's financial model.

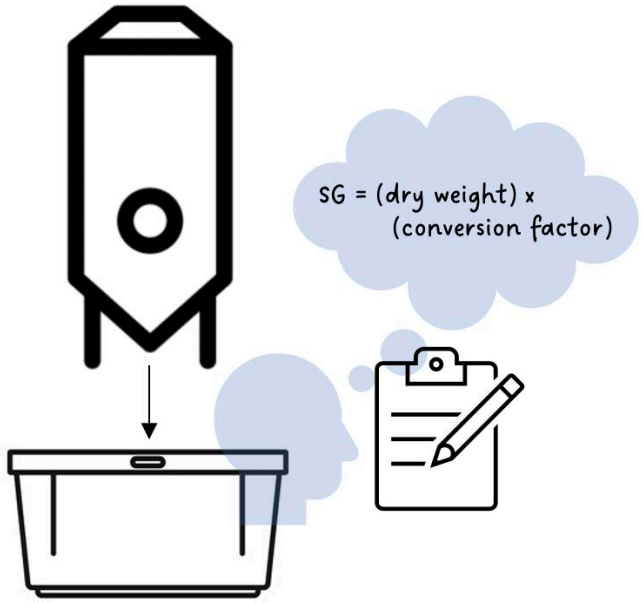

Figure 3.17. Representation of Section 2 data conclusions relating to brewers spent grain.

Survey Section 3: Upcycling Spent Grain

The third portion of the survey was developed to understand more detailed information regarding upcycling spent grain among Canadian craft breweries. The following thirteen questions were asked of participants:

10. *Does this brewery currently upcycle it's spent grain?*
11. *Has this brewery considered upcycling it's spent grain?*
12. *Are you planning on implementing upcycling activities in the following time frames:*
13. *What percentage of this brewery's spent grain is upcycled regularly?*
14. *Are there any beer styles that are intentionally not upcycled?*
15. *What style(s) of beer are excluded from upcycling? Briefly explain why.*
16. *What are all the human food products that incorporate/use this brewery's spent grain?*
17. *Does this brewery have a restaurant or brewpub associated with it?*
18. *Do you upcycle spent grain at your own restaurant/brewpub?*
19. *What is the name of the business/company that upcycles your brewery's spent grain?*
20. *Do you pay to have spent grain removed from the brewery/property?*
21. *How much does it cost to have spent grain removed from your brewery/property?*
22. *How much do you get paid for your spent grain by the business/company removing it?*

Table 3.8. Section 3 (Question 10-22) response statistics.

	Answered	Skipped	Total Possible
Question 10	137	31	168
Question 11	60	27	87
Question 12	30	0	30
Question 13	114	24	138
Question 14	116	22	138
Question 15	9	0	9
Question 16	92	46	138
Question 17	108	30	138
Question 18	55	1	56
Question 19	69	69	138
Question 20	131	37	168
Question 21	23	40	63
Question 22	113	55	168

Question 10 kicks off section three with determining who currently upcycles their spent grain. This question purposefully did not specify upcycling to human food products though that is the focus of this project. Upcycling is defined as adding value to the product meaning the value is subjective. For example, some breweries may not have the opportunity to upcycle spent grain to human food products, but they have access to composting options. In that case composting may be the highest value for the brewer's spent grain and is certainly better than just throwing it away. A different brewer may have the opportunity to upcycle their spent grain to human food products, in which case that would be considered the highest value. A total of 81 participants indicated that they do upcycle their spent grain.

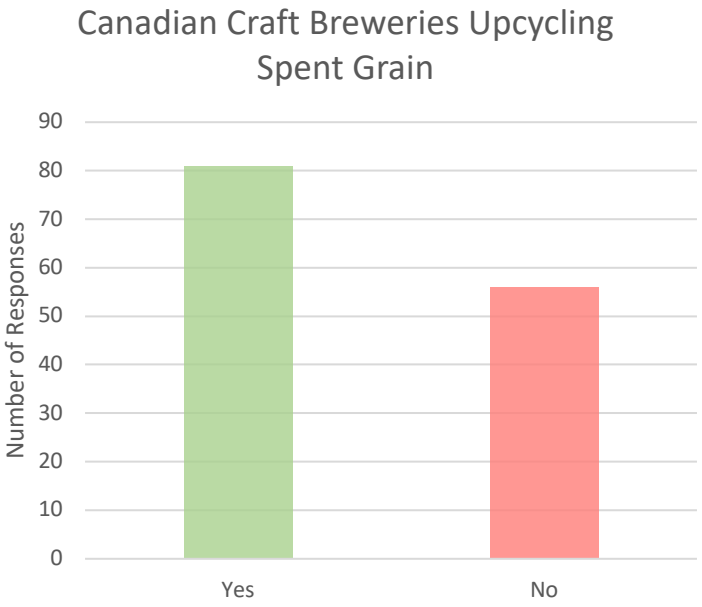

Figure 3.18. Question 10 data chart: Number of Canadian craft breweries upcycling spent grain.

Question 11 was directed at those who answered no to question 10 and found a balance between those considering and not considering upcycling their spent grain. This balance may be the result of one or many factors, but it serves as an estimate of what we might expect from the Winnipeg craft brewers while developing the framework. If we assume that the average craft brewery is the model found in section 1, and we estimate that half the breweries would consider upcycling their spent grain, we then have a rough estimate of the spent grain volume available as input and/or needing to be processed on a regular basis. Equipment selection will largely depend on the available spent grain volumes as the framework intention is to be zero-waste.

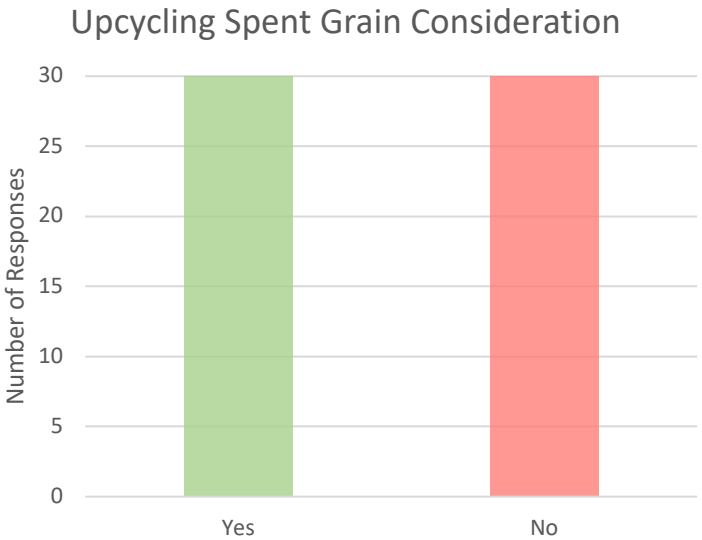

Figure 3.19. Question 11 data chart: Number of Canadian craft breweries considering upcycling their spent grain.

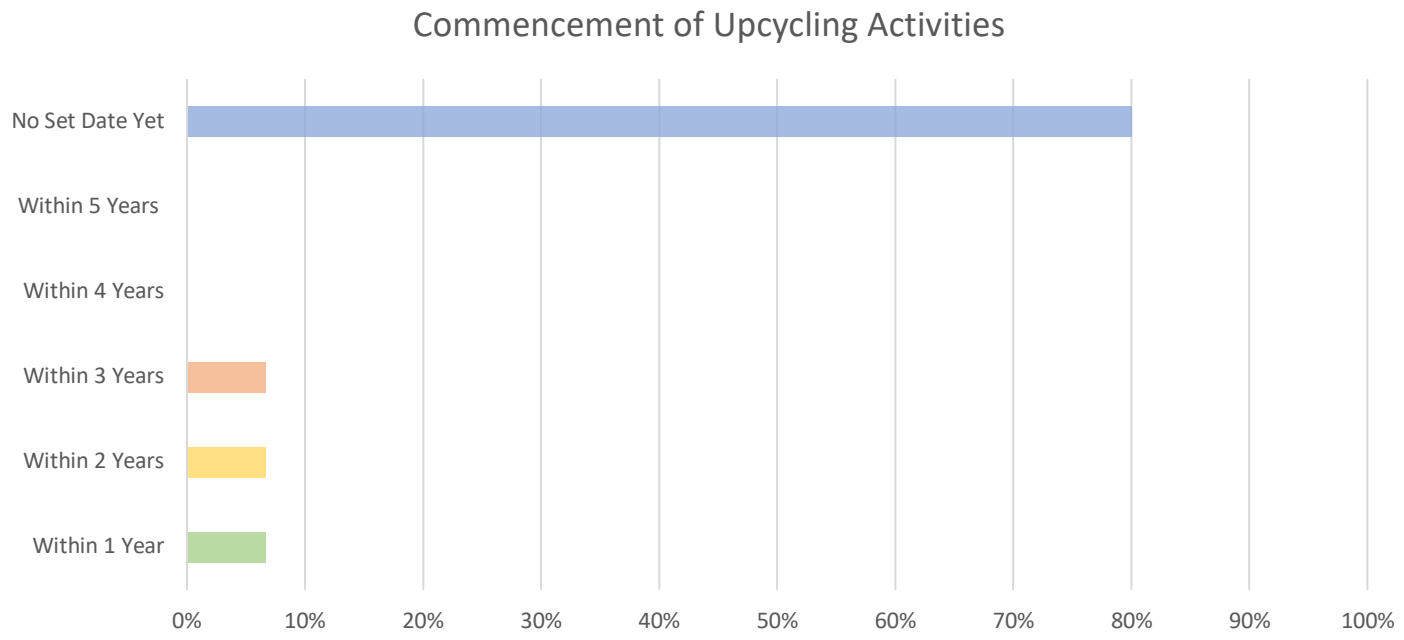

Figure 3.20. Question 12 data chart: Percentage of breweries and the associated projected commencement of spent grain upcycling activities in years.

Question 12 adds depth and detail to the previous question by asking participants to disclose their projected timeline of implementing upcycling activities. As this project is researching upcycling spent grain in Winnipeg, there is technically a consideration with no set date meaning the potential participants currently sit with the majority of respondents on this matter (unless they're currently upcycling in other ways). The above responses indicate that 20% of Q12 participants have time frames, thus have found/been provided with an opportunity to add value to their by-product. While 20% is not a huge number, it tells us that the 'spent grain upcycling industry' is in fact growing and gaining popularity which makes this an exciting project for brewers. The framework becomes of growing importance with the current food trends in three primary ways:

1. As of 2019, the Canada Food Guide is recommending a higher portion of protein intake from fruits and vegetables and to eat more whole grain foods (4) as shown in *Figure 1*. Spent grain is high in protein and fibre and can add nutrition to any food product it's incorporated into.
2. After the public introduction of the new food guide, there's been an increasing number of plant-based protein products on the market.
3. On November 16, 2022, the U.S. Food and Drug Administration (FDA) completed the first pre-market consultation with Upside Foods (5) and has found the product safe for human consumption (6).

While this question is based on a small data set, those 3 reasons alone indicate there's a shift in the food industry happening, particularly in moving away from eating farmed animals. This would suggest that it would be wise to stay ahead of the curve and find a higher value for spent grain before the 'animal feed' is potentially not an option. Apart from the feel-good sensation of reducing food waste and becoming part of a sustainability movement, the beneficial environmental impacts of switching to a plant-based diet have been studied multiple times which we'll review in the data conclusions of this report.

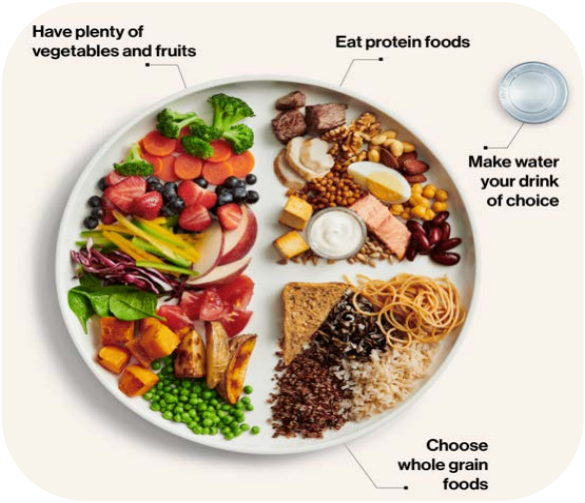

Figure 3.21. The 2019 Canada Food Guide Plate (4).

Participants were asked to disclose the percentage of spent grain that was upcycled from their brewery on a regular basis in question 13. The following graph includes data from participants who answered yes to question 10 (indicating that they currently upcycle spent grain) and participants who skipped questions, assumed to be at minimum the 29 participants who answered 0% to this question. Not including the 0% responses, the graph shows a total of 85 participants who regularly upcycle spent grain, 70 of which indicated they upcycle 100% regularly. One participant indicated they upcycle 98% of their spent grain regularly, one upcycles 10%, four participants upcycle 5%, three upcycle 2%, and six participants upcycle 1% of their spent grain on a regular basis. From the graph we see that craft breweries either upcycle a small portion or almost all of their spent grain, with no responses at an in-between value. The lower values might suggest that breweries are experimenting with their spent grain and/or trying to find new uses but do not have a demand, while the higher values suggest that the upcycling activities use the entire supply. In the development of the framework, the higher values suggest two key considerations. First, the breweries choosing to upcycle their spent grains should feel confident that they have reliable spent grain removal and do not need to find secondary management strategies. Second, all of the spent grain collected must be upcycled in some way.

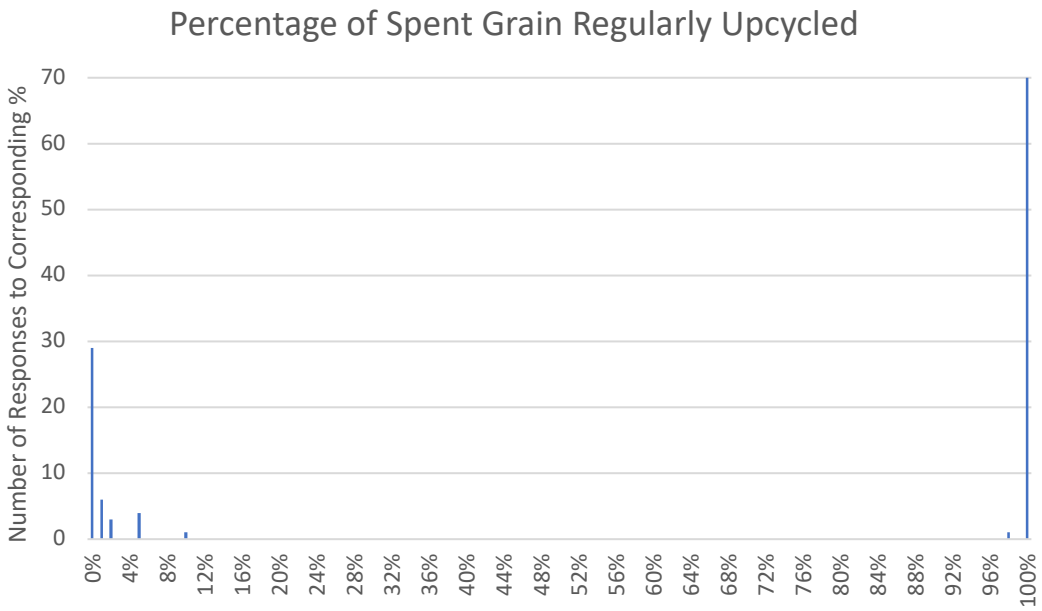

Figure 3.22. Question 13 data chart: Percentage of individual brewery's spent grain regularly upcycled as reported by survey participants.

Table 3.9. Survey data for question 13 Data Chart.

% Upcycled	# Responses
0%	29
1%	6
2%	3
5%	4
10%	1
98%	1
100%	70
	114

The results from question 14 both compliment and correspond to the data from the previous question. Of 116 responses, only 8 participants indicated that they exclude some beer styles from upcycling, thus validating that 70 participants actually do upcycle 100% of their spent grains but does not clarify the low values on question 13. Further details from the 'yes' participants are asked in the next question. For the Winnipeg upcycling framework, the response data further supports the conclusion that upcycling 100% of participating craft brewery's spent grain is possible and is actually being done in other parts of the country. In section 1 we found that the average brewery brews 17-20 different beer styles annually but this shouldn't be a barrier as there's upcycling potential for it all.

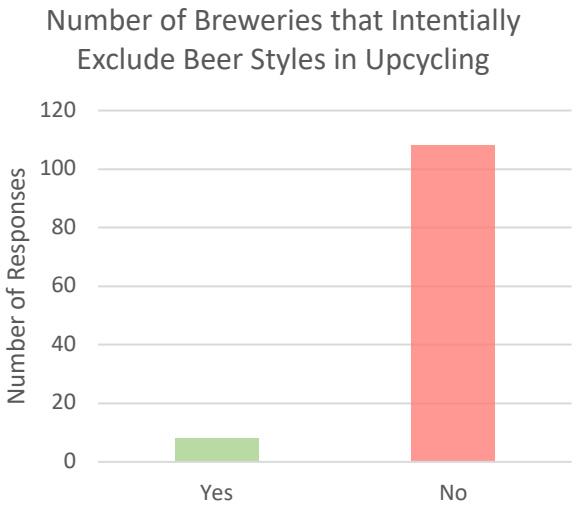

Figure 3.23. Breweries who intentionally exclude beer styles from upcycling.

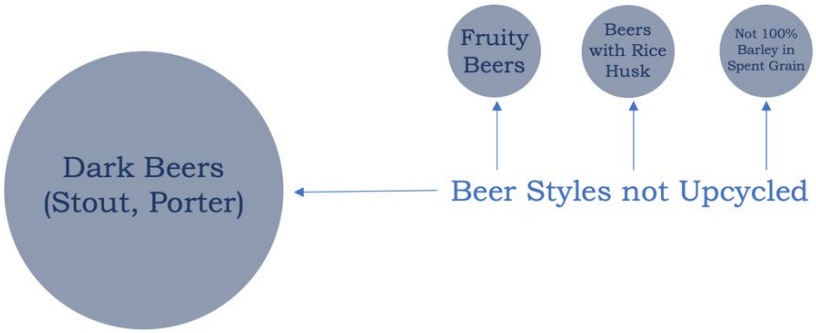

Figure 3.24. Question 15 data chart: Beer styles intentionally not upcycled with the circle size representing the number of similar responses.

Question 15 was only available to those who answered yes to the previous question with the intent on clarifying which beer styles were excluded from upcycling and why. *Table 10* provides participants original responses corresponding to the data chart. From the eight responses, three were identified as "dark beers", one as "fruity beers", one as "beers with rice husk", and one as "not 100% barley".

In the dark beer grouping, participants refer to the roasted grains as the reason for upcycling exclusion with one specifically referring to the end use of spent grain in "crackers, bread, and dough, which are all light-coloured items". From preliminary research and literature review, we know that darker malts add a noticeable amount of colour to light-coloured food products as well as a variety of flavours that may not be complimentary or expected of those products.

The 'not 100% barley' group was reasoned as "the person upcycling our spent grain won't take anything with roast or crystal malts or anything other than barley". As the upcyclers reason for this is not addressed here, it's reasonable to assume that it may be related (but not limited) to final product consistency, final product nutritional labeling, or some extension of consumer food demands. The explanations for the 'fruity beers' and 'beers with rice husk' are not clear but in all categories, it's assumed that the beer styles are mixed in the final upcycled product if the sensory characteristics are of concern.

This question provides data of specific interest to equipment selection in the framework development, particularly in choosing a continuous or batch-style process. The isolated data from this question would suggest a batch-style process could eliminate mixing spent grain varieties all-together and better control final product consistency, or some spent grain varieties would be excluded or processed separate from the upcycled human food product in maintaining consistency through a continuous process. However, as 93% of breweries don't exclude any beer styles in upcycling (question 14), the Winnipeg framework should be capable of upcycling all spent grain varieties in some way that's of higher value than sending it to landfill.

Table 3.10. Original participant responses and associated data grouping for *Question 15 Data Chart* stating which beer styles are excluded from upcycling and why.

Beer Style Grouping	Participant Responses
Fruity Beers	Some of the seasonal ales due to extra fruit or potatoes
Dark Beers	Dark beers (stouts, porters, etc.) We're going to use the spent grain in crackers, bread, and dough which are all light-coloured items. If we start making dark breads (rye, pumpernickel etc.), we could then start utilizing
(Style Unclear)	We upcycled two styles, as our capacity to upcycled is limited and primitive, we upcycle a dark lager, and a sweeter pilsner grist. We only pull spent grain from the middle of the grist and never scrape the protein etc from the top of the mash.
Beers with Rice Husk	styles of beer which contain rice hulls in the grist (typically beers with large amounts of wheat, flaked grain, or other adjuncts
(Style Unclear)	We have a small batch system for 100L. We don't upcycle these grains.
Not 100% Barley	Anything that isn't 100% base malt barley, the person upcycling our spent grain won't take anything with roast or crystal malts or anything other than barley
Dark Beers	Stout - too much roasted grains
	Hefeweizen - rice hulls are used as a filter aid
Dark Beers	Brews with dark roasted malt are not upcycled because we use the spent grain to make dog biscuits.

The preliminary project research outlines a variety of human food products capable of successfully incorporating upcycled spent grain while maintaining positive consumer acceptance scores. Of those products, the most common are bakery foods where spent grain is in flour form (dried and milled) and incorporated as part of a flour mixture. This question is designed to compare theoretical uses for spent grain with actual practice. While further research is needed, the data is valuable for equipment selection and process design for the Winnipeg upcycling framework.

From the question 16 data chart we see that bread is the most common human food product in which spent grain is incorporated into. Crackers and pizza dough are the second most popular, and a variety of mostly baked goods were also mentioned. Mustard was an interesting answer as this was not seen in the background research but expands spent grain potential for this project. The baked goods listed below are most likely using upcycled spent grain in flour form, but a few answers (granola, snack mix, bread) could potentially use spent grain in dried and whole form. In terms of equipment selection, the framework will require a dryer (onsite) and milling (either onsite or contracted with existing grain millers) most likely depending on factors such as (but not limited to) whole-milled ratio of final product, environmental impact of framework options, equipment price and operational costs.

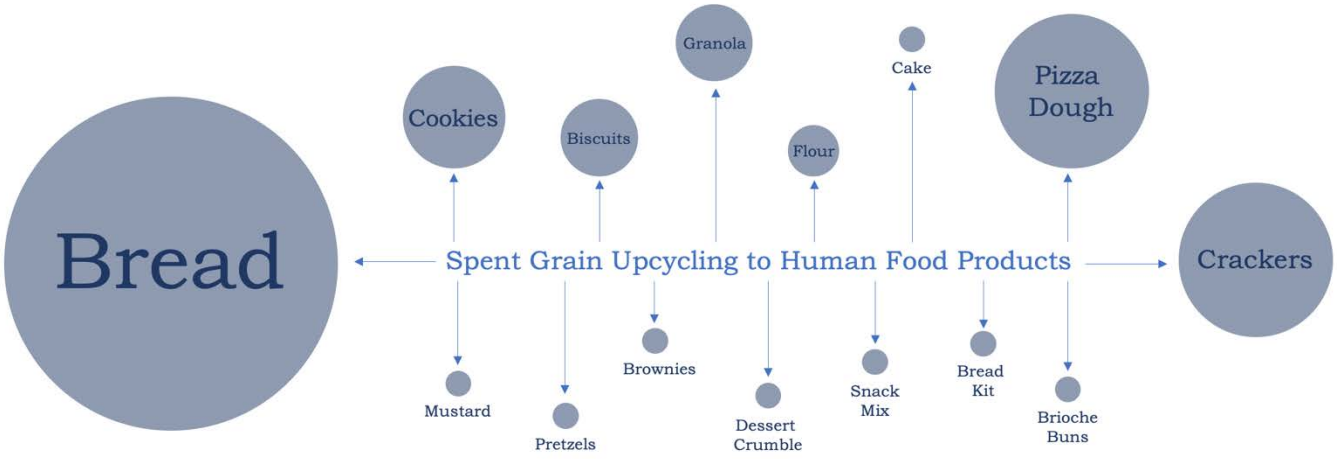

Figure 3.25. Question 16 data chart: Foods that spent grain are upcycled to as reported by survey participants, with the increased number of same responses represented by increased circle size.

Question 17 specifically assesses if there is opportunity of upcycling onsite at participating Canadian craft breweries. Restaurants and brewpubs are most likely going to serve food products capable of incorporating upcycled spent grain and would greatly reduce the barriers of transporting the high moisture ingredient for processing. 108 responses were collected for a ratio of 56 breweries that do have an associated restaurant/brewpub and 52 that don't. If the following data is representative, it suggests that just under half of the craft breweries in Winnipeg have restaurants and/or brewpubs that can use the upcycled spent grain. The potential merits consideration of onsite upcycling of the wet spent grain as well as offsite processing to a new food product the brewery can use in its food (such as a flour with multiple uses).

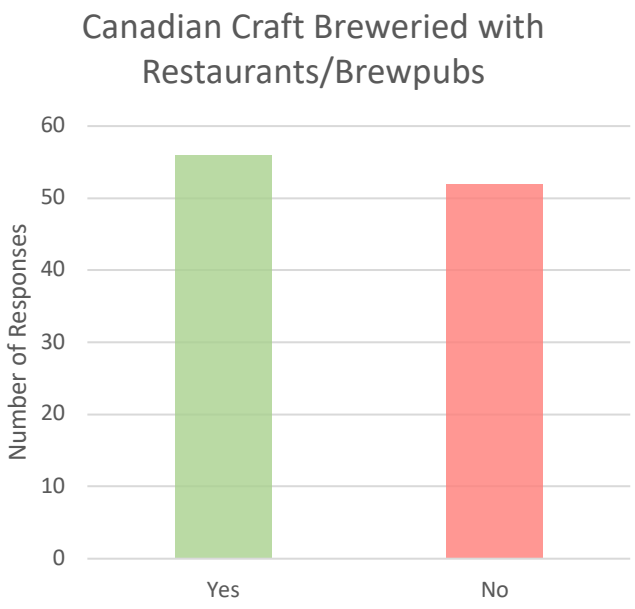

Figure 3.26. Question 17 data chart: Craft breweries with restaurants/brewpubs.

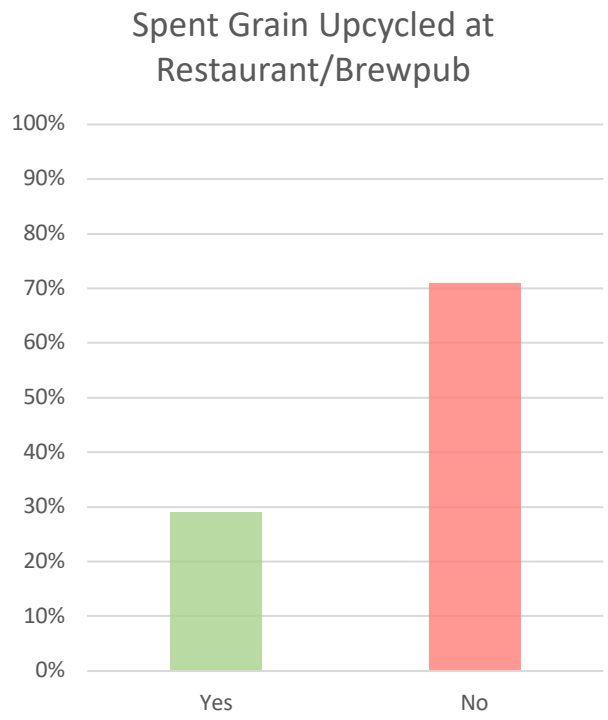

Figure 3.27. Question 18 data chart: Responses indicating if spent grain is upcycled within restaurant/brewpub.

While there are many reasons a brewery might not want or be able to upcycle onsite, it's of interest as to how many have overcome those barriers and are able to. Of the 56 participants that have a restaurant and/or brewpub, only 29% (16 participants) upcycle through their own food products. Despite the low value, it's evident that it's possible and requires thought in the Winnipeg spent grain upcycling framework. The benefit and value of upcycling onsite requires further details related to the spent grain format, the volume requirement/capacity that can be upcycled regularly, equipment requirements and associated operational costs to the brewery, staffing requirements for implementation, etc. Looking back at question 16, it seems as though only pizza dough and bread could incorporate spent grain in wet form, suggesting that these may be the onsite choices for upcycling, or the spent grain is dried and milled before use. Evidently this is not a straightforward yes or no, but the potential is likely present within Winnipeg. Whether or not the potential is the best option will need to be evaluated further.

Question 19 asked participants to name the business/company they upcycle spent grain with. A total of 75 responses were provided by 69 participants. Of those, 37 were unnamed or listed as "local farmer", and 4 of the listed companies were not able to be directly identified due to having the same name as another Canadian business or being part of a chain with multiple Canadian locations. There were 44 identifiable responses from across the country as shown in the question 19 data chart, with 36% in BC and 39% in Ontario, with primary business types summarized below in *Table 11*. The most named business was that of a craft brewery, which could indicate that the respondent is upcycling spent grain onsite or upcycling at another craft brewery. Second was a farm producing non-meat food for humans. Other companies included restaurants/brewpubs, bakeries, food production, other farming, and 'other'. Again, this tells us that craft breweries are upcycling onsite but there are also many other options for upcycling spent grain that can be considered in the framework and be the most convenient, affordable, effective, etc.

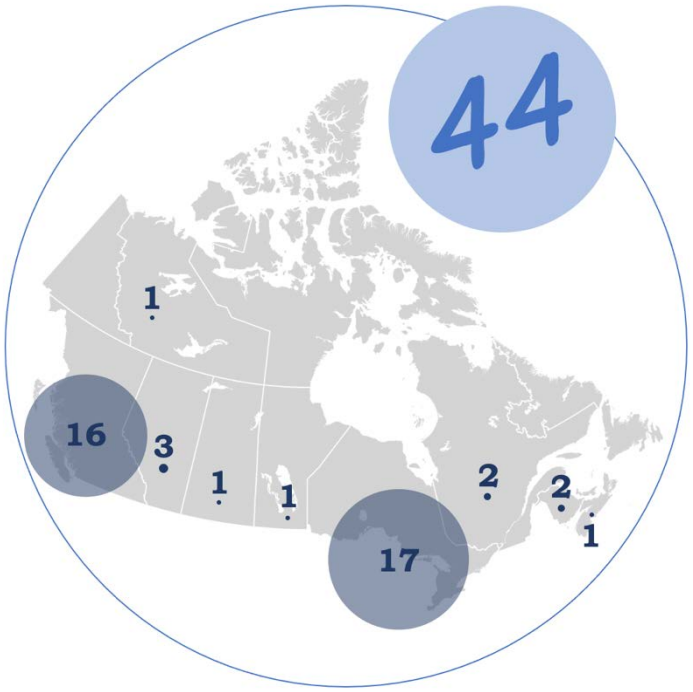

Figure 3.28. The number of identifiable responses of companies/businesses that upcycle spent grain.

Table 3.11. Primary business type of named companies in question 19 identifying where/who breweries upcycle their spent grain to.

	Brewery	Restaurant / Brewpub	Bakery	Food Production	Farm (Meat)	Farm (Dairy)	Farm (Food)	Other
Responses	13	5	3	2	6	2	7	5

The following three questions (20-22) address the financials of managing spent grain. In the development of the framework, it's of interest to know what the common financial exchanges are (if any) of removing spent grain from the brewery thus identifying the 'market value' of the food ingredient to base an approximate value in the framework.

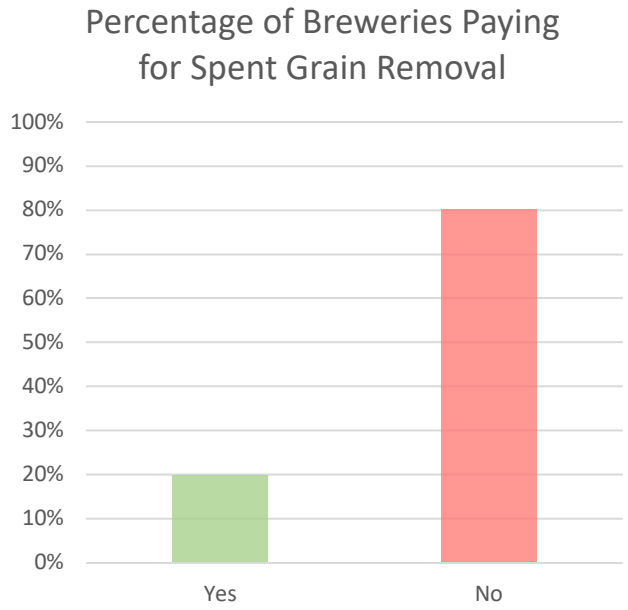

Figure 3.29. Question 20 data chart: Percentage of breweries paying for spent grain removal.

Preliminary project research found that in general, breweries view spent grain as 'a burden to dispose of' for various reasons, with the most common waste management strategies being animal feed, compost, and landfill (7). One reason may be associated to the cost of removal which is an important consideration in encouraging Winnipeg breweries to participate in local upcycling as conventional waste management routes could all have an associated cost but could also not. The survey generated 131 answers with only 19.85% of those breweries paying to have spent grain removed from the property. The data tells us that 4 out of 5 breweries do not pay for spent grain removal, while 1 does. Any number of factors could be determining the associated costs but a no-fee pick-up would appear to be the goal in the framework to remain competitive and encourage breweries to give their grains a second life as a value-added human food product.

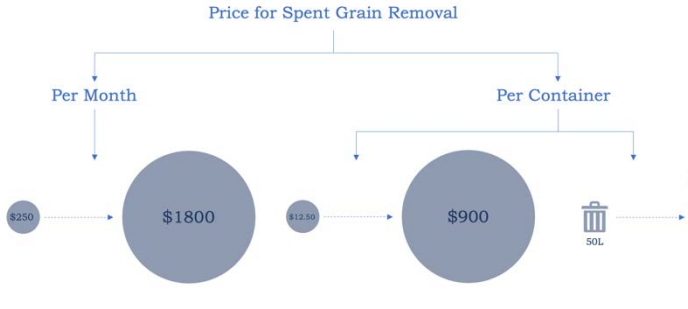

Figure 3.30. Price range of brewery payment for spent grain removal.

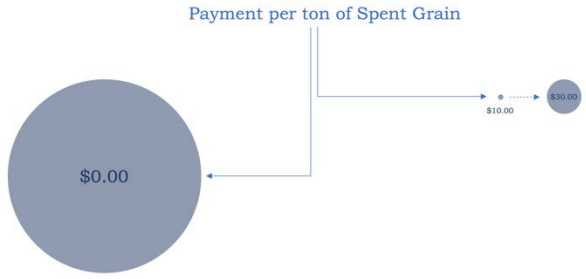

Figure 3.31. Representation of payment to brewery for spent grain.

Question 21 and 22 are very closely related and provide a very important insight when compared. The 26 participants who indicated they pay for spent grain removal were directed to question 21, where 23 participants provided a large range of responses, provided in *Table 12*. The answers were divided into 'price per month' and 'price per container'. The 'per month' prices ranged from $250-1800 and may (or may not) have a volume restriction. The 'per container' responses ranged from $12.50-900 per container with container sizes ranging from 50L to 2000L. The participants who indicated they don't pay for spent grain pickup (as well as all other participants) were directed to question 22 which asked if they were paid for spent grain. It's a possibility that if breweries aren't paying for pickup, they might be getting paid for their spent grain, but this assumption was not accurate. All 168 participants were presented this question and of 113 answers, 2 participants received a monetary payment and 1 received 50lbs of pork chops/bacon annually in exchange as shown in *Table 13*. From the survey data, the industry standard seems to be that the costs of managing spent grain are the responsibility of the brewery despite the end use. While this is understandable if it's going to landfill but if it's going to another use as an ingredient, it's evident that it's not currently seen as a valuable one and remains a 'burden' to the brewery.

Table 3.12. Original participant responses for *Question 21 Data Chart* indicating the amount paid by the brewery for BSG removal.

Price Per Month	Volume Restriction	Price Per Container	Container Size
		$900.00	Dumpster
		$75.00	300L Tub
$360.00	N/A		
		$65.00	1200L Tub
		$12.50	50kg Bucket
		$100.00	100L
$250.00-300.00	N/A		
		$15.00	500kg Tote
		$80.00	Pick-Up
$650.00	30 Bins (270kg)		
		$175.00	Ton
$1800.00	N/A		
$250.00	N/A		
		$55.00	m^3 tote
$650.00	N/A		
		$17.89	1 m^3 bin
		$75.00	2000 L Tub

Table 3.13. Original participant responses for *Question 22 Data Chart* indicating the amount paid to the brewery for spent grain.

Number of Responses	Payment for Spent Grain	Volume for Payment
109	$0.00	Any
1	Donation	Any
1	$30.00	Metric Tonne
1	$10.00	Tonne
1	50 lbs Pork Chops and/or Bacon	(Annually)

The financial exchange between the brewery and upcycling activity/business is an important part of the Winnipeg upcycling framework for a variety of reasons affecting the breweries, upcycling business/activities, and the final customers. Questions 21 and 22 were intended to act as a starting point and reference. From the combined data we know that of 168 Canadian craft breweries 110 experience no financial exchange for spent grain removal, 23 breweries pay to have it removed, and 3 receive a form of payment for their spent grain.

The fees for spent grain removal are highly varied and appear be very expensive for the brewery. Factors affecting the significance of the cost to the brewery boil down to the price per unit and the production volume of the brewery. While the data in questions 21 and 22 are not linked to the production volumes of the brewery, we don't know how many containers the breweries are needing to have removed and how much the monthly-charged breweries are producing to have been offered a set price and therefore don't have an average price-per-unit. What we do know is that the majority of breweries have free pickup of their 'wastes' and some pay for removal, which really points to the fact that spent grain is not a valued ingredient. This is highlighted by the fact that only 2 breweries are paid for their spent grain at a price that's significantly lower than any of the fees to have it removed.

Upcycling is defined as adding value to a food product conventionally seen as waste. Questions 21 and 22 highlight that spent grain is clearly not seen as a valuable product in industry, as evident with the financials listed in *Table 12* and *Table 13*. Specifically for the Winnipeg framework, it's important that value is added to spent grain in every way possible including the initial financial transactions of acquiring the ingredient for upcycling whether paid or free. Careful financial assessment is also important in creating a final product that's attractive and affordable to customers.

Section 3 Data Conclusions

The questions in section three address general information about upcycling among Canadian craft breweries spent grain. This is an important consideration in the final framework development when considering spent grain as a valuable food ingredient in a variety of ways. The 13 questions aimed at understanding upcycling provide us with the following generalization to consider in the Winnipeg upcycling framework:

Most breweries are upcycling spent grain in some way, and half of those who are not currently doing so are considering it. For the breweries who are, 100% of their spent grain is usually upcycled, most likely in house, to a bakery food product of some sort, or to a farm. It's rare to exclude beer styles, and even more rare to receive payment for spent grain. Most breweries have it picked up for free, but if not, it's likely to cost the brewery a non-standard fee determined by the pick-up company.

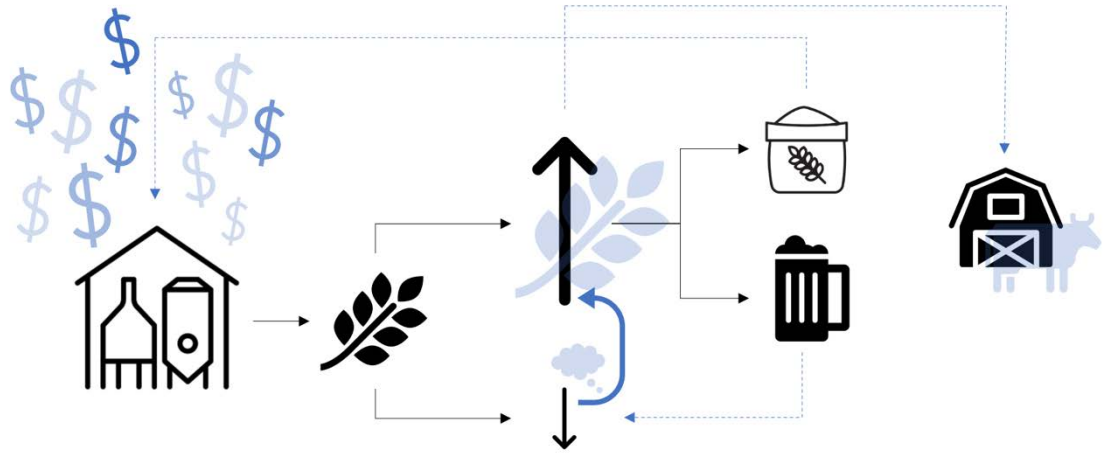

Figure 3.32. Representation of Section 3 data conclusions relating to current upcycling of spent grain in Canada.

The data in section three really highlights the current market value for spent grain as 'a burden to get rid of'; corresponding to what was found in the projects preliminary research and literature review. If farmers are relying on spent grain to feed their animals, it seems as though they are getting the most value from the ingredient, but if they are taking it as a favour to the breweries and trying to make use of it, it would then be the breweries benefitting most of the current situation with free pickup. It might also be that both are true in different places.

Question 10 had 81 participants indicate that they upcycle their spent grain, but only 69 participants named the company their upcycling to in question 19 where it was found that only 23 of the named companies were for human food uses. Question 19 emphasizes that upcycling (adding value) can be defined in many ways, which might just mean 'not going to landfill' in the brewing industry at the point in time. The framework needs to clearly redefine what value-added means in a time of climate and dietary change as it's obvious that brewers spent grain has a high potential.

In adding value to spent grain, the framework might consider offering a payment for spent grain as an ingredient or a reliable and consistent pick-up service at no charge to encourage participation. These considerations must be tailored to the framework and can be assessed post-interviews but might be of value to secure spent grain supply in upcycling efforts and move more breweries from 'considering upcycling' to 'actively upcycling'. The framework must also consider the farmers that rely on the spent grain for feed as to not upset the transition and movement of food ingredients. Question 13 also makes it clear that the Winnipeg framework needs to develop a system where brewers have reliable pick-up for all spent grain and doesn't leave them in a situation of needing to find another waste-management option no matter how creative they get with finding beer styles that consumers are willing to pay them for. As the entire project is focused on sustainability and reducing food waste, it only makes sense to have a zero-waste policy in upcycling brewers spent grain.

Survey Section 4: Spent Grain Waste Management

The final survey section has a total of one question that was intended to generate an overview of the final destination of spent grain generated from craft breweries in Canada. The following question was asked to participants:

23. *What percentage of this brewery's total spent grain volume is disposed of in the following ways (Must add up to 100%):*

Table 3.14. Section 4 (Question 23) response statistics.

	Answered	Skipped	Total Possible
Question 23	127	41	168

Section 4 included a total of one question to summarize where spent grain is going in Canada after leaving craft breweries. It's of interest to us, with spent grain upcycling being relatively new to industry, to know what the full potential of this industry is, especially with the variety of industry changes happening because of climate change. Of 168 possible answers, 127 breweries indicated what percentage of their spent grain regularly goes to ruminant feed, compost, landfill, upcycling, and other uses, and is summarized in *Table 14*.

The question 23 data chart provides a snapshot of spent grain waste management strategies across Canada. While 127 participants represent only 10.8% of Canadian craft breweries, it's clear that the upcycling industry has a large volume potential, especially if/as more people adopt plant-based diets and move away from farmed meat. While the data does not divide ruminant end use (for example the number of dairy cows for milk, cows for meat, sheep for wool, pigs for meat, etc.) most animals farmed would decrease as a whole in that situation and virtually eliminate the ruminant feed route all together. It's of interest to breweries to consider staying ahead of this trend and find a higher value for their spent grain.

It's a relief that an average of only 1.54% of spent grain goes to landfill as per the survey results. As found in the initial project research, global food waste is estimated to be 30% of all food grown but the brewing industry has found waste management strategies that have greatly reduced their industry's food waste.

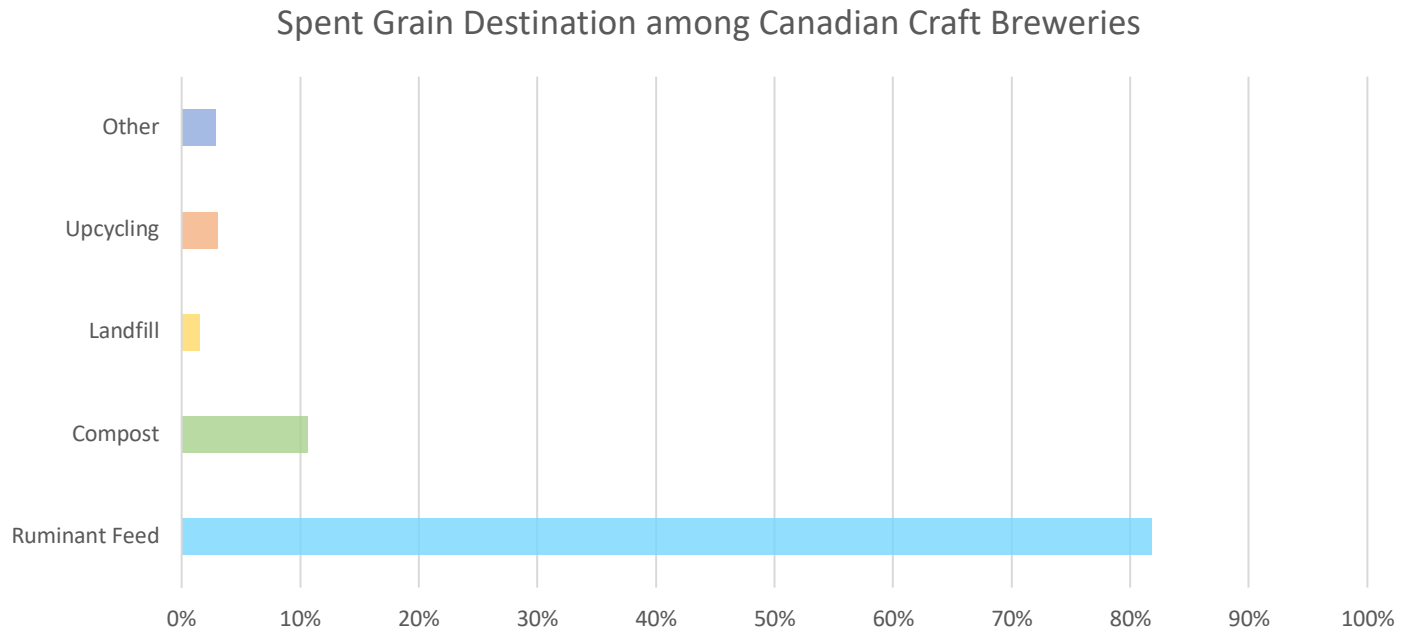

Figure 3.33. Question 23 data chart: Percentage of total spent grain volume destined to associated waste management strategies among Canadian craft brewers.

Table 3.15. Original participant responses from Question 23 detailing the percentage of spent grain destined to the associated waste management strategies per individual brewery.

Ruminant Feed	Compost	Landfill	Upcycling	Other	Sum of Responses
0.00	0	0	0	100	100.00
95.00	0	0	5	0	100.00
0.00	0	0	0	100	100.00
0.00	100	0	0	0	100.00
99.00	0	0	0	1	100.00
100.00	0	0	0	0	100.00
100.00	0	0	0	0	100.00
80.00	0	0	20	0	100.00
99.00	0	0	1	0	100.00
100.00	0	0	0	0	100.00
100.00	0	0	0	0	100.00
100.00	0	0	0	0	100.00
99.00	0	0	0	1	100.00
100.00	0	0	0	0	100.00
100.00	0	0	0	0	100.00
5.00	25	0	2	68	100.00
100.00	0	0	0	0	100.00
100.00	0	0	0	0	100.00
0.00	100	0	0	0	100.00
100.00	0	0	0	0	100.00
100.00	0	0	0	0	100.00
100.00	0	0	0	0	100.00
0.00	100	0	0	0	100.00
100.00	0	0	0	0	100.00
100.00	0	0	0	0	100.00
100.00	0	0	0	0	100.00
95.00	5	0	0	0	100.00
100.00	0	0	0	0	100.00
100.00	0	0	0	0	100.00
100.00	0	0	0	0	100.00
90.00	0	0	10	0	100.00
90.00	0	0	10	0	100.00
100.00	0	0	0	0	100.00
100.00	0	0	0	0	100.00
100.00	0	0	0	0	100.00
100.00	0	0	0	0	100.00
100.00	0	0	0	0	100.00
0.00	0	99	1	0	100.00
95.00	0	0	5	0	100.00
0.00	100	0	0	0	100.00
100.00	0	0	0	0	100.00
0.00	98	0	2	0	100.00
100.00	0	0	0	0	100.00
100.00	0	0	0	0	100.00
100.00	0	0	0	0	100.00
80.00	20	0	0	0	100.00
80.00	20	0	0	0	100.00
100.00	0	0	0	0	100.00
97.00	2	1	0	0	100.00
99.00	0	0	1	0	100.00
80.00	20	0	0	0	100.00
100.00	0	0	0	0	100.00
100.00	0	0	0	0	100.00
90.00	5	0	5	0	100.00
0.00	0	0	100	0	100.00
100.00	0	0	0	0	100.00
0.00	100	0	0	0	100.00
100.00	0	0	0	0	100.00
100.00	0	0	0	0	100.00
80.00	20	0	0	0	100.00
100.00	0	0	0	0	100.00
100.00	0	0	0	0	100.00
100.00	0	0	0	0	100.00

	100.00	0	0	0	0	100.00
	0.00	0	0	100	0	100.00
	98.00	2	0	0	0	100.00
	20.00	80	0	0	0	100.00
	80.00	20	0	0	0	100.00
	95.00	0	0	5	0	100.00
	100.00	0	0	0	0	100.00
	100.00	0	0	0	0	100.00
	100.00	0	0	0	0	100.00
	90.00	10	0	0	0	100.00
	0.00	100	0	0	0	100.00
	100.00	0	0	0	0	100.00
	100.00	0	0	0	0	100.00
	100.00	0	0	0	0	100.00
	80.00	20	0	0	0	100.00
	100.00	0	0	0	0	100.00
	100.00	0	0	0	0	100.00
	100.00	0	0	0	0	100.00
	75.00	25	0	0	0	100.00
	100.00	0	0	0	0	100.00
	100.00	0	0	0	0	100.00
	100.00	0	0	0	0	100.00
	98.00	0	0	2	0	100.00
	100.00	0	0	0	0	100.00
	100.00	0	0	0	0	100.00
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	100.00	0	0	0	0	100.00
	100.00	0	0	0	0	100.00
	100.00	0	0	0	0	100.00
	100.00	0	0	0	0	100.00
	90.00	10	0	0	0	100.00
	90.00	10	0	0	0	100.00
	70.00	30	0	0	0	100.00
	100.00	0	0	0	0	100.00
	100.00	0	0	0	0	100.00
	100.00	0	0	0	0	100.00
	0.00	0	0	100	0	100.00
	100.00	0	0	0	0	100.00
	100.00	0	0	0	0	100.00
	95.00	0	0	5	0	100.00
	75.00	25	0	0	0	100.00
	100.00	0	0	0	0	100.00
	100.00	0	0	0	0	100.00
	99.00	0	0	1	0	100.00
	100.00	0	0	0	0	100.00
	90.00	0	0	10	0	100.00
	100.00	0	0	0	0	100.00
	100.00	0	0	0	0	100.00
	100.00	0	0	0	0	100.00
	100.00	0	0	0	0	100.00
	10.00	89	0	1	0	100.00
	0.00	100	0	0	0	100.00
	100.00	0	0	0	0	100.00
	100.00	0	0	0	0	100.00
	40.00	60	0	0	0	100.00
	0.00	0	0	0	100	100.00
	99.00	0	0	1	0	100.00
	0.00	0	95	5	0	100.00
	100.00	0	0	0	0	100.00
	50.00	50	0	0	0	100.00
	100.00	0	0	0	0	100.00
	100.00	0	0	0	0	100.00
	95.00	5	0	0	0	100.00
	100.00	0	0	0	0	100.00
Average:	**81.82**	**10.64**	**1.54**	**3.09**	**2.91**	

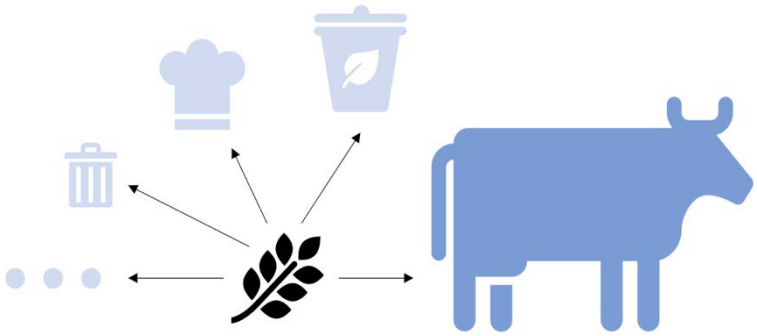


Figure 3.34. Representation of Section 4 data conclusions relating to spent grain waste management in Canada.

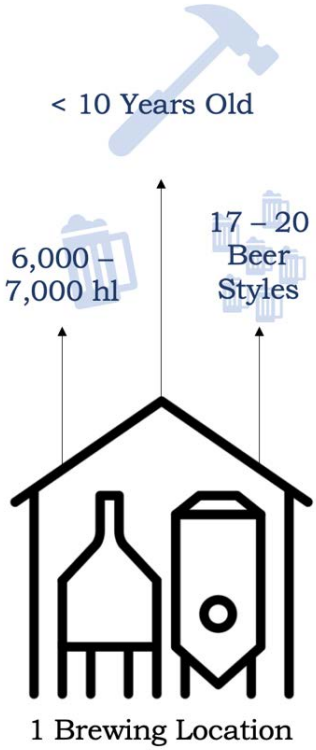
The data summary in section 4 indicates that ruminant feed is by far the most popular waste management strategy (or upcycling route depending on the adopted definition of upcycling) at 81.82% of participants spent grain. The following generalization can be made from section 4:

Craft brewers send less than 2% of their spent grains to landfill as they've found better uses for the ingredient such as ruminant feed (most popular), composting, upcycling and 'other'.

In developing a framework for Winnipeg, this is an important data set for various reasons. First, it's important that the potential of a new local upcycling industry is understood to evaluate the projected success of such activities. Second, the future of these waste management/upcycling strategies may be affected by emerging food industry trends if they continue in the same direction. Third, as craft breweries/small businesses are generally more involved with their communities, the people relying on spent grain should be considered in the final framework.

Survey Data Analysis

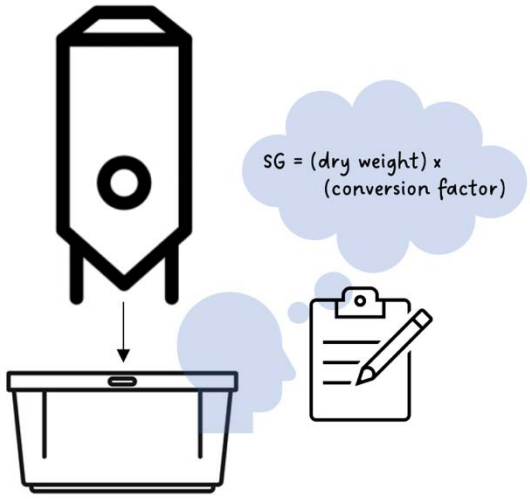
Putting the data together:

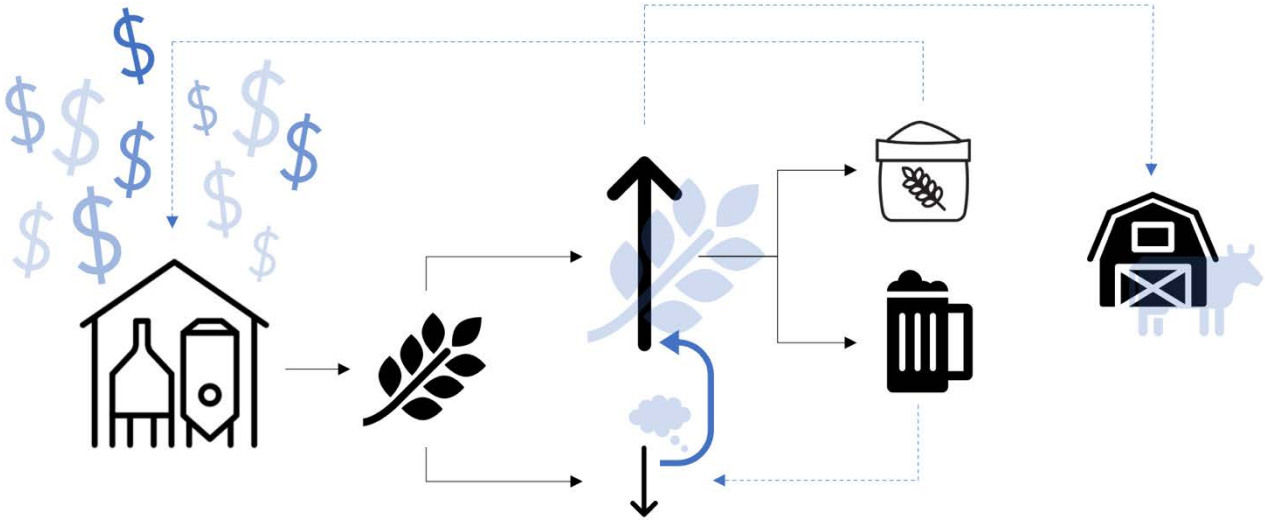


(1) The average Canadian craft brewery has a single location for brewing, is less than 10 years old, and brews 17-20 different beer styles for an average annual production volume of 6,000-7,000 hectolitres.

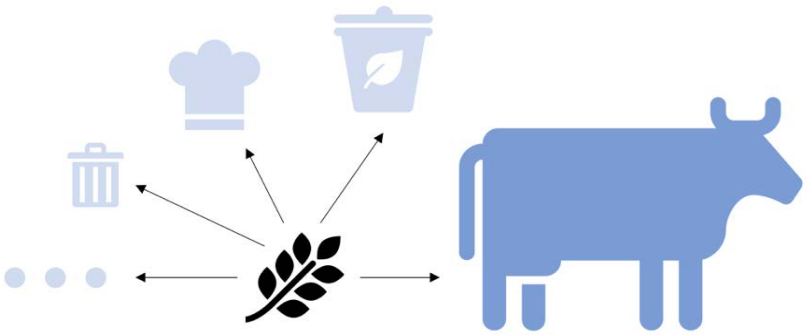
(2) Among all sizes of craft breweries in Canada, only a small portion track their spent grain, usually with a dry ingredient conversion and usually immediately after emptying the mash tun.

(3) Most breweries are upcycling spent grain in some way, and half of those who are not currently doing so are considering it. For the breweries who are, 100% of their spent grain is usually upcycled, most likely in house, to a bakery food product of some sort, or to a farm. It's rare to exclude beer styles, and even more rare to receive payment for spent grain. Most breweries have it picked up for free, but if not, it's likely to cost the brewery a non-standard fee determined by the pick-up company.





(4) Craft brewers send less than 2% of their spent grains to landfill as they've found better uses for the ingredient such as ruminant feed (most popular), composting, upcycling and 'other'.



The four averaged section results serve as a base for developing an upcycling framework specific to Winnipeg and evaluating the feasibility of implementation/operations. The most important feature of the survey is to validate information found in the projects preliminary research for Canadian craft breweries and link research with practical implications. The following analysis outlines some important insights generated from the survey apart from the generalized section data.

An annual production of 6,500 hl of beer is equivalent to 650,000 L annually, which equals roughly 1,780 L/day. Depending on the equipment needed and available for upcycling spent grain, the survey suggests that we can expect a large and consistent volume of spent grain available throughout the year. However, despite large quantities there are seemingly low rates of upcycling in Canada and very few in Winnipeg which need to be explored further during interviews.

A thought in the framework was to develop a process like most other businesses where ingredients are paid for, processed, and sold to businesses/consumers, therefore the current perceived value of spent grain is useful. Only 17 participants indicated they measure, weigh, or track spent grain in question 6 but 81 indicated they upcycle spent grain (question 10). Combined with the question 21 and 22 data stating that most breweries have spent grain removed for free and most others pay for removal, it's evident that upcycling spent grain is not a typical industry where ingredients are highly valued and paid for. We know from the literature review, website review, and the survey that the definition of upcycling varies and can be dependent on a variety of factors. In most cases ingredients are sought after and paid for to create a consumer product but it's evident that brewers are left with the costs of removing spent grain from their property despite the final use of the ingredient. This means that brewers are paying to acquire and dispose of the ingredient. While sustainability is a common global goal, it is our intention to develop a framework where consumers do not absorb extra costs in making environmentally friendly decisions. The website review introduced us to numerous spent grain upcycling companies with exciting products, but it's of interest to us to have a product priced for the average consumer to expand and grow demand of upcycled ingredients.

For the breweries wanting to participate in upcycling, it would seem most convenient for the framework to guarantee pickup of 100% of their spent grains to avoid them having to find other management routes. Question 13 indicates that most breweries who upcycle are upcycling 100% of their grains while some are upcycling low volumes. The low rates of upcycling may indicate that breweries are experimenting or trying to find uses for spent grain or have an upcycling option with low ingredient demand. One brewery indicated an upcycling rate of 98% which may link to question 14 and hint that they're excluding some beer styles for various reasons. In that case it could be that the brewery is only brewing 2% fruity or dark beers and can upcycle all other spent grain. While this is only speculation and if exclusion is necessary, the associated volume needs to be quantified and considered in the final framework and should still allow for 100% upcycling rates of each participating brewery whether some styles are excluded from the final product or not.

The survey data suggests that an exact measurement of spent grain is not necessary in upcycling and should not be a huge concern of how or when to measure as long as the brewery and upcycling company can agree on the method. The survey data also indicates that the most popular final products that incorporate spent grain are bakery products, suggesting that spent grain is most commonly dried and milled before incorporated into products but some may be able to incorporate the wet form if done soon after removal from the mash ton. With a moisture content of approximately 85%, its evident that spent grain degrades rapidly so it makes sense to stabilize the product for a variety of reasons, most importantly to ensure a safe product for consumers and to increase the likelihood that the upcycled product will actually be consumed. While some Winnipeg breweries may have the potential to upcycle onsite, it seems as though those options are limited and almost impossible to do with 100% of the spent grain supply without investing time and money into the necessary equipment.

Section 4 concludes that most spent grain in Canada is going to farmers as ruminant feed. While an intention of the research is to find use for spent grain in plant-based diets and staying ahead of the curve as consumer food trends are shifting, the farmers that continue to farm animals should not be ignored in the framework. It's evident that the upcycling industry has a lot of room to grow but should not exclude members of the current supply chains/communities. In conclusion, the framework should be inclusive of all affected parties and consumers of all economic backgrounds.

Framework considerations from Survey Data

The following is a list of specific objectives and goals of the final Winnipeg spent grain upcycling framework that arose from the survey data analysis:

1. Framework should operate as a typical business (Ingredients are valued and paid for, processed into a human food product, and sold to consumers)
2. Final product should be priced competitively to appeal to more consumers
3. The framework is based on community and sustainability, therefore all affected parties should be considered in all decisions
4. The time and precision of spent grain measurement is not vital to upcycling success and can be agreed upon between the breweries and the upcycling company
5. Upcycling should guarantee processing 100% of the brewery's grain
6. Upcycling framework must operate on a zero-waste commitment
7. The framework must cater to different sized breweries and be able to manage variation in spent grain supply throughout the year
8. The framework needs to manage growing variation in spent grain types from varying beer styles
9. The framework needs to be convenient and flexible to encourage brewery participation and satisfaction with services/outcomes
10. The framework should consider final products that are appealing to the brewery, other businesses, and consumers to encompass all possible target markets

Further Research

The survey serves as part of the bridge between the literature review and the Winnipeg upcycling framework, along with the website review and interviews as shown below. The literature review provides us with a strong knowledge base but is not directly applicable as data originates from various global sources. The website review provides a general impression about upcycling among Canadian craft breweries and the survey data further states what the 'average' craft brewery is doing in Canada. The combination of data acquired at this point in the research outlines what we might expect from Winnipeg craft brewers. Not only does this reinforce the literature review data, but it narrows down the data from global to national. This generalization of Canada craft breweries data clarifies both what is possible for upcycling in Canada and currently being done in the same country of the framework we're building.

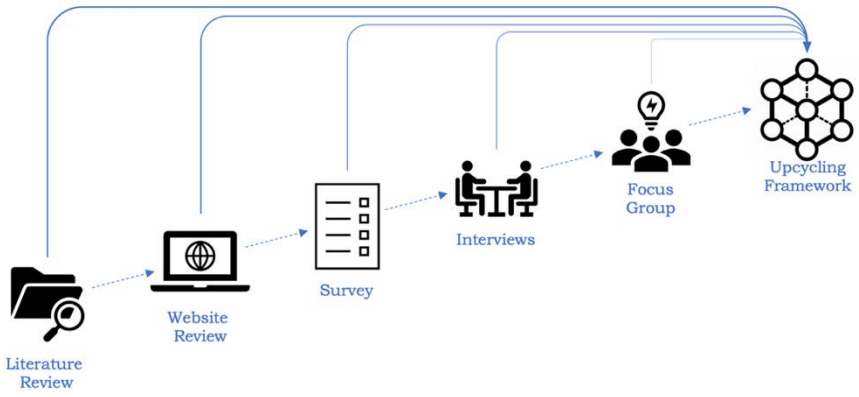


Figure 3.35. Visual of how the combined research methods contribute to the final upcycling framework recommendation.

The following questions have arisen from the survey data and should be addressed in the interview and final literature research phases for consideration in the final framework. While the survey provides an overview of Canadian spent grain upcycling, the framework requires detailed information that is specific to Winnipeg craft brewers and Manitoba food processes. The following list of questions will be assessed in later research stages to make the framework realistic and feasible:

Section 1

1. *What province does this brewery operate in?*
    a. What is (if any) the link between upcycling (to human food products) and the existence of an upcycling company within the same city?
    b. Is upcycling more likely to happen in provinces with larger populations?
2. *In what year was this brewery established?*
    a. Is there a link between the age of the brewery and efforts to operate sustainably?
    b. Are the rates of upcycling higher in newer breweries? If so, what is the reason for this?
3. *Does this brewery have more than one location for its brewing operations?*
    a. Where are all the available spent grain supplies?
4. *What was the annual volume of beer produced at your brewery in the following 5 years (Include the numerical value as well as the unit of measurement. Eg. 300,000 hl):*
    a. If you don't measure your spent grain, can we calculate the approximate spent grain volume supply in Winnipeg from the average production volumes?
    b. Can we generate a link between average production volumes and upcycling rates? Is there a minimum volume needed to 'make it worthwhile'?
    c. Is Winnipeg producing above, below, or par with average Canadian beer volumes?
        i. If so, how does this affect the framework?
    d. Can we generate an overall estimate of spent grain volumes for all Winnipeg breweries combined? (What is future potential of the framework?)
5. *In the past 2 years, how many different styles of beer did you brew?*
    a. What is the average spent grain characteristics variation we can expect to be managing in the framework?
    b. Does increased variation affect our ability to upcycle spent grains?
        i. Does it decrease/increase upcycling potential?
    c. Would the implementation of an upcycling framework restrict breweries from being creative and innovative with their products?

Section 2

6. *Does this brewery measure/weigh/track the amount of spent grain produced?*
    a. Is this vital to the success of the framework?
    b. Would framework implementation require Winnipeg brewers to measure/weigh/track their spent grain? Would they need specialized equipment for this?
7. *What was the amount/volume of spent grain produced in the following 2 years? (Include the numerical value as well as the unit of measurement)*
    a. What is the link between the average volume of spent grain and the number of breweries upcycling this product? (Average volume x number of breweries = average expected supply for the framework?)
    b. Do the measured volumes correspond to the literature value of 20kg/100L beer?
8. *After spent grain is removed from the mash filter, when is it measured? (Select the best answer)*
    a. Does the tote allow moisture to drain or just sink to the bottom?
    b. Can we estimate the moisture content depending on when it was measured?
    c. How important is the timing of measurement in the Winnipeg framework? (Does this dictate any part of the framework for brewers or the upcycling company?)

9. *How do you measure spent grain at this brewery? Include a brief description of what the weighing/measurement process of BSG is, as well as the measurement units)*
    a. What level of accuracy is needed in the Winnipeg upcycling framework?
    b. Does the framework require breweries to purchase weighing equipment? Can the framework provide the measurement service?
    c. Is a 'per-container' estimate satisfactory to the brewers and upcycling company?

Section 3

10. *Does this brewery currently upcycle it's spent grain?*
    a. How are breweries defining upcycling?
    b. Is there a link between the location (province, city, neighbourhood) of the brewery and the ability to upcycle?
    c. Is the value of spent grain dependent of the brewery location? (Eg. If the brewery is on a farm, is compost more valuable to them than upcycling to a human food product? If the brewery is in the city, is the highest value human food products?)
11. *Has this brewery considered upcycling it's spent grain?*
    a. Are Winnipeg brewers thinking about upcycling or are they happy with their current waste management strategies?
        i. Are brewers interested in finding a higher value for their 'wastes'?
            1. Does higher value mean payment for spent grain? Convenient and reliable grain removal from property? Most sustainable option no matter the cost?
    b. Why wouldn't a brewery consider upcycling to human food products?
    c. What would encourage breweries to participate in local upcycling?
12. *Are you planning on implementing upcycling activities in the following time frames:*
    a. What's preventing a brewery from establishing an upcycling-commencement date?
    b. What is the difference between implementation in 1 year, 2 years, or 3 years?
    c. How can we speed up the start of upcycling activities?
    d. How much notice/planning is needed for a brewery between deciding they want to upcycle and actually starting to upcycle?
        i. Is this dependent on their financial implications? (Eg. Needing to buy new equipment?) Is it dependent on current contracts? What is the dependency?
    e. Are breweries aware of emerging food trends and dietary guidelines that may affect their waste management strategies in the future?
13. *What percentage of this brewery's spent grain is upcycled regularly?*
    a. Is it possible to upcycle 100% of a breweries spent grain?
    b. What are the barriers/limitations of designing a zero-waste upcycling framework?
        i. Is it possible for the framework to divert every lb of spent grain from landfill?
    c. Is there a link between the percentage of upcycled spent grain and the company doing the upcycling? (Eg. Can a brewery upcycle 100% of their spent grain on site? Can a bakery upcycle 100% of the spent grain supply? Is it possible for the framework to process all spent grain supply to a shelf stable product before it degrades?)
14. *Are there any beer styles that are intentionally not upcycled?*
    a. Does the Winnipeg framework need to consider excluding some beer styles from being upcycled or can we use all styles?
    b. Does the exclusion of some styles in the framework demand brewers to change their brewing schedules to accommodate upcycling?
    c. Does exclusion limit the framework to only having one processing option (batch or continuous style)?
    d. What is the final destination of the excluded beer styles? (Does this need to be a farm, compost, are there human food uses, etc?)

15. *What style(s) of beer are excluded from upcycling? Briefly explain why.*
    a. Can we make a framework that doesn't exclude any beer styles?
    b. Is there a potential market for the typically-excluded styles?
    c. Is there a way to blend these spent grains with the more typical styled beers?
16. *What are all the human food products that incorporate/use this brewery's spent grain?*
    a. Is it best to make a general final product (eg. Flour) or a specialized product (eg. A bread mix, a pancake mix, etc.)?
    b. Are the bakeries in Winnipeg interested in upcycled spent grain flour to incorporate into their products?
    c. Is there a potential market for unmilled-dried spent grain?
17. *Does this brewery have a restaurant or brewpub associated with it?*
    a. *Does this increase the likelihood of upcycling spent grain?*
    b. *What foods/dishes can easily incorporate upcycled spent grain?*
    c. *Would this typically be in wet form?*
18. *Do you upcycle spent grain at your own restaurant/brewpub?*
    a. Would Winnipeg craft brewers be interested in upcycling spent grain at their own establishments?
        i. What process would this require? (Would spent grain need to be processed and returned as a new product? Can they upcycle easily onsite? Etc.)
19. *What is the name of the business/company that upcycles your brewery's spent grain?*
    a. What food companies in Winnipeg have potential for upcycled spent grain?
    b. Are the businesses listed producing products that are/can be made in Winnipeg?
20. *Do you pay to have spent grain removed from the brewery/property?*
    a. What is the industry standard in Winnipeg for spent grain removal?
    b. Who picks it up and where is it going?
21. *How much does it cost to have spent grain removed from your brewery/property?*
    a. What is the cost of removal to breweries?
22. *How much do you get paid for your spent grain by the business/company removing it?*
    a. Is there potential for the framework to add enough value to brewers spent grain that it's viewed (and paid for) as an ingredient (not waste)?
    b. What is the appropriate price for a unit of spent grain?

Section 4

23. *What percentage of this brewery's total spent grain volume is disposed of in the following ways (Must add up to 100%):*
    a. Where is spent grain going in Manitoba compared with the survey data?
    b. What are the 'other' potential uses for spent grain waste management?
    c. What is the potential of upcycling? (ie. What volume has potential for diversion into upcycling as opposed to other waste management strategies?)

With the conclusion of the Canada-wide survey, the project 'Exploring the Potential of Upcycling Brewers Spent Grain in Winnipeg, MB' now has multiple data layers to establish a base for the development of the Winnipeg framework. The literature review provides a variety of possibilities of upcycled spent grain uses, upcycling options, and the need for sustainability in the food industry at the global scale. The website review provided a general sense of Canadian craft breweries concern regarding sustainability through public online information, and the survey provided data regarding upcycling in Canada.

The next research stage is conducting interviews with Winnipeg craft brewers, Manitoba food companies, and spent grain upcycling companies to acquire the necessary data to develop a framework that is specifically suited to the needs of those affected by the framework. The above questions will be addressed through multiple interviews and combined with further literature review and market research. The interview stage will allow for the development of a framework with varying options to be assessed and finalized with a focus group to ensure the highest quality framework.

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Chapter 4: Interviews Final Report

Deliverable Synopsis: This deliverable presents the data obtained from semi-structured interviews conducted with Winnipeg craft brewers, Manitoba food companies, and North American upcycling companies. The interview data contributed to the overall project objectives by providing case-specific data relating to the feasibility, level of interest, and local options/possibilities associated with upcycling brewers spent grain needed for the framework creation.

Exploring the Potential of Upcycling Craft BSG in Winnipeg, MB

North America & Winnipeg, MB Interviews
Full Data Report
February 2023

Partially funded by the University of Manitoba Graduate Fellowship (UMGF) and Social Sciences and Humanities Resource Council Grant #435-2020-0923

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Disclaimer

The following is a summary report of all interviews conducted as a part of a master's practicum project, administered by Marika Boryen of the University of Manitoba. The following report is based on voluntary data provided by Winnipeg craft brewers, Manitoba food and milling companies, and North American upcyclers. As such, data interpretations are not an accurate representation of the entire population, and instead a representation of the data provided by participants.

Your use of any of this Report is at your sole and absolute risk. None of the authors, contributors, administrators, vandals, or anyone else connected with this project, in any way whatsoever, can be responsible for your use of the information in this summary report. The survey questions were designed to address a specific set of objectives towards the research project "Exploring the potential of upcycling craft brewers spent grain in Winnipeg, MB" and therefore should not be applied to research/data outside of the intended use, or for any other purpose outside this project.

The interpretation of the generalized data is solely that of the principal researcher (Marika Boryen), and is not necessarily to the author's educational institution, employer, organization, committee, or other group or individual. Marika Boryen assumes no responsibility or liability for any errors or omissions in the content of this report. The information contained in this report is provided to you on an "as-is" basis with no guarantees of completeness, accuracy, usefulness, or timeliness and without any warranties for any kind whatsoever.

Objective 1

Quantitatively determine if there is enough BSG in Winnipeg to render upcycling plausible.

Winnipeg Craft Brewers

Winnipeg craft brewers are a group of people full of passion and life. While speaking with participants, their love of the brewing industry was described in many ways; primarily that it's a job that allows for a lot of creativity while creating a strong Winnipeg identity. Winnipeg craft breweries have unique and iconic identities resulting from hard work and a variety of other motivations. Craft brewers strive to make products for people to share life's moments over. Our brewers strive to support local businesses and to make Manitobans proud. Winnipeg brewers have been part of the beer industry's revolution in creating new beers and using unique ingredients and evolving techniques. While the brewing industry makes huge efforts to operate with circular economy principals, there's potential and opportunity to add even more value to this industry through upcycling brewery wastes, namely brewers spent grain.

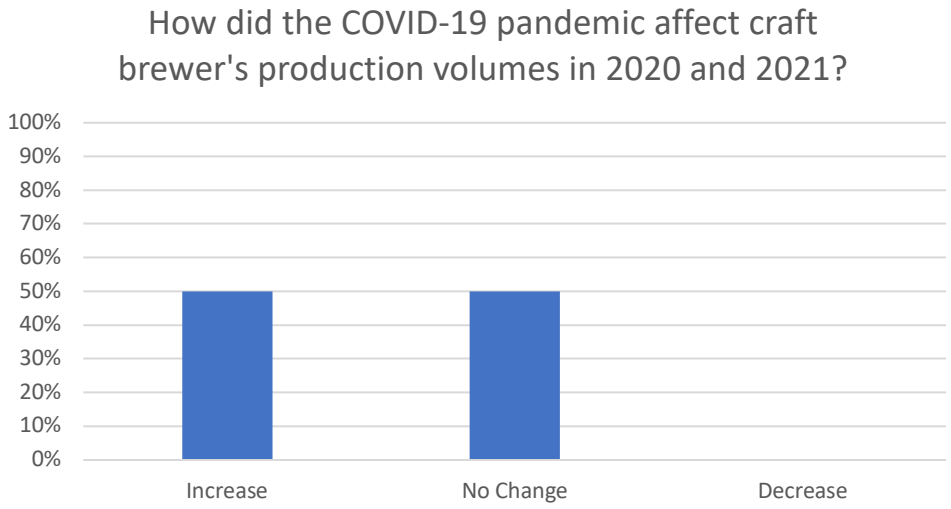


Figure 4.1. How Covid-19 affected average annual beer production among interviewees.

Production volumes from 2017-2021 were obtained from participants to determine certain values of interest to the research. As seen in the chart to the left, half of the participants had an increase in beer production during the pandemic years, half saw no difference, and none of the participants experienced a decrease. From this data, we determined the average annual production to base spent grain upcycling potential on in Winnipeg, MB.

The following tabulated data was determined during data analysis which serves as 'an average Winnipeg craft brewery' for the purposes of this research. The average brewery with interest in spent grain upcycling makes 16 styles of beer, 7 of which are permanent or core styles. The core styles make up approximately 75% of the brewery's beer styles, meaning the upcycling framework is faced with approximately 2000 hl of variation on an annual basis.

Table 4.1. Breakdown of number and styles by annual beer production volumes of local Winnipeg craft brewers.

	Average Annual Production	Total Number of Beer Styles	Permanent Styles	Seasonal Styles	Limited Edition	Other
01		15				
02	5000 hl	18	9 3650 – 3925 hl	Varies 250 hl	Varies 75 – 100 hl	Contract Brews 750 – 1000 hl
03	2174 hl	Varies	7 1950 hl	Varies 225 hl		
04	1000 hl	16	6 500 hl		Varies 500 hl	
Total	8174+ hl	16.33 avg.	7.33 avg. 6100 – 6375 hl	475 hl	575 – 600 hl	750 – 1000 hl

When considering the potential for a consistent product, the data shows we're working with 22+ core beer styles. These core styles are vital to the uniformity of a product and offer some reliability for consumer demand. The creativity of Winnipeg craft brewers is evident with the seasonal and limited-edition beers they've produced. Some styles mentioned are a winter porter, honey oat saison (made with fresh honey in fall), hoppy beers (made in spring with fresh hops), and raspberry wheat. It's evident that seasonal beers are not consistent month-to-month or year-to-year, but as the name suggests, these styles use seasonal ingredients. The variation among these styles does not make them suitable for a consistent product but offers the upcycling framework with an opportunity to also work with and promote seasonal ingredients/flavours. Breweries have also made limited-edition or one-off beers such as barrel aged beers, fruit beers, high ABV beers, fundraiser brews, a botanical beer, and other unique flavours. As with the seasonal beers, these beers are not well suited for a consistent product and introduce batches of variability that the framework needs to consider.

Among the participants, 75% indicate they do not measure their annual volume of spent grain produced while ¼ of participants do. Among those who do, spent grain is measured by roughly estimating the number of totes needed to empty the mash ton to plan for the removal of spent grain. The lack of volume tracking and precision among measurements clearly indicates that spent grain is not of high value to Winnipeg craft brewers at this time. The silver lining is there is nothing but opportunity to add value to this 'waste' product.

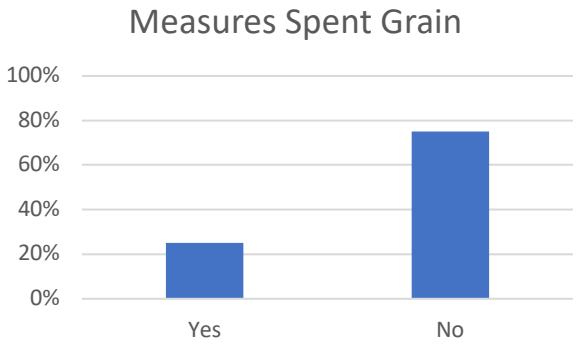


Figure 4.2. Percentage of brewers that currently measure spent grain.

As defined by the Upcycled Food Association (1):

"Upcycled foods use ingredients that otherwise would not have gone to human consumption, are procured and produced using verifiable supply chains, and have a positive impact on the environment."

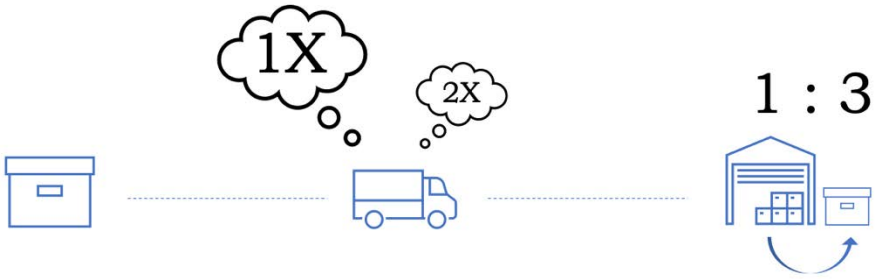


Figure 4.3. Depiction of weekly spent grain removal as 1-2 times per week, with 1 brewery storing spent grain indoors and 3 storing it outdoors.

Upcycled foods going to human consumption need to remain food safe throughout the entire process. The data found that all the brewery participants use food-safe totes to store spent grain. 75% of participants have spent grain removed from the property once per week while the other ¼ has a twice-weekly removal. Among the participants, ¾ store spent grain outside of the brewery, while the other 25% store the grain indoors on the loading dock. As the shelf life of spent grain is relatively short, spent grain needs to be dealt with quickly to keep it at a human food grade quality. The storage method of spent grain among all participants needs to be considered as the totes need to remain in a food-safe area inside the building, not outside.

Manitoba Milling Companies

Brewers spent grain is commonly upcycled in bakery products in a dried and milled form as part of a flour mixture, therefore milling is an important consideration in the development of the final framework. The spent grain upcycling framework options include on-site milling and having spent grain milled with a company that already mills grains. A Manitoba milling company brought up some key considerations for choosing the final framework, starting with the spent grain itself.

The company we spoke with specializes in organic grains, therefore a non-organic product requires careful planning for all affected parties. As spent grain is warm and approximately 85% moisture after removal from the mash tun, it's a favourable environment for mold growth. The safety of the product needs to be closely monitored throughout the process to ensure customer safety and be carefully considered for approval from the Canadian Food Inspection Agency (CFIA). The wet spent grain needs to be dried to a 10-14% moisture content prior to milling, which needs to be considered in the movement of spent grain. Dried spent grain has a much longer shelf life than wet spent grain, but transportation and milling schedules would need to be incorporated into the production planning. Other considerations include (1) if the grain is dehulled, (2) if its sprouted or germinated, (3) if it's organic or not, and (4) how fine of flour is desired.

A final consideration with milling off-site is that of the final product. The milling company we spoke with packages and labels the final product but would need accurate nutritional labeling information. Mixed flours are harder to get consistent, so there would be a potential limitation on what beer's spent grains can be included in a consistent product such as a upcycled flour. Many (or maybe all breweries) have seasonal or limited-edition beers. To mill a small-batch product with CFIA specifications would take a lot of work including nutritional testing for accurate labelling, thus also requiring the brewer's personal recipe(s).

North American Upcycling Companies

There are a number of companies already upcycling spent grain throughout North America, a few of which participated in an interview to contribute valuable industry data towards the development of a spent grain upcycling framework for Winnipeg, MB. An important consideration for Objective 1 is understanding the volume capacity of drying equipment. The capacity of such equipment can either be limiting to the interested breweries or create growth potential for the future. Large scale drying can be done in a variety of ways such as on a continuous belt, in a drum dryer, and with trays, each method with its pro's and con's.

Depending on the requirements of current spent grain supply and the needs of the framework, options ranging from 1000 lbs/day to 800-1000 lbs/hour are available and currently used by other upcycling companies.

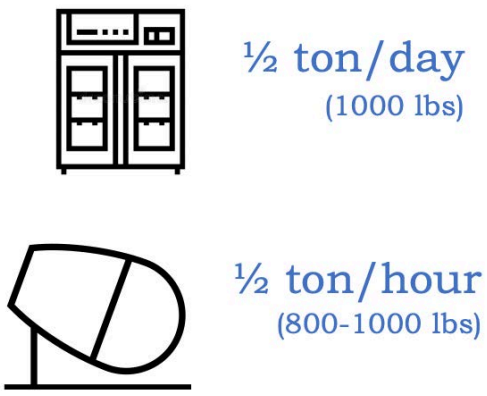


Figure 4.4. Visualization of BSG drying equipment options and drying rate.

At a 1000 lbs/day capacity, operating a regular 40 hour work week, Monday to Friday, a large tray dryer system could dry approximately 4000 lbs per week without operating on weekends. Operating 50 weeks/year could equal 200,000 lbs of upcycled spent grain annually. At 800-1000 lbs/hr capacity, operating a regular 40 hour work week, Monday to Friday, a drum dryer could process up to 5 or 6 batches of spent grain per day (dependent on the equipment's loading and unloading time). At 5 batches per day, the drum dryer could process 4000-5000 lbs of spent grain per day, equalling 20,000-25,000 lbs of spent grain weekly. Operating 50 weeks/year could equal 1,000,000-1,250,000 lbs of upcycled spent grain annually.

Some preliminary considerations in developing the framework around either drying method include (but are not limited to: (1) the current interest in upcycling spent grain vs. the projected growth of demand locally, (2) the scale of operation desired (will this be a local effort or is there desire to grow nationally/internationally), (3) equipment pricing, (4) funding and investment availability, (5) resource requirements (personnel and equipment), (6) volume management & traceability, (7) moving spent grain to upcycling facility, (8) storage space, location, and time of spent grain before processing, and (9) capacity of other equipment included in the framework.

Manitoba Food Companies

Broadly speaking, barley sugars (and other grains used in various beer styles) are used in the brewing process which leaves spent grain with approximately 19-30% protein, 30-50% fiber, 10% lipids, and 2-5% ash. (A detailed nutritional profile with references is provided on page 91.) When speaking with food company participants, not one representative was aware of the nutritional profile of spent grain which indicates an educational portion is needed within the final framework.

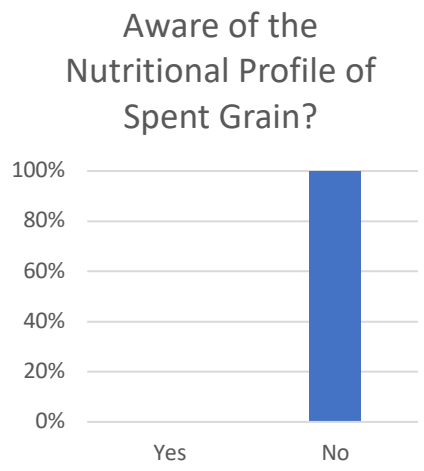


Figure 4.5. Number of food companies aware of BSG nutritional profile.

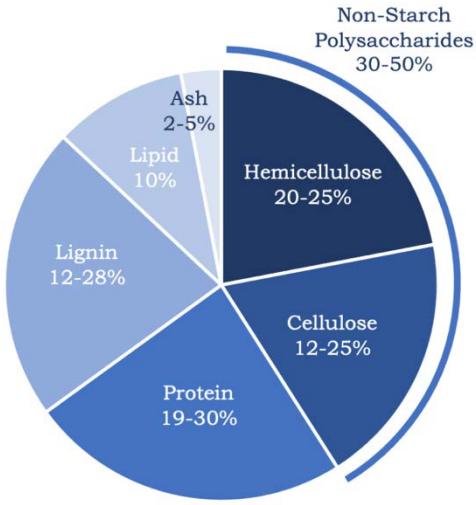


Figure 4.6. BSG nutritional profile.

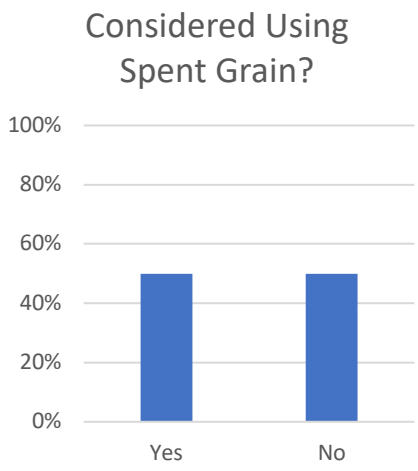


Figure 4.7. Number of food companies who've considered using BSG.

Despite not knowing the high protein and fiber content of spent grain, 50% of participants have considered using spent grain in their products. In order to use spent grain, it would need to be in a dried and milled form and used as a flour replacement or part of a flour mixture.

In bakery products, brewers spent grain flour is best used at a 10% ratio in a wheat flour blend to minimize unwanted sensory characteristics. (See page 93 for information on sensory characteristics and associated references.) At a 10% ratio, individual company demands can range from 0.055-0.082 lbs/day (20-30 lbs/year) to 6,613 lbs/day (3,000 kg/day) according to the data, suggesting that a wide variety and number of revenue streams are needed.

The average daily supply of dried spent grain is shown on the graph with an orange marker. To sell all current/available supply in the framework, three market levels are shown and based on participant data. An individual demand could be as small as 0.055-0.082 lbs/day (20-30 lbs/year). It would take 3,756-5,600 customers to use up 112,471 lbs of spent grain annually at this demand volume. A local business or small retail demand of 43-85 lbs/day (300-600 lbs/week) would require 4-7 customers to use up 112,471 lbs annually. To meet an industrial demand of 6,613 lbs/day, we would need 22X the amount of spent grain currently available, which translates to 1,122,352 kg (2,474,362 lbs) annually.

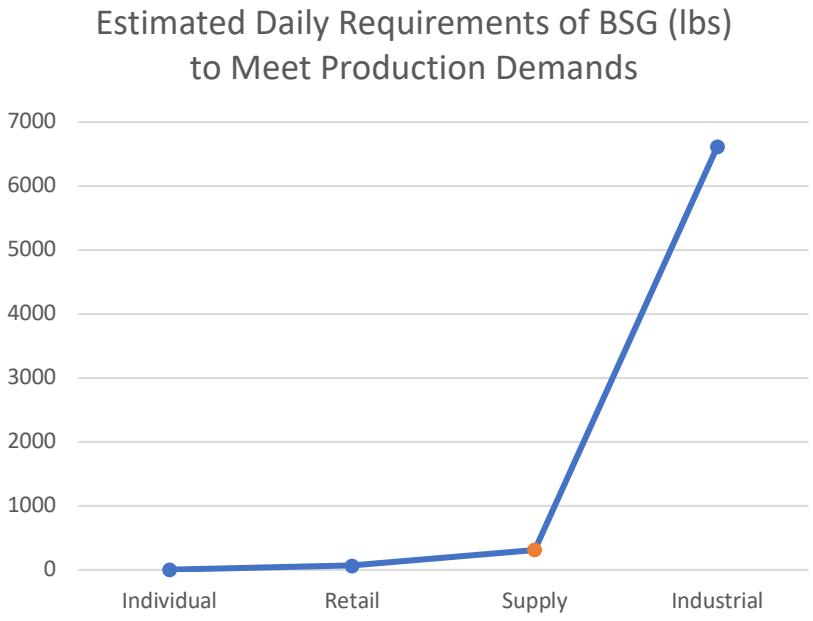


Figure 4.8. Daily BSG supply graphed against projected daily demand of various consumer bases including individual/household use, retail/small business, and industrial.

Objective 2

Quantify and map what local breweries currently do with their spent grain.

Winnipeg Craft Brewers

Figure 4.9. Final destinations of spent grain for four Winnipeg craft breweries marked in red as Elie, Anola, Beausejour, and West St Paul (Google Maps).

Participants identified a variety of locations as the destination for the majority of their spent grain including Elie, West St. Paul, Anola and Beausejour as shown on the map above. The significant effort towards moving spent grain is primarily for the purpose of using it as ruminant feed on farms. All distances have been calculated from Winnipeg's centre for participant anonymity.

An estimated average of 6-12 totes of spent grain are moved from Winnipeg to Beausejour once per week. The trip is 61km from downtown Winnipeg making it a 122km round trip. A shipment of spent grain is made to Anola once per week with numerous totes. Anola is 39km from downtown Winnipeg, equalling a round trip of 78km for the brewery. A third weekly trip is made from Elie to Winnipeg by a local farmer to pick up totes of spent grain. Elie is located 46km from downtown Winnipeg equalling a 92km round trip. A fourth movement of spent grain is made to West St. Paul with several totes of spent grain on a weekly basis. The destination is 24km from downtown Winnipeg for a total of 48km round trip. Of the participant responses, 75% receive free removal of spent grain while the other 25% take on the cost of removing spent grain in addition to the costs of production.

The lack of numerical precision in the measurement/tracking of spent grain is likely due to the fact that estimating is mainly done for transportation/removal planning. However, research states that approximately 20 kg of spent grain are produced for every 100 L of beer made, which can be used to estimate the approximate volume of spent grain available for upcycling in Winnipeg. Based on participant data, there's an estimated 182,200 kg (401,682 lbs) of wet spent grain annually in Winnipeg. The associated volume of dried spent grain (13% moisture) is 51,016 kg as follows:

$$182{,}200\ \text{kg} - (0.85 \times 182{,}200\ \text{kg}) + (0.13 \times 182{,}200\ \text{kg}) = 51{,}016\ \text{kg} \rightarrow \frac{51{,}016\ kg}{182{,}200\ kg} \times 100\% = 28\%$$

Wet Spent Grain | Remove 85% Moisture | Add 13% Moisture | Dried Spent Grain | Loss of 72% of Product Weight

An 85% moisture spent grain is very heavy with water and loses 72% of its original weight in the process of drying to 13% moisture. The 182,200 kg of wet spent grain gives us 51,016 kg of dried product annually if we're able to upcycle 100% of the available volume from the interested Winnipeg craft breweries. This also highlights that upcycling 182,200 kg of spent grain involves the removal of 131,184 kg (or 131,184 L) of water annually that should be considered in some way.

Table 4.2. Estimated total volume of BSG among four Winnipeg craft breweries and associated volumes by disposal method.

	Average Annual Production	Estimated Volume of BSG (20kg/100L beer)	Cattle Feed	Compost	Landfill	Other
01		18,720 kg	98% 18,345 kg	0% 0 kg	2% 374 kg	<1% <187 kg
02	5000 hl	100,000 kg	100% 100,000 kg	0% 0 kg	0% 0 kg	0% 0 kg
03	2174 hl	43,480 kg	100% 43,480 kg	0% 0 kg	0% 0 kg	0% 0 kg
04	1000 hl	20,000 kg	85% 17,000 kg	15% 3,000 kg	0% 0 kg	0% 0 kg
Total:	8174+ hl	182,200 kg	178,825 kg	3,000 kg	374 kg	<187 kg

North American Upcycling Companies

A primary barrier to upcycling 100% of a brewery's spent grain by the upcycling company is that brewers are known to change their brewing schedules which then affects the upcycling company as well. Another noted barrier is that if the upcycling company and brewery are both working Monday-Friday and a brewery empties the mash tun on a Friday after the latest pick-up/drop-off time, the spent grain sits at the brewery for 3 days before being picked up. This causes a significant issue as spent grain has a very short life span, but this barrier was not encountered on a regular basis.

As the drying methods offer opportunity for batch separation, another consideration to upcycling spent grain is the final product(s). One upcycling company we spoke with offers a consistent final product and noted that dark beers, beers with unique flavours (eg. Fruity beers), and wheat beers are not included because they alter one or more sensory components of the final product and/or the nutritional profile therefore requiring a new analysis and nutritional label.

Figure 4.10. Visualization of beer styles intentionally not included in upcycling including fruity beers, dark beers, and beers that alter grain nutritional profile.

As seen in *Objective 1:Winnipeg Craft Brewers*, seasonal and limited-edition batches account for approximately 1,000 hl of the total volume which equates to 20,000 kg of wet spent grain. This means that we are guaranteed to have approximately 11% of the total spent grain supply that cannot be included in a consistent blended product such as a flour and must have an alternative market. To add to that, if the darker styles of beer within the 'permanent or core styles' were also not included, the volume of product needing a different market would increase but the associated volume could introduce a second consistent product for consumers. With this in mind, the current supply could be used with 4 retail demands (84% of daily supply) and 695 individual demands (16% of daily supply). This also means that if approximately 15% (Seasonal, limited-edition, and dark beers) of the current supply could not be used in the flour, we'd require 25X current supply to meet 1 industrial demand.

1,000 hl x $\left(\frac{100\ L}{1\ hl}\right)$ x $\left(\frac{20\ kg}{100\ L}\right)$ = 20,000 kg (44,092.45 lbs) Spent Grain (85% MC)
Ratio: $\left(\frac{20{,}000\ kg}{182{,}200\ kg}\right) x$ 100% = 10.98% of the total spent grain supply
Dried Grain: 51,016 kg x 10.97% = 5,596.45 kg (12,338.06 lbs)

Objective 3

Document the barriers brewers face in using/moving/storing their spent grain.

Winnipeg Craft Brewers

The following tree diagram organizes the barriers brewers face with spent grain into three primary categories: using, moving, and storing spent grain. Of the three primary categories, storing spent grain is the most common response among all participants indicating this is the primary issue needing to be addressed in the final framework to minimize brewer barriers in upcycling spent grain. Of the barriers mentioned, those most significant (as described by brewers and marked with orange text) are (1) the large volume, (2) that it degrades quickly, (3) that spent grain attracts rodents during storage, and (4) issues with transportation of spent grain.

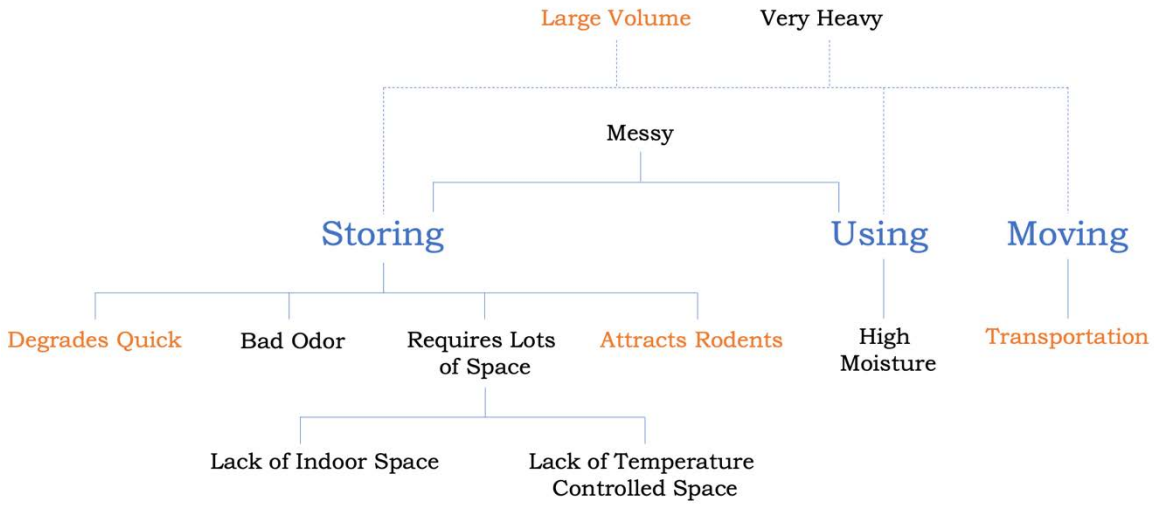


Figure 4.11. Diagram of brewer barriers to upcycling BSG by category, with the most named concerns in orange.

North American Upcycling Companies

There are a considerable number of barriers that companies upcycling spent grain face as shown in the tree diagram below. The most significant barrier spans all three primary categories and has to do with the financials of upcycling including (1) obtaining investing/funding/subsidies for start-up and operations, and (2) the price of equipment. Other barriers noted were having to manage a changing schedule with everyday pickups, the quick degradation, and developing a market for upcycled spent grain products.

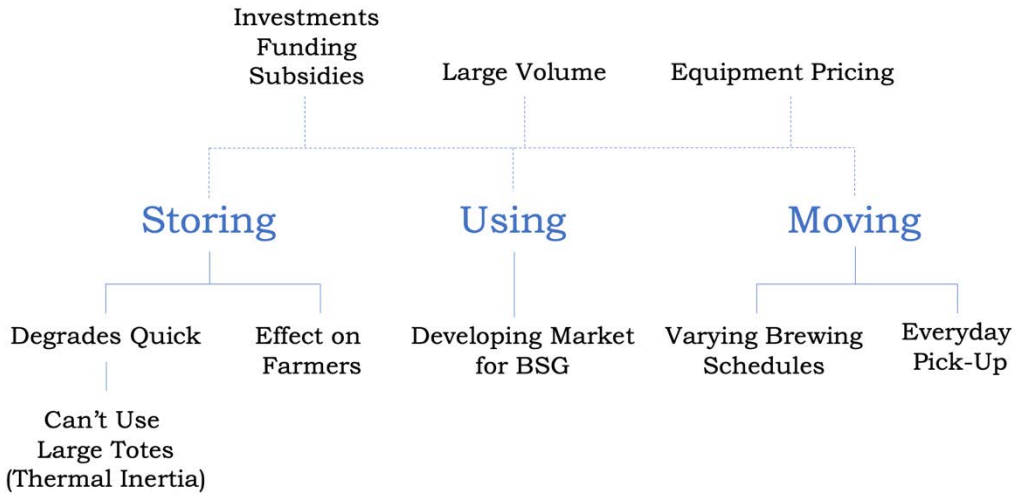


Figure 4.12. Documented upcycling company barriers to upcycling BSG, organized by category.

Manitoba Food Companies

Interview data analysis found that the majority of barriers that food companies face are with using upcycled spent grain in their existing products. A common concern surrounds the fact that spent grain is approximately 85% moisture upon removal from the mash tun and degrades quickly, but a more shelf-stable product would be potentially appealing. Another common barrier mentioned was that product/recipe development would take time and could not guarantee a demand or consumer acceptance at this point, and how to scale production to meet that demand. The financial implication for the food company would need to be considered when deciding on the final product(s), especially if they require specialized equipment (e.g. A mill) to use the product.

Figure 4.13. Documented barriers that Manitoba food companies face in using upcycled BSG by category.

Objective 4

Determine if/which breweries are interested in BSG upcycling potential?

Winnipeg Craft Brewers

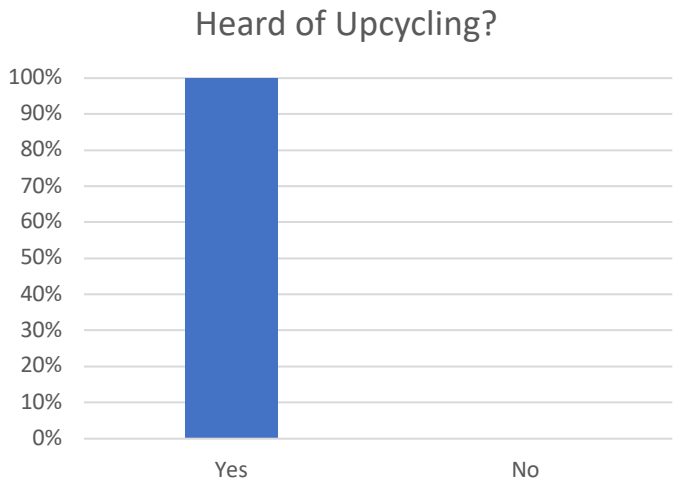


Figure 4.14. Percentage of breweries that have heard of spent grain upcycling.

Based on the data, any business structure for the upcycling framework would theoretically work in Winnipeg as all participating breweries indicated they were willing to work with other Winnipeg craft breweries to upcycling spent grain. The level of cooperation could vary and requires further investigation, but it could range from (1) being satisfied that there's multiple breweries upcycling with one framework, (2) coordinating brewing schedules to supplement demand, or (3) operating a Co-Operative together.

Among the Winnipeg craft brewers who participated in the research, 100% have heard of 'Upcycling' before. Breweries were asked "Have you thought about, been involved with, or operated upcycling of spent grain?" and 75% of participants responded yes. Most participants have experience with upcycling spent grain to bread but faced difficulties with the high moisture content and finding use for the vast volume of spent grain as upcycling in bread is done at a low wheat-spent grain ratio.

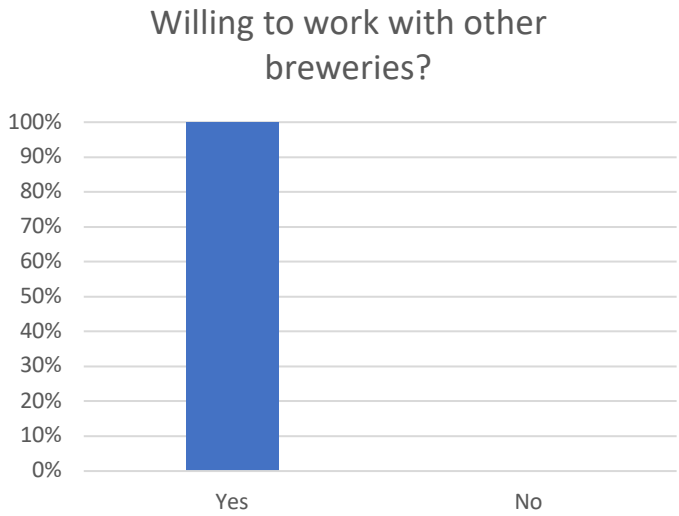


Figure 4.15. The recorded percentage of local craft breweries willing to work together to upcycled spent grain.

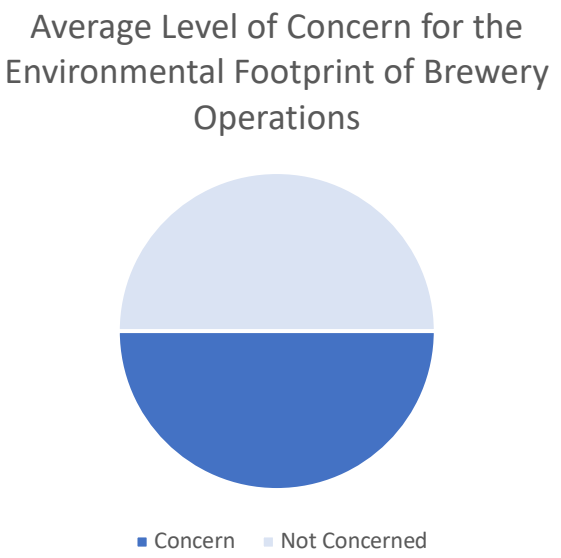


Figure 4.16. The average level of concern (in %) for the environmental footprint of brewery operations.

Winnipeg craft breweries show an average of 50% level of concern for the environmental footprint of the brewery's operations. Values were generally explained as follows: breweries are aware of their operations outputs and current high-priority global environmental issues. They consider the environmental effects of decisions whenever possible both financially and realistically. Some level of 'not concerned' arises from that they have already made significant efforts within their operations to increase sustainability such as not having spent grain sent to landfill and instead finding better uses for it. Some difficulties arise with sustainability efforts to do primarily with access to better options for spent grain and technology to reduce their environmental footprint.

A primary benefit of working with craft breweries, specifically the ones interested in upcycling their spent grain, is that they are privately owned. This is beneficial in the fact that a business decision can be made fairly quickly and is typically evaluated mostly based on capital and operational cost assessments. It's assumed that a lower or lack of capital cost will increase the likelihood of brewer participation, along with low or no ongoing fees. It can also be assumed that a payment for spent grain would increase the likelihood of brewer participation.

Manitoba Food Companies

As with the brewers, all the food company participants have heard of upcycling prior to the interview, and 75% of the companies are already involved in upcycling their own food wastes to other human food products.

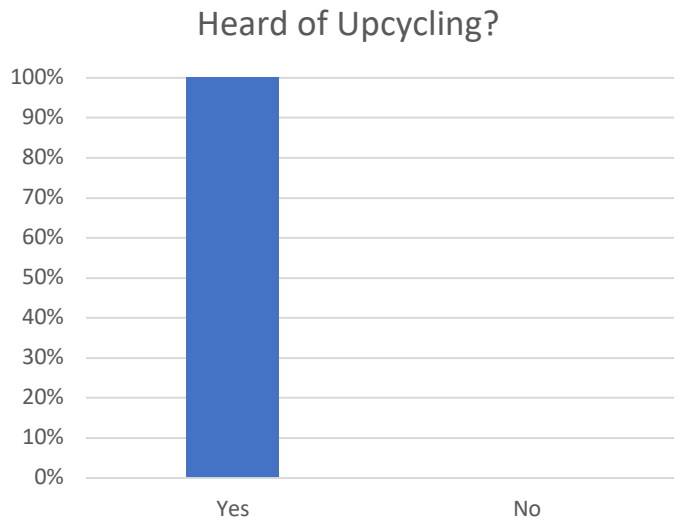


Figure 4.17. The recorded percentage of interviewed food companies that have heard of food upcycling.

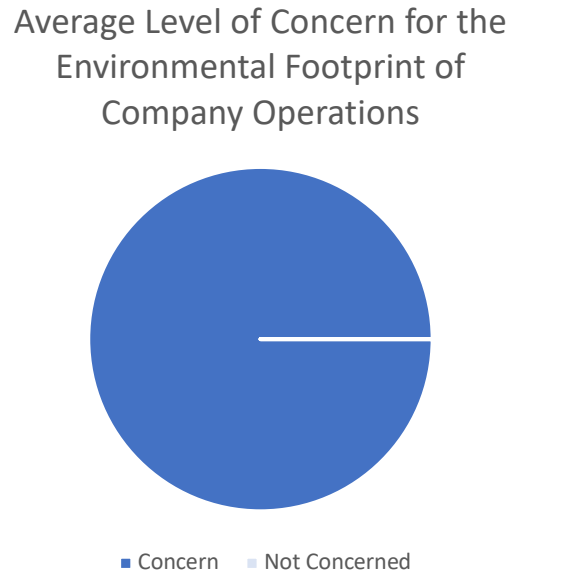


Figure 4.18. The average level of concern (in %) for the environmental footprint of food company operations.

100% of participants indicated that the company they were representing currently operated using circular economy principals. The 10 R's of a circular economy are provided in *Figure 1* for reference. Some common practices mentioned are buying local whenever possible to support local and reduce transportation of goods, it's part of the company's mission and core values, and they don't want to waste because they care about the environment.

Every single participant indicated that the company they were representing is concerned with the environmental impact of their operations. Actions resulting from this concern include on-site recycling/compost, purchasing local ingredients when possible, using organic products to avoid fertilizer use, using biodegradable and compostable take-out materials, and using hybrid vehicles for business purposes (e.g. Deliveries).

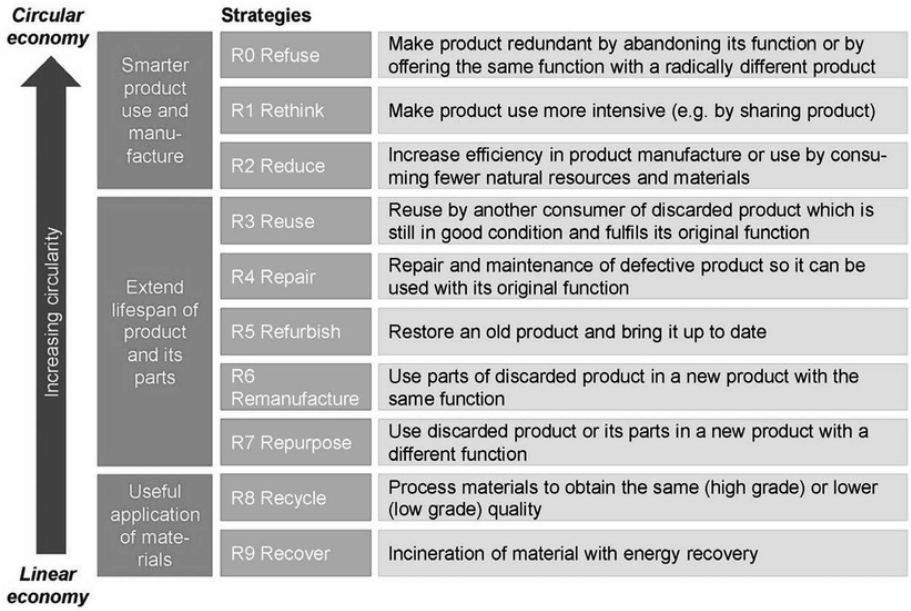


Figure 4.19. The 10 R's of a circular economy, with R0 being the most circular and effective principal and R9 being the most linear and least effective principal (44).

Objective 5

Research and identify who the potential users are of BSG as an input in Winnipeg.

Winnipeg Craft Brewers

Brewers spent grain can be upcycled in a variety of ways and in various products. It was of interest to assess if there was any potential for in-house upcycling of spent grain to reduce the movement of spent grain or to increase the number of locations/businesses that upcycled products were available to consumers. Availability could be through in-house sales of a consumer product and/or in-house use of the upcycled product.

As shown in the pie-graph to the right, 50% of participating craft breweries have a taproom which introduces opportunity for a consumer-ready upcycled spent grain product. 25% of participants have a kitchen within their facility meaning they have an opportunity to use an upcycled spent grain product within their menu. The remaining 25% of participants have a restaurant and taproom meaning they have opportunity for either type of upcycled product.

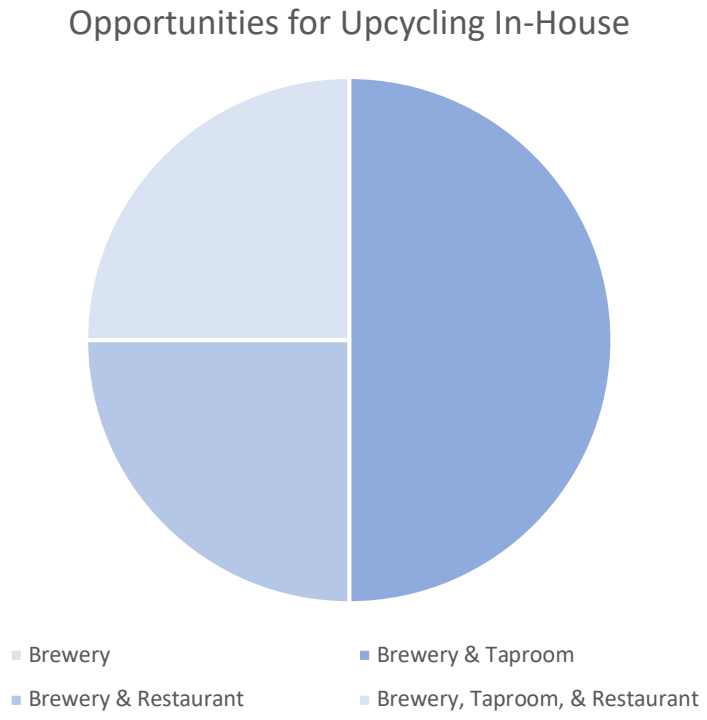


Figure 4.20. The ratio of breweries that have opportunity for upcycling BSG in-house by means of an associated restaurant and/or brewpub.

North American Upcycling Companies

Typical revenue streams for product are retail, wholesale, direct to consumer (B2C), and business to business (B2B). With the introduction of a new product such as an upcycled spent grain product, it's of interest to make purchase widely available and convenient to encourage people to become new and repeat customers. North American upcycling companies shared that their success has primarily been through the three circled sales routes: retail, direct to consumer, and business to business. Such opportunities exist for upcycling in Winnipeg thus adding to the potential of success. One upcycling organization mentioned that participating breweries are a great opportunity for upcycled product sales, bringing awareness to the spent grain circular cycle, and can offer immediate education to potential customers through staff and product packaging.

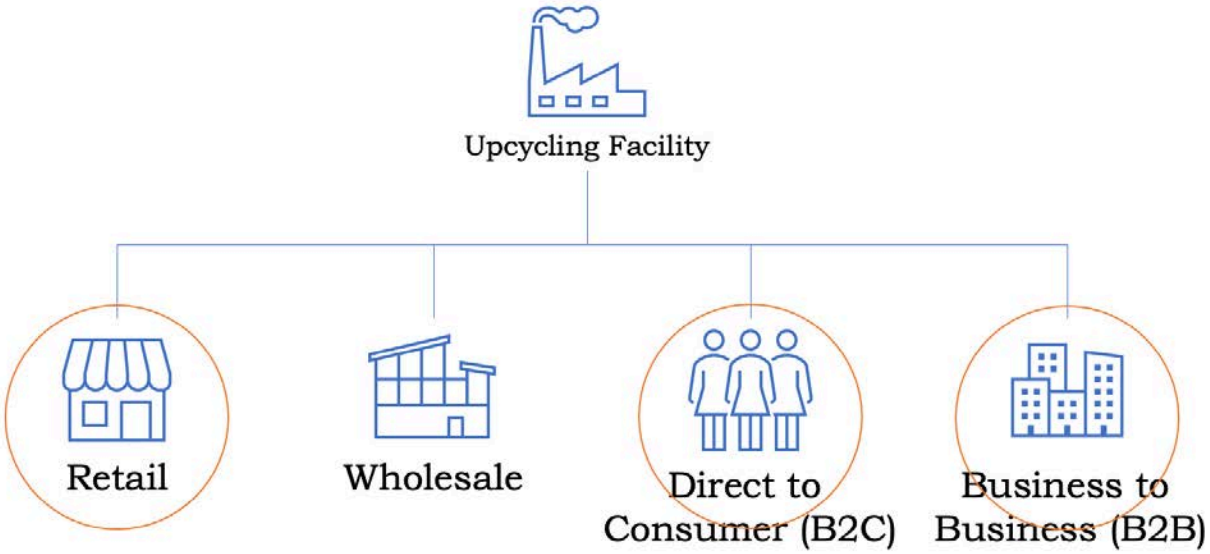


Figure 4.21. The most common customer bases of existing and interviewed BSG upcycling companies.

Manitoba Food Companies

Among the products already made by participating companies and the potential they have for product/recipe development, five primary food types were identified as being able to use/incorporate upcycled brewers spent grain as depicted below. Within the bakery category, cookies, breads, and buns are most able to incorporate BSG as part of a flour mixture. Other uses included soup and incorporation into take-home meals where spent grain could be used in wet or dry form, but primarily as a flour replacement or additive as the wet form has a very short shelf life.

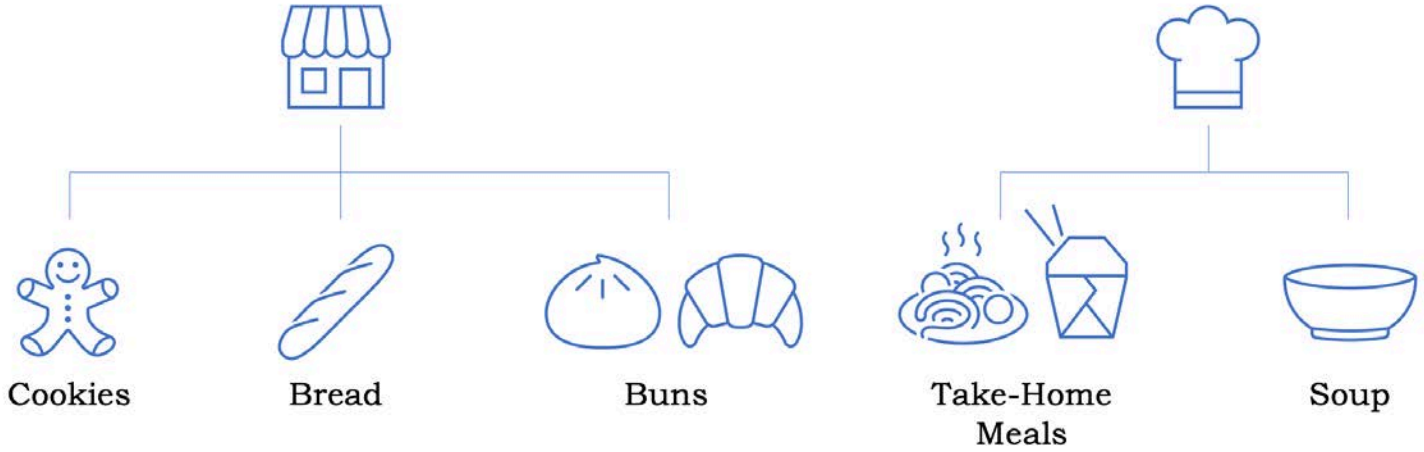


Figure 4.22. The most likely products of existing and interviewed food companies to incorporate upcycled BSG.

Objective 6

Identify and evaluate the intermediate steps required to link BSG with potential users.

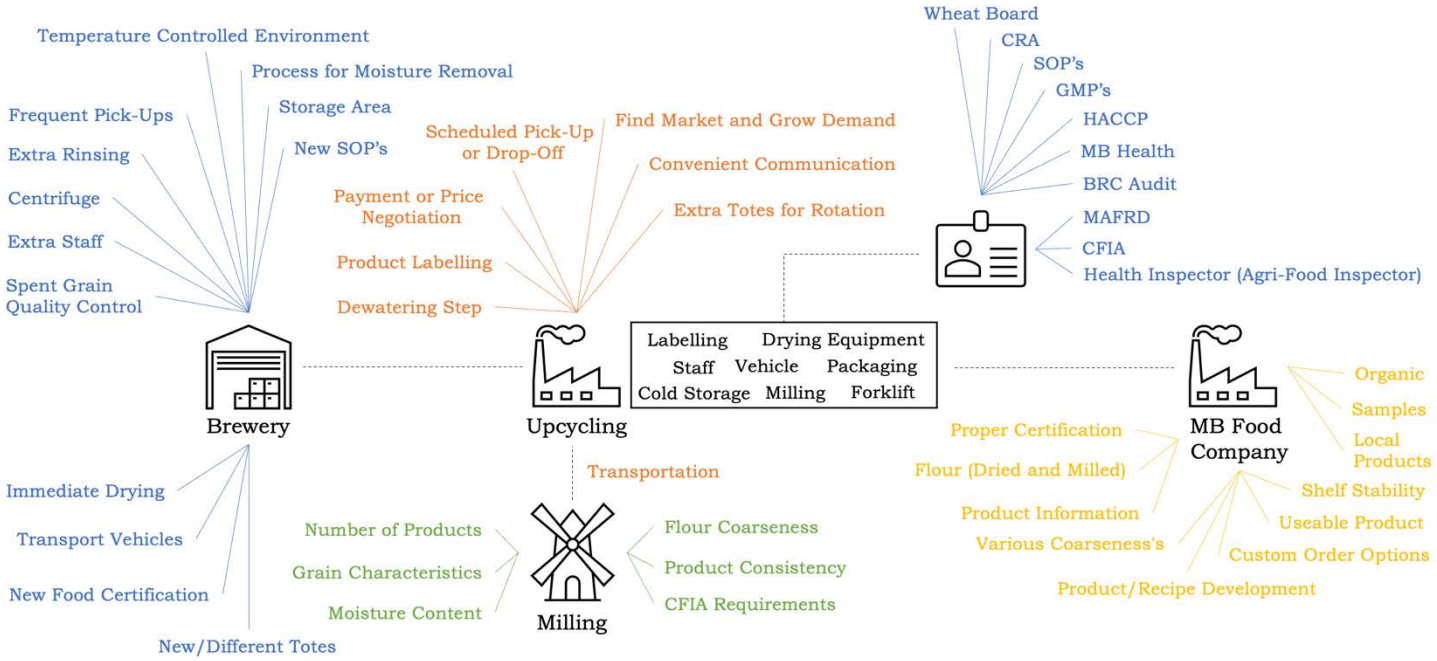


Figure 4.23. The intermediate steps required to upcycling BSG in Winnipeg as noted by all interview participants and divided by industry with brewery and regulatory steps in blue, upcycling company in orange, milling in green, and food company in yellow.

The above figure is a representation of the combined responses of all participant's suggestions for the steps, processes, equipment/materials, and regulatory processes/authorities that need to be considered in the framework development. Suggestions are divided by the associated industry it affects, with the regulatory considerations potentially affecting more than one industry. The black text in the black box outlines the overall steps involved in upcycling to be considered.

The considerations suggested by Winnipeg brewers are primarily associated around concerns of on-site and inside storage, as well as how current operations will be affected. In order for spent grain to remain a human-grade product, there are potential changes needed with the way it's stored and handled to ensure product quality and safety, especially with indoor brewery space being limited and valuable. The primary considerations to do with the upcycling operation have to do with transportation and the market demand. The development and introduction of a new food product involves a lot of planning to ensure success. As this is the research stage, thorough planning and realistic scaling options are a priority. Aspects to consider when evaluating the feasibility of milling grain off-site have to do primarily with the characteristics of the raw product and the desired final product(s) and will be compared with an option for on-site milling with emission and sustainability aspects as part of analysis. Food company considerations are centered around their ability to create a feasible and desirable final product. The framework options will take into consideration the current products of participating companies as well as the potential of making similar upcycled spent grain products to what other upcycling companies are already doing, which will further consider scaling and retail options. Finally, regulatory requirements are primarily needed for the upcycling operation with some changes potentially needed within the brewery and food company.

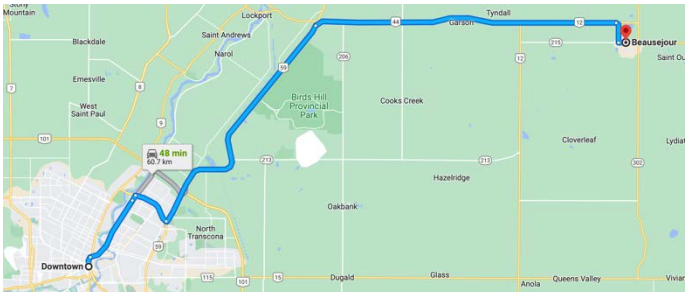
The purpose of this question was to generate as many ideas as possible for the framework to create a variety of suggestions of potential routes. The data above considers the needs of each affected industry within the framework and will be used in combination with each industry's barriers to evaluate the best possible option for all affected parties. The intention is to consider all the above suggestions in a variety of ways that might change the affected industry/establishment and/or remove/minimize the barriers as much as possible to encourage participation.

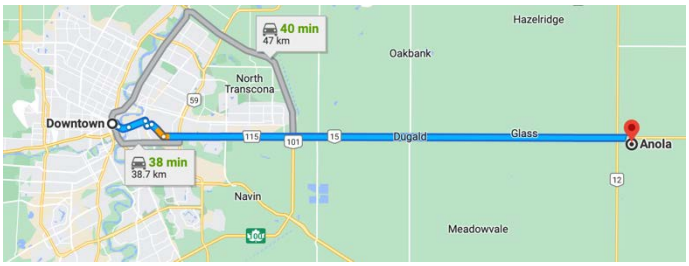
Objective 7

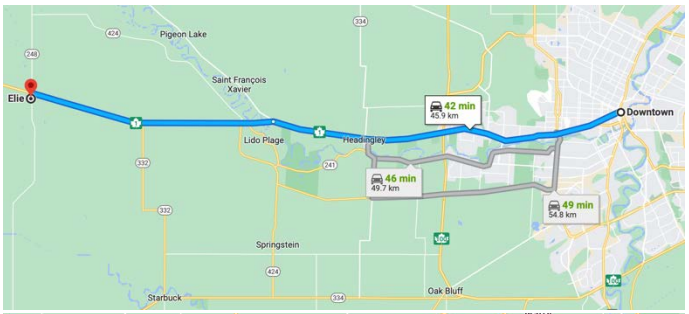
Quantify the energy/CO_2 emission differences of current waste management strategies compared with the final framework.

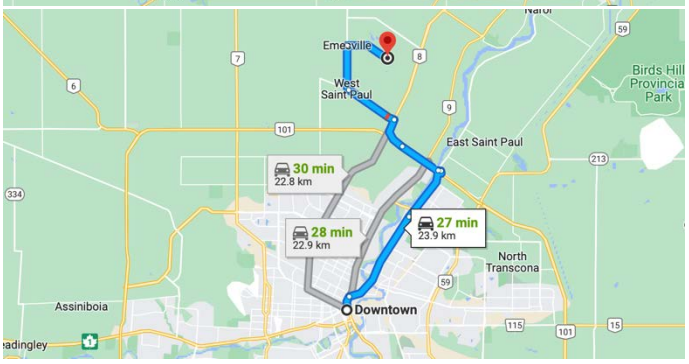
Winnipeg Craft Brewers

A combined 340 km are driven almost every single week of the year in an effort to upcycle spent grain to farmers as ruminant feed. Google Maps was used to map travel distances and visualize trips made for this report (2). For calculation purposes, all distances are measured from 'Downtown Winnipeg' with 'City' being the distance inside the perimeter highway and 'Highway' is outside.









Route 1

Figure 4.24. Beausejour to Winnipeg route (Google Maps).

Beausejour to Winnipeg
Farmer Picks Up
61 km/trip = 122 km Total
Once per Week
Dodge 2500, Diesel
14.5 L/100km HW, 18.9 L/100km City (3)

Route 2

Figure 4.25. Winnipeg to Anola route (Google Maps).

Winnipeg to Anola
Brewery Drops Off
39 km/trip = 78 km Total
Once per Week
5-Ton Truck
29.6L/100km

Route 3

Figure 4.26. Elie to Winnipeg route (Google Maps).

Elie to Winnipeg
Farmer Picks Up
46 km/trip = 92 km Total
Once per Week
Pickup Truck w/ 2 Axle Flatbed Trailer
14.5 L/100km HW, 18.9 L/100km City

Route 4

Figure 4.27. West St. Paul to Winnipeg route (Google Maps).

West St. Paul to Winnipeg
Farmer Picks Up
24 km/trip = 48 km Total
Pickup Truck w/ Flatbed Trailer
14.5 L/100km HW, 18.9 L/100km City

Trip 1: ((47 km Highway x 2) x 14.5 L/100km) + ((14 km City x 2) x 18.9 L/100km) = 18.92 L (D)
Trip 2: ((24 km Highway x 2) x 29.6 L/100km) + ((15 km City x 2) x 29.6 L/100km) = 23.09 L
Trip 3: ((32 km Highway x 2) x 14.5 L/100km) + ((14 km City x 2) x 18.9 L/100km) = 14.57 L
Trip 4: ((13 km Highway x 2) x 14.5 L/100km) + ((11 km City x 2) x 18.9 L/100km) = 7.93 L

Price: (18.92 L (Diesel) x $1.60/L) + (45.59 L (Gasoline) x $1.53/L) = $100.02/Week

To move brewers spent grain 340 km/week, a total of 18.92 L of Diesel and 45.59 L of gasoline are consumed, costing an average total of $30.27 in Diesel and $69.75 in Gasoline (Feb. 16, 2023 prices) every week. If this is done every week of the year, a total of $5,201.04 is spent moving brewers spent grain.

According to Natural Resources Canada, every litre of gasoline produces 2.29 kg (5.05 lbs) of CO_2 emissions, and every litre of diesel produces 2.66 kg (5.86 lbs) (4). This means that not only does it cost $100.02/week ($5,201.04 Annually) to move spent grain, but this effort to upcycle produces a total of 154.73 kg (341.12 lbs) $C0_2$ every single week of the year (50.33 kg (110.96 lbs) CO_2 from Diesel, 104.40 kg (230.16 lbs) CO_2 from Gasoline). To put this into perspective, the annual CO_2 emissions of this upcycling route is 8,045 kg (17,738.24 lbs).

Fuel type	CO_2 tailpipe emissions (kg/L)
Gasoline	2.29
E10 (10% ethanol + 90% gasoline)	2.21
E85 (85% ethanol + 15% gasoline)	1.61
Diesel	2.66
B5 (5% biodiesel + 95% diesel)	2.65
B20 (20% biodiesel + 80% diesel)	2.62

Figure 4.28. CO_2 emissions of various fuels according to Natural Resources Canada (4).

Manitoba Milling Companies

Within the development of the final framework recommendation lies a choice of whether to mill onsite, which requires the purchase of milling and labelling equipment, or whether to have milling done with an established milling company. Because the exact vehicle is not known, a cost and emissions calculation will be done using the same values used for the previous transportation calculations (5-ton truck = 29.6 L/100km, Pickup w/ trailer 14.5 L/100km HW, 18.9 L/100km City). Dan DeRuyck of *The DeRuyck's Top Of The Hill Farm* (Treherne, Manitoba) provided information about the milling process and his business offers grain cleaning services, milling, and packaging and labelling of finished product (https://www.topofthehillfarmderuyck.ca), and will be used for analysis.

With the current supply of spent grain of participating brewers, a total of 51,016 kg (112,471 lbs) of dried spent grain is produced annually, equalling approximately 981 kg (2,163 lbs) weekly or 140 kg (308 lbs) daily. While the exact totes and vehicle are not known at this time, it can be assumed that a truck with a flatbed trailer would need to make a weekly trip which a 5-ton enclosed truck might be able to carry 2 weeks' worth of dried product.

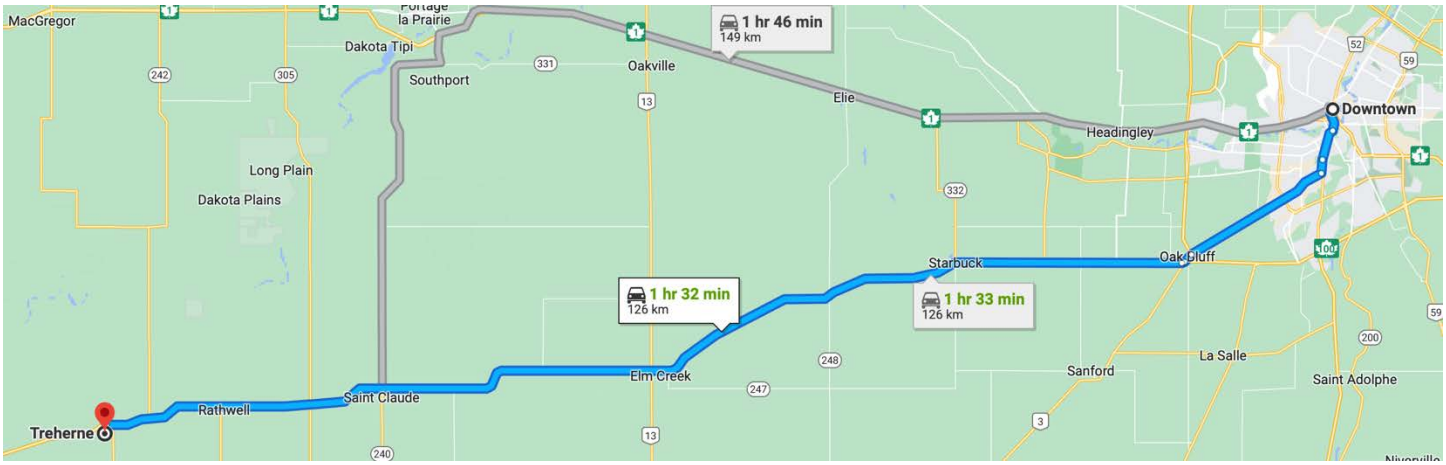


Figure 4.29. Most direct route from Winnipeg, MB to Treherne, MB (Google Maps).

Milling Route Calculations

Winnipeg to Treherne = 126 km/trip (105km HWY, 21 km City) = 252 km roundtrip

- Pickup truck w/trailer = Weekly Route = 14.5 L/100km HW, 18.9 L/100km City
  ((105 km x 14.5 L/100km) x 2) + ((21 km x 18.9 L/100km) x 2) = 38.39 L Gasoline/Roundtrip
  Price: 38.39 L x $1.53/L = $58.74 Roundtrip x 52 Weeks = $3,054.48 Annually
  CO_2 Emissions: 2.29 kg/L x 38.39 L = 87.91 kg x 52 weeks = 4,571.32 kg CO_2 (10,078.03 lbs)

- 5-Ton Truck = Bi-Weekly Route = 29.6 L/100km
  ((105 km x 29.6 L/100km) x 2) + ((21 km x 29.6 L/100km) x 2) = 74.59 L Gasoline/Roundtrip
  Price: 74.59 L x $1.53/L = $114.12 Roundtrip x 26 Weeks = $2,967.12 Annually
  CO_2 Emissions: 2.29 kg/L x 74.59 L = 170.81 kg x 26 weeks = 4,441.06 kg CO_2 (9,790.86 lbs)

If milling off-site were the ideal option for the framework, a weekly round trip in a pickup truck with a trailer would be almost equivalent in price ($3,054.48 vs $2,967.12 annually) and CO_2 emissions (4,571.32 kg CO_2 vs 4,441.06 kg CO_2 annually) as a bi-weekly trip in an enclosed 5-ton truck (with the 5-ton scoring slightly better in both categories). The choice to mill off-site would then likely also result in the decision to use a 5-ton truck for transportation for three primary reasons: (1) the price and carbon emissions are slightly lower with this option, (2) the enclosed vehicle provides shelter to the food product, and (3) a bi-weekly route is less likely to be affected by Manitoba weather than if the framework were dependent on a weekly route. However, an important consideration with this option is how scheduling will be done as DeRuyck's specializes in organic grains, therefore a conventional grain requires considerable equipment cleaning after milling.

The Case in Winnipeg and Manitoba

So what do we know as a result of all this data? What do the numbers say? The graph below outlines some core numerical values within the framework and is based on data provided from the breweries and food companies who have participated in interviews.

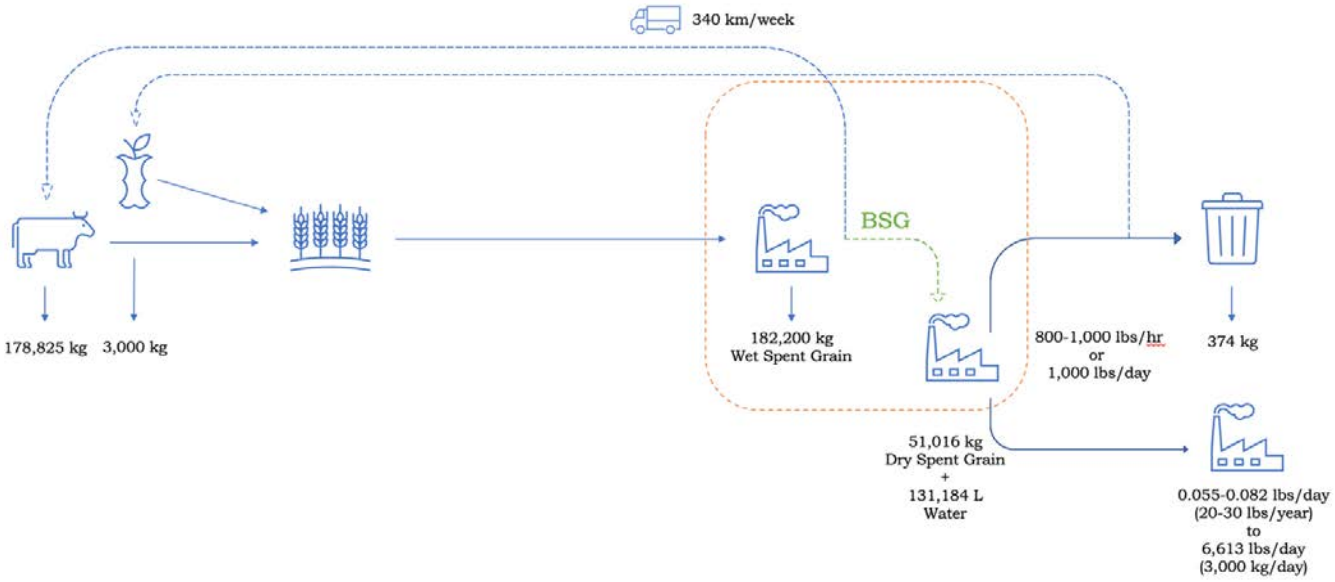


Figure 4.30. Visualization of spent grain movement and associated volumes with the proposed local BSG upcycling.

There is approximately 182,200 kg of wet spent grain produced annually among the participating Winnipeg craft brewers. 374 kg of that wet spent grain goes to landfill, 3,000 kg goes to compost, and a total of 340 km are driven weekly to transport 178,825 kg of spent grain to farmers for animal feed. If the total spent grain volume were upcycled, the process would yield approximately 51,016 kg of dried spent grain and 131,184 L of water. The available drying equipment options could dry either 1000 lbs/day or 800-1000 lbs/hr.

An annual wet spent grain supply of 182,200 kg would require an average of 700 kg of spent grain to be dried on a daily basis (260 working days, Monday to Friday schedule). 700 kg is equal to 1,543 lbs, therefore requiring the 800-1000 lbs/hr drying capacity for a Monday-Friday operation schedule. If a Monday-Sunday schedule were chosen, 182,200 kg annually requires an average of 500 kg to be dried daily and the 1000 lbs/day tray dryer would be sufficient.

An annual supply of 51,016 kg of dried spent grain is equal to 112,471 lbs, and averages to approximately 308 lbs every day of the year (365 days). This will be an important value throughout analysis as it indicates that the current potential supply cannot meet large or industrial sized demand and the potential users would need to be multiple small-scale operations, and/or retail. While this value is based on current supply and demand, a lot of consideration will need to go into the possibility and desire for scaling and how that affects equipment and framework choices. As it appears, the tray dryer will limit scaling potential while the drum dryer would allow upcycling to grow in Winnipeg.

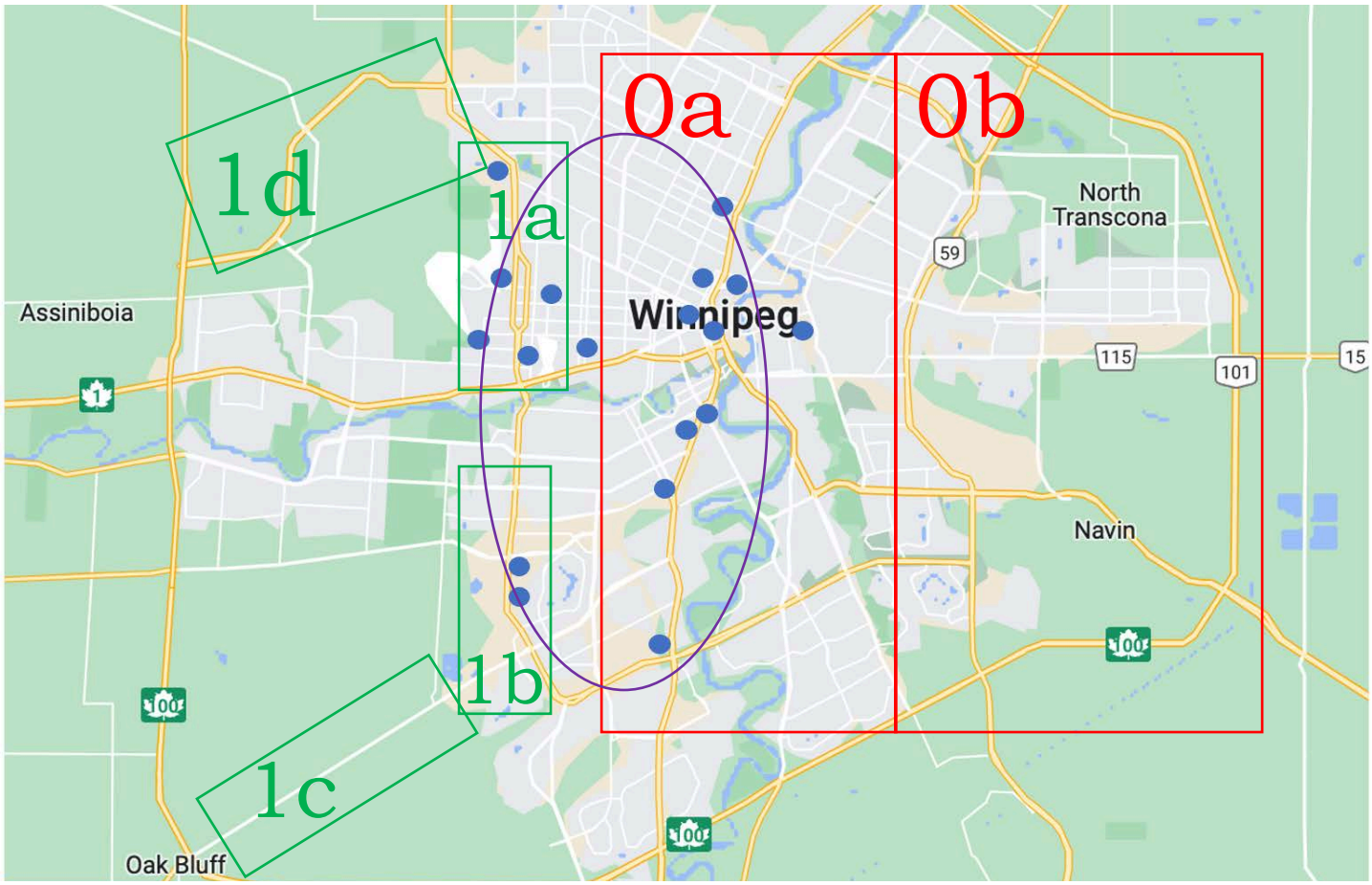


Figure 4.31. Mapped preliminary considerations for upcycling company placement within Winnipeg, MB with existing breweries marked in blue, desirable facility location areas marked in green, and undesirable areas marked in red (Google Maps).

The above map of Winnipeg marks all brewing locations with blue dots, and the purple oval represents a general transport route loop among all breweries with the consideration that the upcycling spent grain would grow in both supply and demand. Considerations for the location of the upcycling establishment are as follows:

- Zone 1a: Area encompasses multiple breweries and has many industries/businesses within a short distance. This area offers the potential for convenient retail space to consumers and is moderately accessible with large vehicles.
- Zone 1b: Area encompasses 2 large breweries, offers room for growth/storage, and is surrounded by industries/businesses. This area offers the potential for convenient retail space to consumers and is accessible with large vehicles (e.g. delivery vehicles and farmers).
- Zone 1c: Area is increasingly developed and offers room for growth/storage and/or a large establishment with easy access for larger vehicles. Less potential for a successful retail space.
- Zone 1d: Area is increasingly developed and offers room for growth and/or a large establishment with easy access for larger vehicles. Not ideal for retail space.
- Zone 0a: Not desirable as the area is dense/busy and would be difficult to operate delivery vehicles in at certain times of day. Also not convenient for farmer access.
- Zone 0b: Not desirable as it's the furthest away from all brewing locations.

General Thoughts Around Upcycling

Winnipeg Craft Brewers

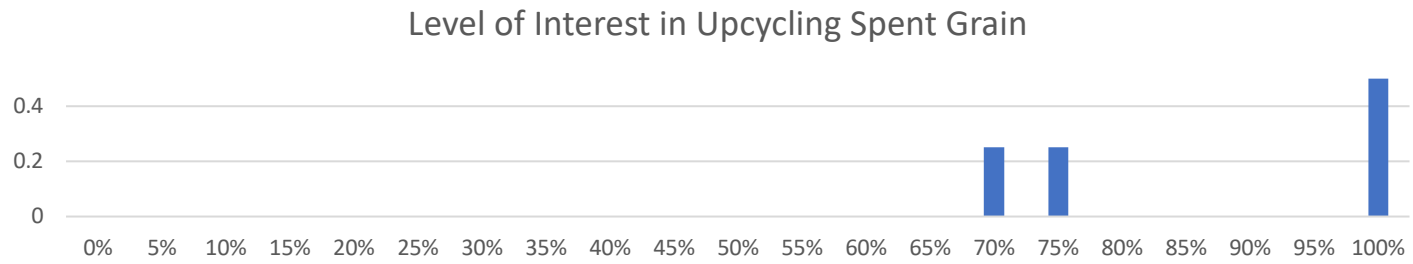


Figure 4.32. The indicated level of brewery interest in upcycling BSG locally at the time of research.

Among the brewery participants, ¼ have a 70% interest in upcycling their spent grain, ¼ have a 75% interest, and 50% have a 100% interest. Breweries are interested in increasing the sustainability of their operations and adding value to spent grain, potentially as a new revenue stream. However, some reservations arise with the unknowns surrounding this potential.

Table 4.3. Tabulated responses of the business structure most likely to succeed for upcycling BSG in Winnipeg, MB with individual's responses each in their own colour.

	Best for Upcycling	Most Interested In
Sole Proprietorship	X	X X
Partnership	X	X
Co-Operation	X X	X X
Other:		

As all breweries indicated they were willing to work with other breweries to upcycle spent grain, it was of interest to know in what way. The table above shows the variation of responses between participants as to what the best business structure for the framework would be. Some benefits of Sole Proprietorship are that the brewery owners wouldn't need to run two companies and decision-making would be more efficient. Some noted benefits of a partnership or co-operation are that there are multiple investors, many sources of intellect and expertise, and breweries could work together to supplement BSG demand and reinvest profits into upcycling initiatives to grow business.

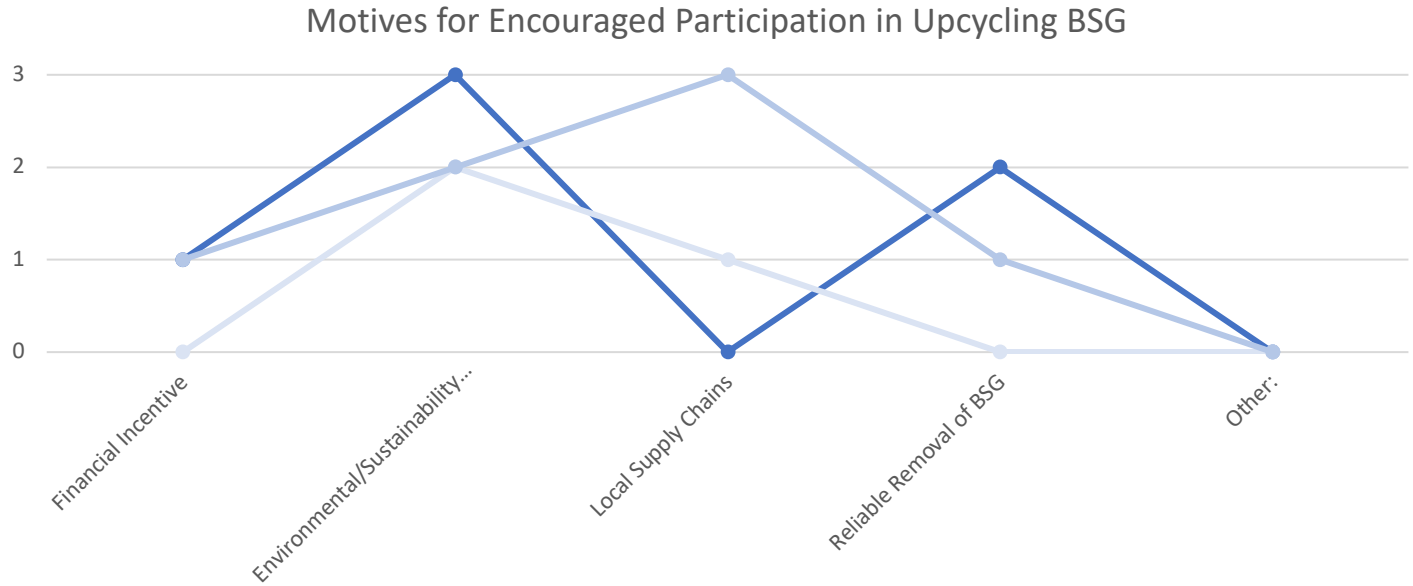


Figure 4.33. Documented motivations of Winnipeg craft brewers for interest in upcycling BSG by their top three motivators in order of importance (1 is most important), with 0 indicating choice is not a primary motivator.

A strong motive to participate is required from all affected parties of the framework for upcycling success to be a real potential. Breweries were asked to value the following motives in the level of importance to them (0: N/A, 1: Highest Motivator, 3: Lowest Motivator). Responses indicate that the strongest motivator for breweries to participate would be a financial incentive, followed by reliable removal of spent grain, and third is environmental/sustainability initiative of upcycling.

Manitoba Milling Companies

The milling company we spoke with had no concerns with the idea of using upcycled food products and expressed that it's a great opportunity if there's demand for such products.

North American Upcycling Companies

When speaking with upcycling companies and representatives, all participants shared they had no reservations or concerns about upcycling. In fact, their businesses are experiencing growth with overall increasing consumer awareness regarding environmental issues and climate change. One company we spoke with is concentrating on research and development, including developing the equipment to give other companies and industries the ability to upcycle. Overall, the companies upcycling spent grain and other products are optimistic and confident the industry will continue to grow and develop.

Brewers spent grain is commonly viewed and treated as a waste product, or at least a product of lesser value than beer. Companies upcycling products commonly viewed as waste have a unique hurdle in advertising and creating demand. The companies we spoke with shared several methods they used to 'create excitement around waste'. First off, upcycling needs to result in a product that tastes good and is nutritious to be desirable to consumers. Local supply chains and sustainability aspects of the product are appealing to consumers who are concerned with such things, especially when they can contribute by buying products they already need. Creating this excitement can be done through consumer education in various ways such as hosting public events, education on packaging, and creating opportunities for direct conversation in businesses (such as breweries!).

Manitoba Food Companies

None of the participating food companies expressed any immediate or long-term reservations or concerns with using upcycled ingredients within their products. In fact, participants are conscious of food waste issues and that they don't want to waste good food, they are interested in trying new ingredients, and expressed that upcycling should be promoted more.

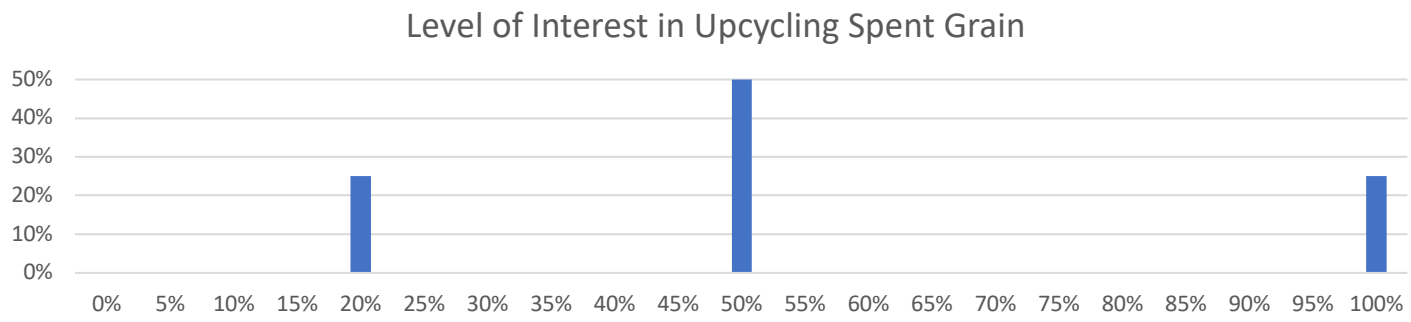


Figure 4.34. The indicated level of food company interest in using upcycled BSG in products at the time of research.

The food company participants expressed a lower initial interest in using upcycled spent grain in their products. 25% of participants indicated they could only be 20% interested at this time, half expressed a 50% interest, and the final ¼ indicated they were 100% interested. Reservations correlated with the barriers to use outlined in Objective 3, primarily to do with how it can be incorporated and how it affects sensory characteristics. As the potential users of upcycled spent grain, participants showed interest in the product but would require more information on the ingredient and obtain samples for product development before committing full interest.

Brewers Spent Grain Nutritional Profile

Brewers spent grain is "constituted by the husks that covered the original barley malt grain in mixture with part of the pericarp and seed coat layers that are obtained as residual solid material after the wort elaboration step" (5 p. 1264). Depending on the type of beer brewed and the desired flavours, other cereal grains may be added therefore changing the nutritional profile of spent grain but this analysis will consist of barley spent grain as it is the base ingredient and major component of brewers spent grain.

Although BSG is largely composed of fibre, proteins and minerals, spent grain can vary in chemical composition due to a number of factors including barley variety, harvesting time and conditions, malting and mashing techniques used by the craft brewery, and other cereals added to the brewing process. However, overall, brewers spent grain is rich in proteins, sugars, and minerals, and samples remain fairly consistent across breweries (5 p. 1264). Appendix A.2 of the background information report shows the variations among BSG in different countries that may arise from one, some or all the factors affecting composition.

Dietary fibre, a significant portion of BSG nutritional profile; is a carbohydrate. Carbohydrates are organic compounds with a ratio of one carbon, one oxygen and two hydrogen in a repeating chain, and consist of simple and complex carbohydrates, depending on chain length. Complex carbohydrates are long chains of monosaccharides, called polysaccharides and can be classified as starches or fibres (6 p. 265). Cellulose is a "complex carbohydrate, or polysaccharide, consisting of 3,000 or more glucose units." It is not digestible by humans (7) and is therefore a significant source of fibre in spent grain. Dietary fibre passes through the human digestive track until they are broken down by bacteria in the large intestine. Fibre provides health benefits including protection against cardiovascular disease, obesity, type 2 diabetes, and is generally important for digestive health (8 p. 291).

Hemicellulose is also a dietary fibre, thus a polysaccharide (8 p. 269). Hemicelluloses are classified into four different cell-wall classes; xylans, mannans, β-glucans, and xyloglucans. Xylans are diverse polysaccharides, part of the plant cell wall, and comprise of 20-50% of the Hemicellulose biomass depending on the type of plant (9 p. 5). Arabinoxylans (AX) are a major hemicellulose component of cell walls of the starchy endosperm and outer layers of cereals grains, and account for approximately 40% of BSG on a dry weight basis (10). Barley grains are high in β-glucans (5-11%), which have shown to have effects on the glycaemic, insulin and cholesterol responses to foods (11).

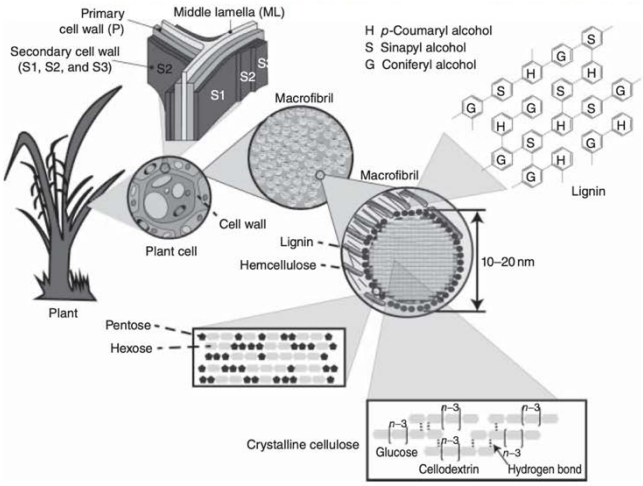


Figure 4.35. Scheme of the microfibril and structure of the plant cell wall (9 p. 5).

Lignin comprises a large portion of BSG but lacks an exact definition due to the diverse structural complexity and molecular complexity of this plant-

derived biopolymer (12 p. 11). Lignins are found in plant cell walls, specifically in the middle lamella and the secondary wall (12 p. 13). As shown in Figure 5, cellulose, hemicellulose and lignin form microfibrils which mediate the structural stability of plant cell walls. Lignans are classified as natural products with many studied and reported biological activities including antiviral, anticancer, cancer prevention, anti-inflammatory, antimicrobial, antioxidant, immunosuppressive, hepatoprotective, and prevention against osteoporosis (12 p. 370). Properties such as antimicrobial, antifungal, antiviral, antioxidant, insecticidal, and antifeeding likely aid in plant defense, but exact functions are not clear (12 p. 383).

Acetyl groups form a small portion of the major components of BSG and is "a small molecule made of two carbon, three hydrogen, and one oxygen atoms. Acetyl groups are added to or removed from other molecules and may affect how the molecules act in the body" (13). "N-acetyl amino acids are being considered as ingredients in chemically-restricted diets and for fortifying plant proteins to increase their biological value" (14 p. 17).

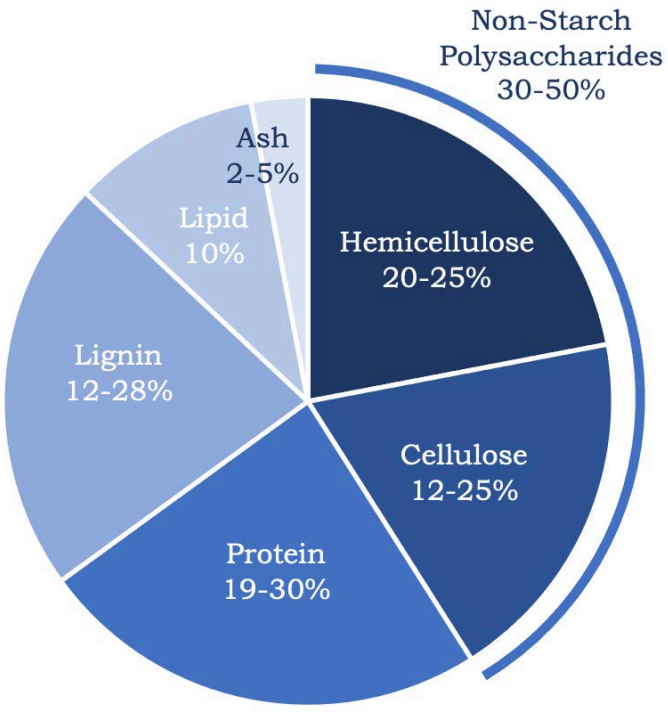


Figure 4.36. Typical barley BSG composition. Graph replicated from (10 p. 555), adapted from (45) and (46)

Brewers spent grain usually has a 20% protein content but may be as high as 30% (10), and consists of mainly hordeins, glutelins, globulins, and albumins (15). Proteins supply the building blocks for protein biosynthesis, a process where cells build proteins, and "directly contribute to the flavour of food and are precursors for aroma compounds and colors formed during thermal or enzymatic reactions in production, processing and storage of food" (14 p. 8). Of the total spent grain protein content, approximately 30% is essential amino acids. Lysine represents 14.3%, leucine at 6.12%, phenylalanine at 4.64%, isoleucine at 3.31%, threonine at 0.71% and tryptophan at 0.14% of total protein. The remaining 70% protein content is non-essential amino acids comprising of histidine at 26.27%, glutamic acid at 16.59%, aspartic acid at 4.81%, valine at 4.61%, arginine at 4.51%, alanine at 4.12%, serine at 3.77%, tyrosine at 2.57%, glycine at 1.74%, asparagine at 1.47%, γ-aminobutyric acid at 0.26%, and glutamine at 0.07%. Lysine is generally a limiting amino acid in other cereals, which makes BSG valuable (16).

A final consideration of the nutritional value of BSG is the 1.13% mineral content, of ™h calcium, magnesium and phosphorous are relatively high. Fortification of food products with calcium may contribute to reduced risk of osteoporosis and colon cancer (17), while magnesium offers protective effects against Type-2 Diabetes. Phosphorous contains an anti-nutrient called Phytate, which is reduced through lactic acid bacteria fermentation, resulting in the increased magnesium and phosphorous minerals. The poly-phenol concentration in BSG is higher than in barley grain, offering "DNA-protective effects by acting as powerful antioxidants" (16 p. 772). Overall, BSG is rich in nutrients and have potential to add quality nutrition in human diets.

Brewers Spent Grain Sensory Qualities

Brewers spent grain has mostly been studied in bakery products with some studies summarized in Appendix 1. As a flour product, BSG is usually dried and then milled. Sieving has also

been studied as various fractions of the milled product can be separated (10 p. 561). Upcycling BSG to bakery products has been tried with breads, biscuits, cookies, muffins, cakes, waffles, pancakes, tortillas, snacks, doughnuts and brownies. BSG can increase the protein, fibre and amino acid contents while decreasing the overall calories in a food product. BSG incorporation increases water absorption and decreases fat absorption but is best incorporated in coloured products to not alter the final products appearance. It's been found that up to 100 g kg^{-1} in food formulations, or 10% has the best results (5 p. 1267) to minimize any unwanted textures in final products.

Barley is a rich source of β-glucans (11 p. 1) at 5-11% (18). As mentioned, Canada primarily grows 2-rowed barley which has been found to be higher in β-glucans than 6-rowed barley varieties (19). "Inclusion of barley β-glucans into breads showed that increased mixing and fermentation times resulted in a decrease in their molecular weight (MW), although the cellotriosyl/cellotetraosyl ratio was unaffected by these processes" (11 p. 8) (20). MW did not differ between dough and baked bread, indicating β-glucans were not affected (11 p. 8) and that health benefits are not compromised.

A 2021 study incorporating spray-dried brewers spent grain and fermented brewers spent grain at two concentrations (source of fibre (SF), and high in fibre (HF)). The higher concentration showed "rapid protein network formulation followed by a fast breakdown" as well as "two peaks, indicating the aggregation of two protein groups" (21 p. 1646) while both concentrations showed a faster and stronger gluten development with increased dough resistance/stiffness. "Fermentation improved bread characteristics resulting in increased specific volume, reduced crumb hardness and restricted microbial growth rate over time" (21 p. 1639). This study shows that fermented BSG can improve bread characteristics as opposed to dried BSG at moderate quantities. Another study done on the incorporation of fermented BSG in Sourdough bread found that the loaf colour darkened as the concentration of BSG increased, and a reduction of bread cross-section likely due to the gluten matrix being interrupted by the increased fibre (22 p. 100).

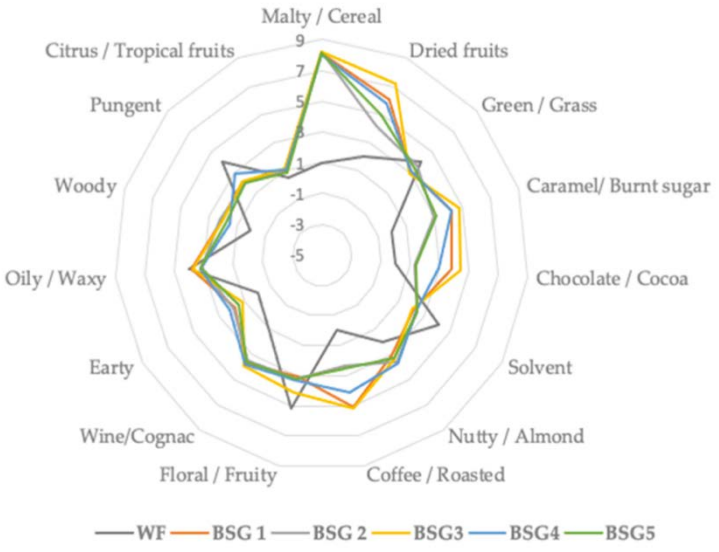


Figure 4.37. Aroma profile of wheat flour (WF) and different BSG types of main compounds classes identified during GC-MS analysis. (25 p. 2511)

A study on the addition of BSG in bread found that the xylan interaction of BSG with starch affects bread-making quality and "studies on the effect of ws-Axs on gelatinization and retrogradation of starch revealed that addition of the xylan had no effect on gelation kinetics, but enhanced the storage modul G', and influenced starch retrogradation" (9 p. 17). Retrogradation is when "disordered amylose and amylopectin molecules of gelatinized starch hydrophobically interact with one another to form an ordered structure." "The retrogradation properties of starch are related to a range of quality attributes of starch-based food products, such as bread staling and digestibility" (23 p. 93).

Also with bread, arabinoxylans (AX) are a major hemicellulose component of cell walls of the starchy endosperm and outer layers of cereals grains, and account for approximately 40% of BSG on a dry weight basis (10). Part of AX is water-extractable while the majority is released in alkali solutions. "The alkali-extractable AX samples are of particular interest as they have similar but stronger bread-improving properties than the water-extractable AX, which were usually supposed to be the most responsible for the baking performance of cereal flours" (9 pp. 10-11).

In making breadsticks, scanning electron microscopy shows that while wheat flour has lentil-shaped starch granules, BSG flour is virtually void of starch and appears rough. BSG was added at 15%, 25% and 35% with a baked colour darker in accordance with higher concentrations of BSG. As with the bread, higher BSG content also resulted in a flatter breadstick which is associated with the increased fibre content, which also jeopardized the cellular structure resulting in a loss of crispness. The breadsticks were observed to have a more stable shelf life due to slow moisture and a_w changes over time as water was bound and not free (24).

BSG was studied as an ingredient in cookies to increase nutritional value, functional properties, and sensory characteristics. Another 2021 study (25) found that various BSG samples used at a 20% ratio with wheat flour showed large variations in final colour of the cookies. As shown in *Figure 7*, the variety among different malts and ingredients can result in a variety of different flavours in a final product that's used BSG. This same study also found a higher moisture content in the BSG samples due to the increased fibre content which could lead to a shorter shelf life, while the increased protein content "influences the spread ratio value in a positive way" (25 p. 2518).

BSG has also been studied in extruded products such as chickpea-based snacks, where it was found to "significantly increase protein content, phytic acid and bulk density, decreased sectional expansion index, individual area and total area of the cells". Higher contents of incorporated BSG resulted in a rougher surface and thicker cell walls. (26 p. 469)

An interesting study incorporated dried and ground BSG of various sizes to beef Frankfurters at 1%, 3% and 5%. Results showed that BSG increased the fibre content of the frankfurters with the course ground having the highest increase. The final colour was not significantly different, but acceptance testing has lower results (lowest was 5.47) when compared with the control Frankfurter (7.57) which is likely due to the decreased fat percentage. While acceptance scores decreased with the increase in BSG concentration, scores were still relatively positive, which led to the conclusion that BSG can be added in small amounts without compromising sensory parameters (27).

In relation to plant proteins, acetyl groups are added to or removed from other molecules and may affect how the molecules act in the body" (13). "Acetylated starches with low DS (degree of substitution) are used in food industry as agents of texture, consistency and stability in food and current being studied in the development of biodegradable packaging and pharmaceutical applications" (28 p. 249). "N-acetyl amino acids are being considered as ingredients in chemically-restricted diets and for fortifying plant proteins to increase their biological value" (14 p. 17).

Upcycled Certification

The Upcycled Food Association (1) is on a mission to 'reduce food waste by growing the upcycled economy and educating consumers about upcycled products', and offers 'the world's first certification program for upcycled food ingredients and products' (29). There are four steps to certification (30):

1. Scoping: Connect with UFA and the certifying body (CB) to determine scope of audit.
2. Audit: Submit documents for an audit which can be a desk audit for 95% of companies.
3. Licensure: Update your packaging and marketing assets with the Mark.
4. Launch: Celebrate your impact with your consumers!

Food and beverage products are eligible for certification and can be (1) Upcycled Ingredient(s) (UI), (2) Product Containing Upcycled Ingredient(s) (PUI), and (3) Minimal Content PUI(s) (31 p. 9). A UI is ≥95% upcycled input, a PUI must be ≥10% upcycled input, and a minimal content PUI is <10% upcycled input (31 pp. 12-13). More information on The Upcycled Food Association and the certification process can be found at https://www.upcycledfood.org.

Appendices

APPENDICES 95

APPENDIX A. FOOD PRODUCTS MADE WITH BSG 96

Appendix A. Food Products made with BSG

Table 4.A.1. Studies done on incorporating BSG in various food products at different concentrations, along with main findings. Replicated from Lynch, Steffen, & Arendt (10 pp. 562-564).

Food Product	Processing/form of incorporated BSG (or component)	Proportion BSG incorporated (% w/w)	Main Findings	Reference
Cookies	Oven dried at various temperatures, milled and fractionated into specific flour components	10, 20, 30, 40	Cookies prepared with 20% sieved BSG (dried, 45 °C) had protein, lysine and fibre contents increased by 55, 90 and 220%, respectively, compared with control dough	(32)
Extruded Snack	Extruded	10, 20, 25, 30	Increased fibre and protein content. Phytic acid increased with BSG inclusion.	(33)
Bread (Wheat), baker's yeast, kefir, *Lactobacillus casei* immobilized on BSG	Untreated, (autoclaving followed by microorganism immobilisation)	6, 8 and 10 BSG-yeast/BSG-kefir, 25, 35, 50 BSG-kefir (sourdough), 50 BSG-Lb. casei (sourdough)	Lower specific volume than yeast leavened control bread Sourdough breads had 4-day increased shelf-life Higher number and concentration of volatile compounds in sourdough compared with yeast-dough breads Sourdough had higher moisture retention during baking, lower rates of staling, maintained freshness for longer	(34)
Ready-to-eat snacks of various bases (e.g. wheat flour, yogurt powder, tomato powder)	Flour	10, 20, 30	Increased protein and fibre content with increased BSG	(26)
Bread (wheat)	Four untreated – BSG flour only added to dough Treated – enzymes also added to each dough: Maxlife 85, Lipopan Extra, Pentopan, Pentopan + Celluclast	10, 20, 30	BSG addition significantly improved the fibre level of breads but increased crumb hardness and decreased loaf volume Enzyme addition (except Maxlife 85) improved the texture, loaf volume and shelf life BSG could be added up to 30% to a bread formulation with appropriate enzymes to improve the loaf volume, texture and shelf life	(35)
Ready-to-eat (extruded) snacks	Dried and Milled	10	Increased total dietary fibre No decrease in phytic acid during extrusion	(36)
Frankfurters	Milled and sieved to various fractions	1, 3, 5 (fat substituted)	Dietary fibre and water holding capacity increased with increasing additions of BSG The textural parameters except springiness reduced because of the amount of BSG and the low level of fat Sensory scores decreased as the content of BSG increased	(27)
Breadsticks	Flour	15, 25, 35	15% BSG doubled the content of dietary fibre Decreased volume with increased BSG content Lack of typical cellular structure and altered textural properties Longer shelf-life compared with control	(37)
Bread	Flour produced by: extrusion and milling – untreated (Celluclast BG	12	Enzymatic treated BSG in extruder – no effect on the characteristics of bread Untreated BSG with enzymes added to	(38)

	and Pentopan Mono BG added to dough) Extrusion and milling – treated with Celluclast BG and Pentopan Mono BG during extrusion		the dough – better texture and volume compared with control (e.g. reduced hardness)	
Bread (wheat)	Untreated flour (BSG) Flour fermented with *Lactobacillus plantarum* (BSG SD)	5, 10, 15, 20	Low levels of BSG-SD resulted in softer bread than the wheat bread control Reduced specific volume in breads with increasing BSG/BSG SD Lightening of crust colour on BSG SD incorporation Staling retarded in BSG SD-substituted breads Sensory acceptability, up 10% BSG/BSG SD Perceived sweetness of bread decreased upon addition of BSG and BSG-SD	(39)
Fruit Beverages	Hydroxycinnamic acid (phenolic extracts), liquid	2.5, 10 (%v/v)	Addition of BSG phenolic extracts to juices and smoothies (2.5 and 10%) did not significantly enhance their total phenolic content nor significantly alter the scavenging activity Only ferric reducing antioxidant power (FRAP) activity was significantly increased in cranberry juice with added phenolic extracts compared with the un-supplemented control	(40)
Dough (wheat)	Flour	15, 25, 35	Increased water absorption and dough development time with increasing levels of BSG Decreased final viscosity Storage and loss moduli were increased, indicating more solid-like behaviour Decreased dough height in rheofermenter. Poor extensibility of dough Breads of low volume and dense structure are to be expected	(41)
Baked snacks (crispy-slices)	Flour	10, 15, 25	BSG addition increased the fibre and the protein content of the samples Addition of >10% BSG affected the texture – high levels of BSG led to a closed, compact structure BSG altered the odour profile in the snacks, compounds present in high levels in the BSG flour were observed in high levels in the BSG-containing snacks Use of 10% BSG resulted in snacks with similar texture and structure as the control and was accepted by panellists	(42)
Bread (wheat)	Untreated flour (BSG)Flour fermented with sourdough starter (BSG SD) ± xylanase or dough conditioner	15	Highest firmness observed for BSG and BSG-SD breads Xylanase and dough conditioner reduced firmness of both bread types Antioxidant activity highest in BSG-SD samples Fermentation reduced the phytic acid content of BSG breads by 30% Dough conditioner alone and the combination of BSG-SD + dough conditioner improved the sensory properties of the BSG breads	(43)

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Chapter 5: Final Framework Recommendation Report

Deliverable Synopsis: This deliverable presents the final BSG upcycling framework recommendation for Winnipeg, MB and is supported by the combined results of all project research and additional supporting research. It contributed to the overall project objectives by combining multiple data types in a comprehensive analysis of this case study to make a realistic and convenient framework for upcycling spent grain locally in a more sustainable manner than what's currently being done to dispose of spent grain.

Exploring the Potential of Upcycling Craft BSG in Winnipeg, MB

Final Framework Recommendation
Full Case Study Report
April 2023

Partially funded by the University of Manitoba Graduate Fellowship (UMGF) and Social Sciences and Humanities Resource Council Grant #435-2020-0923

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Disclaimer

The following is a full report with a final recommendation for a Spent Grain Upcycling Framework for Winnipeg, MB based on all research components conducted (Background research, Canadian craft brewer website review, Canada-wide craft brewer survey, Interviews, and Focus Group) as a part of a master's practicum project, administered by Marika Boryen of the University of Manitoba. The following report is based on voluntary data provided by participants throughout the research. As such, data interpretations are not an accurate representation of the entire population, and instead a representation of the data provided by participants to build a case study.

Your use of any of this Report is at your sole and absolute risk. None of the authors, contributors, administrators, vandals, or anyone else connected with this project, in any way whatsoever, can be responsible for your use of the information in this summary report. The survey questions were designed to address a specific set of objectives towards the research project "Exploring the potential of upcycling craft brewers spent grain in Winnipeg, MB" and therefore should not be applied to research/data outside of the intended use, or for any other purpose outside this project.

The interpretation of the generalized data is solely that of the principal researcher (Marika Boryen), and is not necessarily to the author's educational institution, employer, organization, committee, or other group or individual. Marika Boryen assumes no responsibility or liability for any errors or omissions in the content of this report. The information contained in this report is provided to you on an "as-is" basis with no guarantees of completeness, accuracy, usefulness, or timeliness and without any warranties for any kind whatsoever.

Executive Summary

Humans depend heavily on earth's natural resources in every way we live, and the demand is expected to increase with a rising global population. We are amid a climate, environmental, and biodiversity crisis and yet people continue to live carelessly and waste needlessly, particularly food. Nearly a third of all food produced goes to waste while concerns of feeding a growing population grow. Not to mention approximately 1 in 10 people are malnourished while others indulge in low-nutrient diets. We're fast approaching the planets boundaries and are witnessing real effects of climate change. As a population, we need to change the way we think about food and accept change is needed.

Food upcycling, an emerging trend, is an effective method of reducing food waste through systematic and behavioural changes that simultaneously has environmental and social benefits. Additionally, the following benefits of upcycling contribute to Winnipeg's food and beverage industry's ability to consider global environmental initiatives in local actions:

1. Upcycling saves food from going to landfills and puts it back on people's plates.
2. Upcycling food reduces demand on large-scale agricultural food production systems and can stabilize agricultural land use for food production if done at large scales.
3. Innovative upcycling solutions can ensure that current food production volumes feed a growing population well into the future.
4. Upcycling food waste can help the human population live within the planetary boundaries of our existence so that future generations can enjoy it too.
5. Upcycling food reduces some environmental effects of food and beverage production, namely emissions, and contributes to meeting The Paris Agreement targets.
6. Local efforts to upcycle food contribute to meeting the United Nation's sustainable development goal 12.3 to halve per capita food waste by 2030.
7. The incorporation of fibre and other nutrients in common household food items can help increase the nutritional benefits of the products and contribute to increased human health.

Beer, a widely consumed beverage, produces approximately 20kg of brewers spent grain (BSG) for every 100L of beer produced, resulting is huge volumes of 'waste'. However, brewers spent grain isn't waste at all; it's high in nutrients and has lots of life left. Companies across North America have developed innovative ways of upcycling spent grain and the equipment to upcycle in Winnipeg is as close as Minneapolis, MN. Through four stages of research including literature review, website review, a survey, and interviews, the combined data shows there is local supply and demand of spent grain, affected parties have shown interest in the concept, the proposed framework is convenient for all affected food and beverage industries, and would reduce transportation emissions by up to 50%.

As consumers become increasingly aware of environmental concerns, sustainable and nutritious food products will hold higher value than conventional items. Upcycling Winnipeg craft brewers spent grain locally through nutritious, sustainable, and convenient products with the proposed framework offers the opportunity to reduce environmental impacts of food and beverage production on multiple scales, provide local consumers sustainable food options, and become part of global solutions to a changing climate instead of remaining contributors. Part 1 of this report outlines the primary findings of all four research stages and how the methods contributed to framework decisions, recommendations are supported by additional research provided in Part 2, and Part 3 outlines how the project objectives were met.

Report Layout

This document is the final deliverable for the project 'Exploring the Potential of Upcycling Brewers Spent Grain in Winnipeg, MB'. As such, is a comprehensive analysis of the case study pertaining to Winnipeg specifically. For easy navigation, the report is broken down into three primary sections as follows:

PART 1: Research Data

The first part of the report summarizes the primary findings of each research stage starting with the literature review, then the website review, Canada-wide craft brewer survey, and finally the interview findings. The data is then provided as a combined visualization and provides a summary of each framework function/operation.

PART 2: Supporting Research

The second part of the report provides supporting research data that isn't directly needed to meet the project objectives but provides valuable data to consider if implementing the framework, and provides additional data to reinforce the potential and feasibility of upcycling in Winnipeg, MB. Supporting data includes Canadian upcycled spent grain products review, ingredient review, product recommendations for products in Winnipeg, pricing analysis, North American upcycling framework review, possible facility location considerations, a spent grain pickup route suggestion, and additional considerations for finding and developing market demand.

PART 3: Project Objectives

The third and final portion of the report precisely shows how each of the seven project objectives were met and contributed to the decisions made in the final framework.

The Need for Upcycling & Project Mission

Despite being in the 21st century with all the latest technology and all the knowledge we have, "more than 820 million people have insufficient food and many more consume low-quality diets that cause micronutrient deficiencies and contribute to a substantial rise in the incidence of diet-related obesity and diet-related non-communicable diseases, including coronary heart disease, stroke and diabetes" (1 p. 447). With projections of a growing global population, an estimated 9.7 billion by 2050 (2), questions of resource and food availability come to mind. Where will all these people live? Will there be enough resources to support healthy lifestyles and high standards of living? Can we even feed all these people?

2021 Global Population = 7.87 Billion (3)

The overall global situation, represented in *Figure 1*, starts with 40% (1 p. 468) of land mass producing 100% of humans' food. Of the total food production, approximately 30% is wasted (4 p. 4), leaving 100% of the worlds 7.87 billion people living off 70% of the food harvested and manufactured. Approximately 10.42% of the earth's population (820 million people) (1 p. 447) are malnourished, leaving 89.58% of people full on 70% of the food produced. Simply put, each 10% of global food production currently feeds 1.007 billion people adequately. Therefore, the 30% of food that currently goes to waste has the potential of nourishing 3.02 billion people. That 30% of "waste" could not only feed those who are currently alive and malnourished but could also nourish the 2050 projected population if we can find ways to rethink "waste" and improve our food systems at all stages. While it might be unrealistic to expect that every single ounce of food produced will make it to someone's stomach, the potential of this colossal waste is certainly worth some effort.

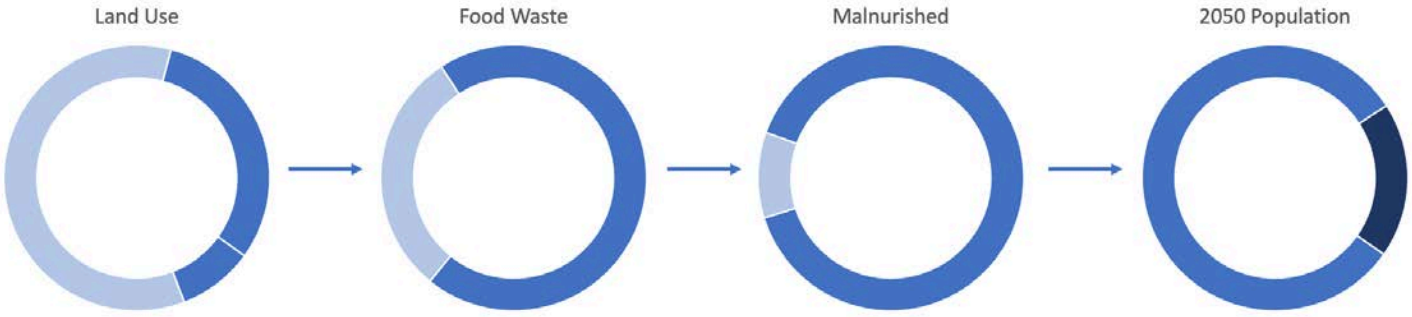


Figure 5.1. Depiction of the projected global population of 2050, highlighting the current number of citizens who are malnourished off modern agricultural production and food waste percentage. Land use is shown as 40% agricultural (23% grazing (lightest blue) and 77% croplands (light blue), while 60% is non-agricultural (dark blue) (1 p. 468). Food waste is shown as approximately 30% of global production wasted (light blue) with 70% consumed (dark blue) (4 p. 4). Malnourishment is shown as 820 million people malnourished globally (light blue), while 7.05 billion are not (dark blue) (1 p. 447). The 2050 global population is shown as a current 7.87 billion (dark blue), with a projected 9.7 billion in 2050 (darkest blue) (2).

Beer, a very popular beverage globally, produces approximately 20 kg of spent grain per 100 L of beer produced (5 p. 556), resulting in substantial amounts of nutritious food wasted as it's not used to it's full potential. Currently, most local brewery's spent grain is transported to farms as animal feed when there's huge potential for use in human food products, mainly as part of a flour mixture in peoples favourite baked products. The numbers suggest we currently produce enough food to feed the projected population if we didn't waste a third of it all. This project specifically concentrates on the brewing industry and upcycling its largest volume by-product to contribute to global efforts in reducing food waste, with special focus on reducing demands on large-scale food production, living within planetary boundaries, The Paris Agreement, The UN's 17 Sustainable Development Goals, and addressing diet gaps with nutritious plant-based foods.

Think global, act local.

Methodology

The overall goal of this project's research is to 'Explore the Potential of Upcycling Craft Brewers Spent Grain (BSG) in Winnipeg, MB'. The objectives include to first define and quantify current waste management strategies for BSG, second is to understand the opportunities and barriers to upcycling BSG, and finally to recommend potential upcycling options. The overall objectives have been broken down in to seven specific objectives as follows:

1. Quantitatively determine if there is enough BSG in Winnipeg to render upcycling plausible
2. Quantify and map what local breweries currently do with their spent grain
3. Document the barriers brewers face in using/moving/storing spent grain
4. Determine if/which breweries are interested in upcycling potential for their BSG
5. Research and identify who the potential users are of BSG as an input in Winnipeg
6. Identify and evaluate the intermediate steps required to link BSG with potential users
7. Quantify the energy/CO_2 emission differences of current management strategies compared with the final proposed upcycling framework

As there are considerably more breweries in Winnipeg than a decade ago, the project is intended to conduct the research necessary to determine if there is sufficient quantity of BSG to generate a local demand of a particular upcycled product(s) which will be presented directly to brewery owners and food processing companies to implement.

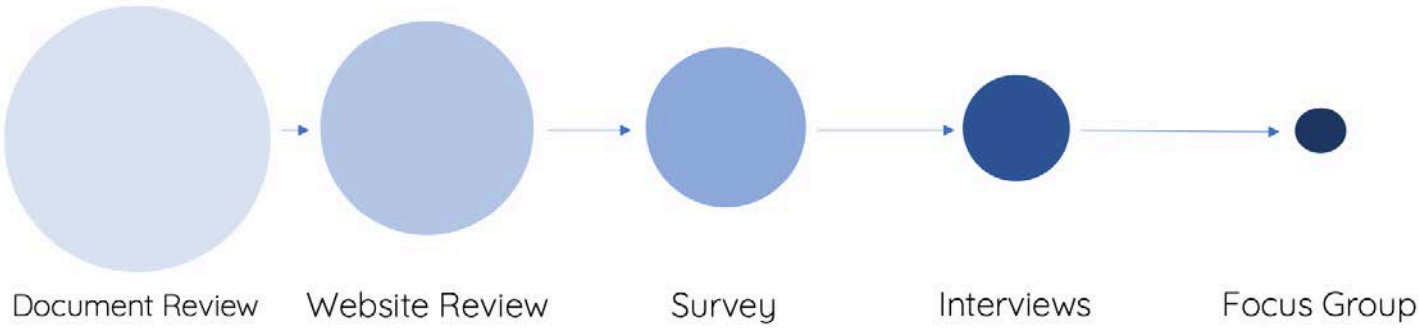


Figure 5.2. A representation of the how the five research stages build upon one another while becoming increasingly specific/detailed.

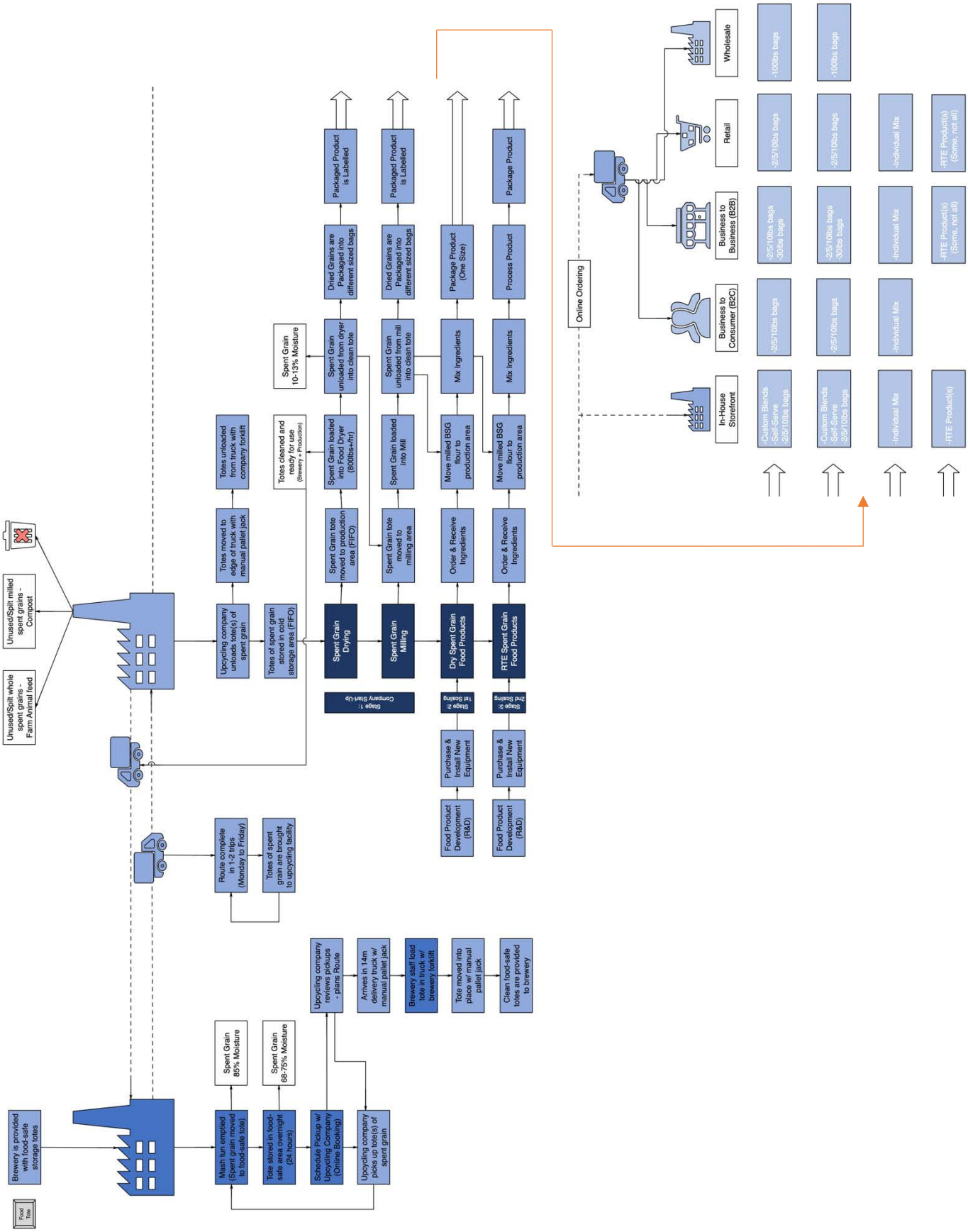
Obtaining data to meet the objectives in this case study will be done with multiple information sources as shown in *Figure 2*, as is typical in qualitative research. Complimentary forms of data will include surveys, interviews, and document review to meet my research objectives rather than basing final recommendations on one data source (6 p. 185).

The project starts with a comprehensive document review to gain as much background knowledge on the research topics and associated issues as possible and is summarized on *Page 112*. This study specifically focuses on upcycling spent grain, the effects/issues with current waste management strategies, current global climate change initiatives, and what upcycling can do to reduce brewery wastes. The second research activity is a website review of all 1165 documented Canadian craft breweries and is summarized on *Page 113*. The website review was specific to Canada and craft breweries and searched for specific terms associated with the research ("Upcycle", "Circular Economy", "Sustainable or Sustainability", "Waste", "Carbon Footprint", and "Spent Grain") to gain a sense of the level of care for the environment among craft breweries. The third data set was acquired from a Canada-wide craft brewer survey as summarized on *Page 115*. Data was specific to upcycling spent grain in Canada and was the first form of participant data. The fourth research stage included interviews with relevant companies to further refine data specifically to Winnipeg brewers and food companies as summarized starting on *Page 117*, allowing for the best possible framework recommendation as shown on *Page 110*.

Table 5.1. A visualization of the projects three main objectives broken down into the seven guiding objectives and the associated data collection methods and data sources/participants to meet project objectives.

Overall Objectives	Guiding Objectives	Data Collection Method	Participants or Sources of Data
Define and quantify current waste management strategies for BSG	1. Quantitatively determine if there is enough BSG in Winnipeg to render upcycling plausible	Document Review	Canadian Craft Brewery Websites Brewery Documents
		Online Survey	Canadian Craft Breweries
		Interviews	WPG Craft Breweries MB Food Processors
	2. Quantify and map what local breweries currently do with their spent grain	Interviews	WPG Craft Breweries
Understand the opportunities and barriers to upcycling BSG	3. Document the barriers brewers face in using/ moving/storing spent grain	Interviews	WPG Craft Breweries
	4. Determine if/which breweries are interested in BSG upcycling potential	Online Survey	WPG Craft Breweries
		Interviews	WPG Craft Breweries
Recommend potential upcycling options	5. Research and identify who the potential users are of BSG as an input in Winnipeg	Document Review	Canadian Craft Brewery Websites
		Literature Review	Peer-Reviewed Journal Articles
		Online Surveys	Canadian Craft Breweries
		Interviews	WPG Craft Breweries MB Food Processors
	6. Identify and evaluate the intermediate steps required to link BSG with potential users	Document Review	Canadian Craft Brewery Websites
		Online Survey	Canadian Craft Breweries
		Interviews	WPG Craft Breweries MB Food Processors
	7. Quantify the energy/CO_2 emission differences of current management strategies compared with the final proposed upcycling framework	Interviews	WPG Craft Breweries
		Literature Review	Peer-Reviewed Journal Articles

Final Framework Recommendation



PART 1: Research Data

Literature Review Data Conclusions

The literature review was the first stage of research and provided a foundation of data that was used to make a preliminary decision of whether or not upcycling was worth considering in Winnipeg, MB. The data obtained from the literature review is shown in *Figure 3*. The largest by-product of brewing is spent grain which accounts for 85% of all brewery 'wastes' and is produced at a rate of approximately 20 kg BSG for every 100 L of beer brewed (7 pp. 103-117) (5 p. 556). Documenting average brewery wastes provides an average value in which to estimate spent grain volume in Winnipeg, whether it's measured or not, thus providing a numerical value towards Objective 1 (O1 on the framework). With the recent increase of craft breweries in Winnipeg, there would appear to be an associated increase in potential for upcycling these 'wastes', yet the three most common waste management strategies for spent grain globally are animal feed, compost, and landfill; marked on the framework as O2. While Objective 2 was not the primary focus of the literature review, it's important to understand what's 'typical or average' in the case study.

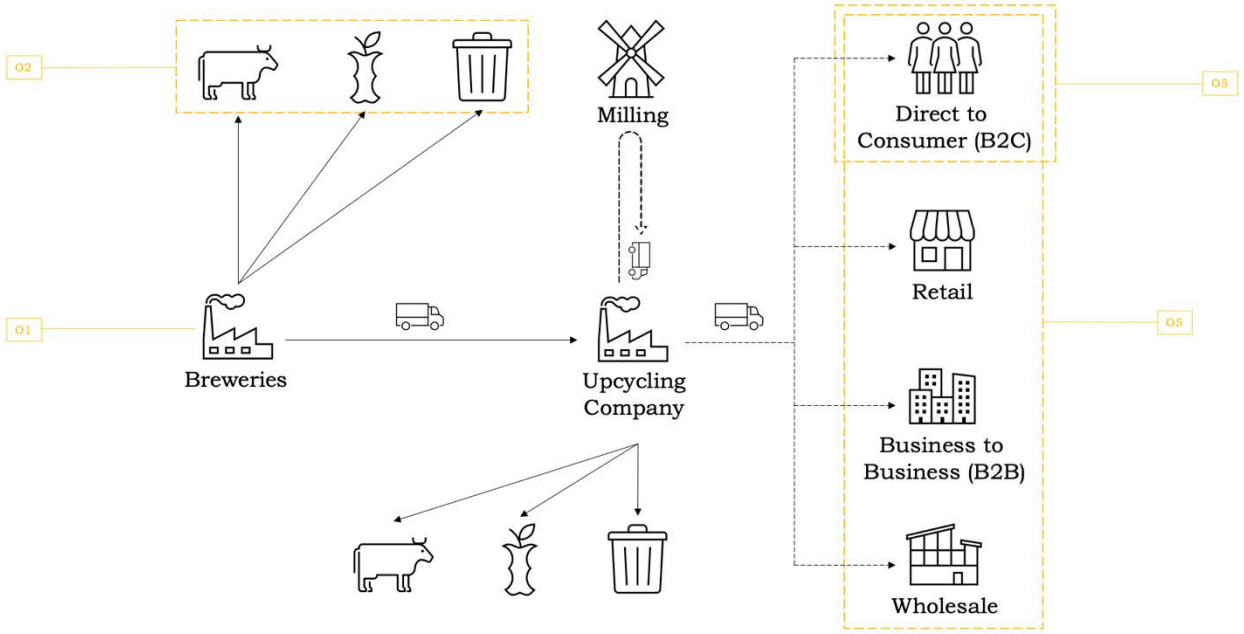


Figure 5.3. The literature review provides data towards Objective 1 (O1), Objective 2 (O2), and Objective 5 (O5) in the development of a spent grain upcycling framework for Winnipeg, MB.

Objective 5

Research and identify who the potential users are of BSG as an input in Winnipeg.

The primary focus of the literature review in the development of an upcycling framework for Winnipeg was the identification of potential uses of upcycled brewers spent grain. The data obtained towards objective 5 included nutritional and sensory analysis. Brewers spent grain is a nutritious ingredient with 19-30% protein, 30-50% fibre, 10% lipids, and 1% minerals on a dry weight basis (5 p. 555) (8) (9), and has potential use in a variety of products which is supported by multiple studies reporting positive sensory qualities and consumer acceptance scores. Upcycling BSG to bakery products has been tried with breads, biscuits, cookies, muffins, cakes, waffles, pancakes, tortillas, snacks (Extruded and Ready-to-Eat), doughnuts and brownies. BSG can increase the protein, fibre and amino acid contents while decreasing the overall calories in a food product and has the best results at a 10% incorporation ratio (10 p. 1267). BSG has even been studied in frankfurters at a 1%, 3%, and 5% ratio which lowered fat content and increased water holding capacity. There are many different food processing facilities and local businesses in Winnipeg that make products with potential for upcycled BSG, indicating there's ample opportunity to generate a demand if there's sufficient supply, which supports the decision to proceed with the research.

Website Review Data Conclusions

With the foundation of data built from the literature review, the website review was intended to generate an overall idea of efforts surrounding global sustainability initiatives at the individual brewery, specifically in reducing food waste through upcycling among the 1165 Canadian craft breweries and 11 Canadian companies upcycling spent grain. This goal was assessed with a Canadian craft brewery website review of specific terms ("Upcycle", "Circular Economy", "Sustainable or Sustainability", "Waste", "Carbon Footprint", and "Spent Grain") with the notion that a company website reflects a company's values. The notion was found to be false as only 7 Canadian craft breweries mentioned upcycling on their websites which is equivalent to less than 1 brewery per Canadian company upcycling spent grain. Despite the low term mentions, valuable data was obtained for the Winnipeg framework.

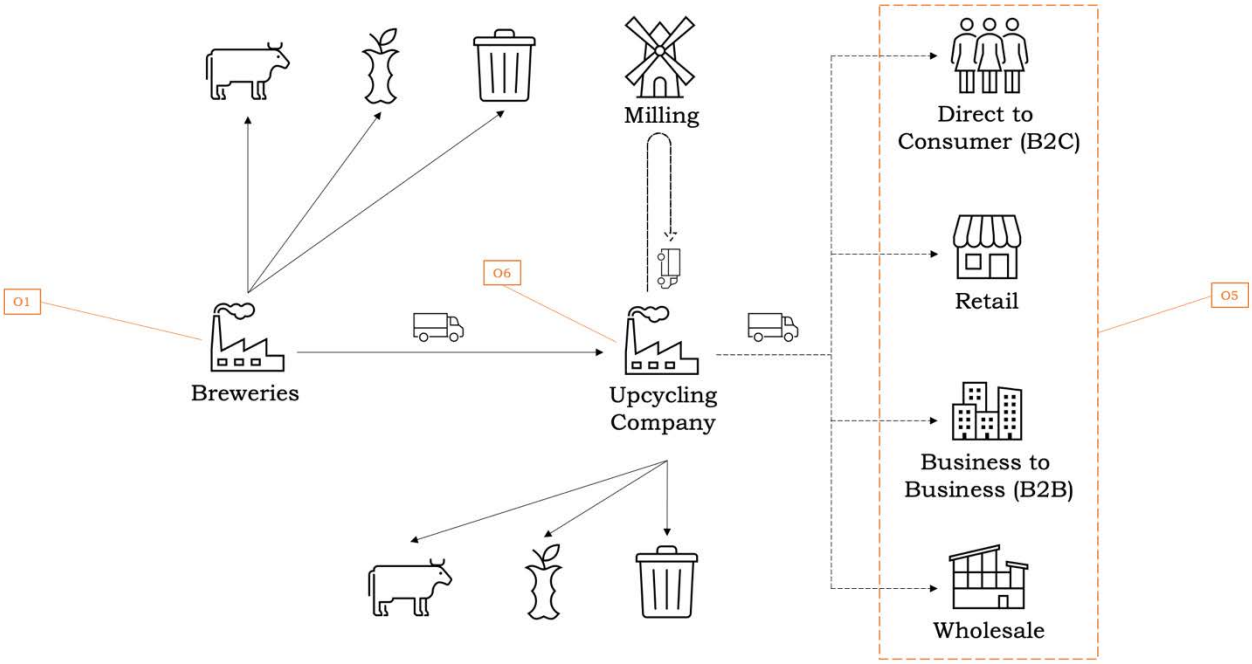


Figure 5.4. The Canadian craft brewery website review provides data towards Objective 1 (O1), Objective 5 (O5), and Objective 6 (O6) in the development of a spent grain upcycling framework for Winnipeg, MB.

Objective 1

Quantitatively determine if there is enough BSG in Winnipeg to render upcycling plausible.

The data gained from the website review provides some comparison information needed to evaluate the case study, specifically by identifying where upcycling is currently happening. Brewery website mention of the company they upcycle with in addition to online company searches identified 11 Canadian companies that are currently upcycling brewers spent grain in some way but did not provide specific values to base a comparison on. Ultimately this means that it's possible to upcycle spent grain in Canada therefore the potential for Winnipeg stands, but upcycling companies are needed in the interview stage of research to provide specific data relevant to the framework.

Some valuable information obtained with the website review towards the framework development was identifying the cities where spent grain upcycling is currently happening in Canada. As seen on *Page 114*, there are spent grain upcycling initiatives in Vancouver (2,842,730 people), Kelowna (235,470 people), Calgary (1,608,340 people), Montreal (4,378,800 people), and Toronto (6,685,620 people) (11). Apart from Kelowna, Winnipeg has a significantly lower population (871,780 people) than the cities currently upcycling which makes the city size a consideration in later research stages. Determining if there is enough BSG in Winnipeg will also require supply and demand values as 'knowing it's possible in other cities' is not enough information to evaluate potential success.

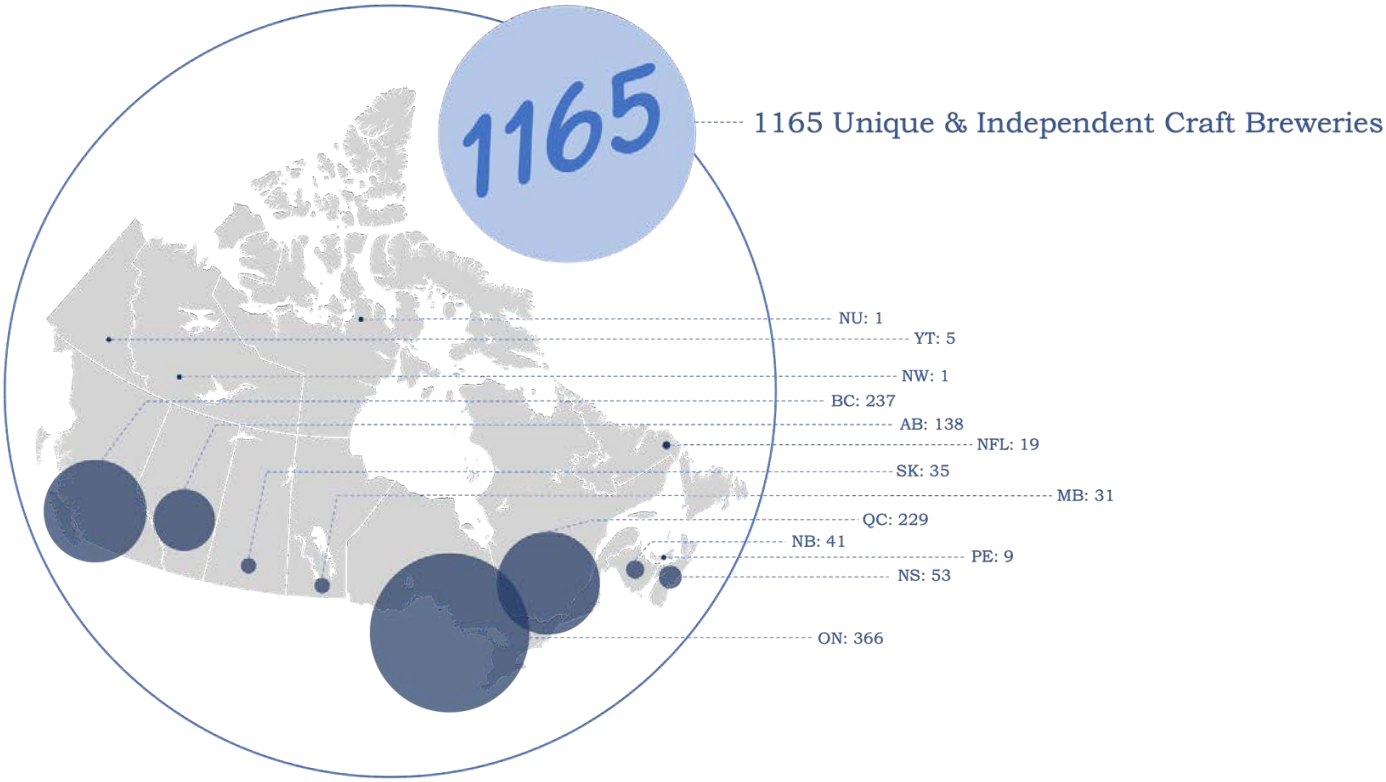


Figure 5.5. Visual of the number of unique and independent craft breweries in Canada by province in Spring/Summer 2022.

Table 5.2. Canadian population to brewery ratio's by province (2022).

	BC	AB	SK	MB	ON	QC	NB	NS	PE	NF	YT	NW	NU
Breweries	237	138	35	31	366	229	41	53	9	19	5	1	1
Population (12)	5,273,809	4,502,858	1,188,338	1,401,967	14,996,014	8,650,692	802,862	1,007,360	168,358	523,043	43,518	45,698	40,403
People per Brewery	22,252	32,629	33,952	45,224	40,972	37,775	19,582	19,006	18,706	27,528	8,703	45,698	40,403

Objective 5

Research and identify who the potential users are of BSG as an input in Winnipeg.

In addition to the products identified in the literature review with potential use for upcycled BSG, the companies currently upcycling spent grain have come up with some innovative and creative products to incorporate the ingredient. The products identified from the upcycling companies include granola (dried, whole BSG), barley flour (dried, milled BSG), premade mixes (cookie, pancake, waffle, banana bread, brownie, carrot cake, pizza dough) (dried, milled BSG, + ingredients), and consumer-ready products such as bread, bagels, pretzels, pizza dough, cookies, snack bars/bites, croutons, crackers, and pasta (dried, milled BSG, + ingredients and process). Further analysis on the potential final products of the framework (with references) is provided on *Page 135*. With the expansion of possible final products, the potential for upcycling in Winnipeg grew with the identification of additional businesses with prospective use.

Objective 6

Identify and evaluate the intermediate steps required to link BSG with potential users.

Most upcycling companies identified in this research stage provided an overview of their business framework/operations in which a review and analysis was conducted. The framework review and references are provided on *Page 143* and was used to help meet Objective 6 in Winnipeg, MB.

Canadian Craft Brewer Survey Data Conclusions

The Canada-wide craft brewer survey is the third research stage and was divided into 4 sections to meet Objectives 1, 4, 5, and 6. The first portion of the Canada-wide craft brewer survey was designed to obtain general information regarding the participating breweries as a general reference and understanding of who the survey participants are. The second section of the survey was designed to understand if and how Canadian craft breweries measure their spent grain. The third portion of the survey was developed to understand more detailed information regarding upcycling spent grain among Canadian craft breweries. The final survey section has a total of one question that was intended to generate an overview of the final destination of spent grain generated from craft breweries in Canada. As a whole, the survey paints a picture of how the average Canadian craft brewery is operating (focusing on spent grain) and how Winnipeg craft breweries will compare.

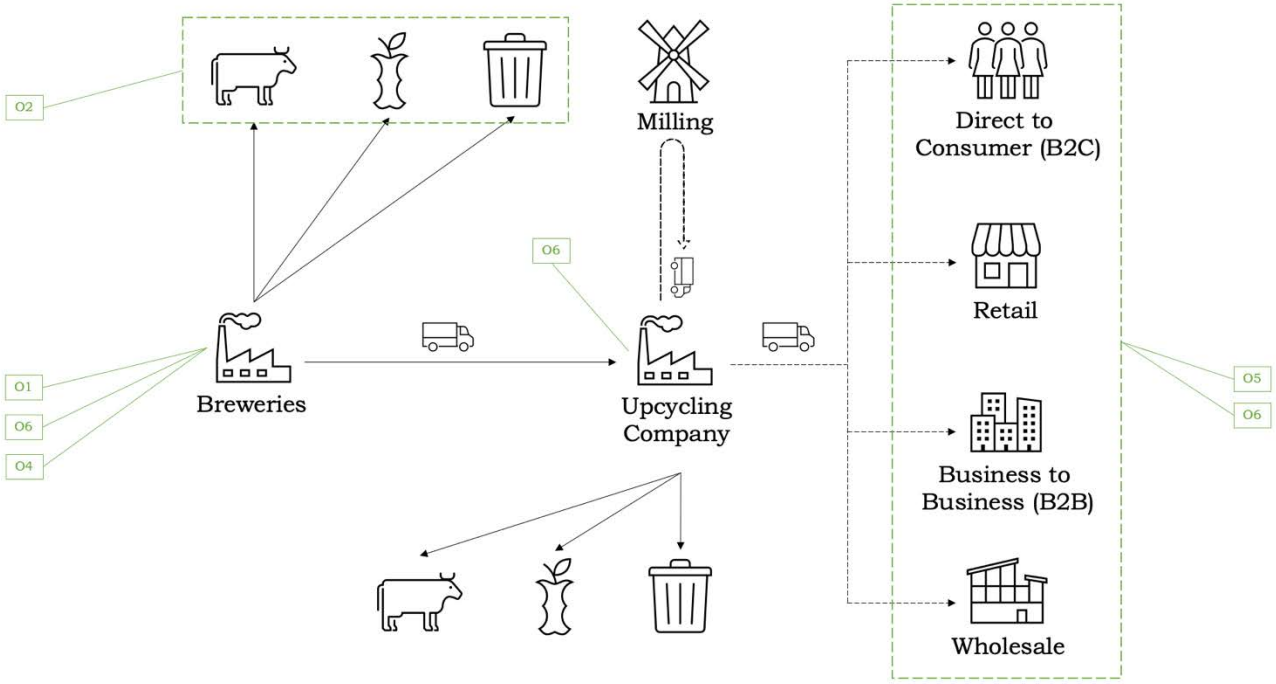
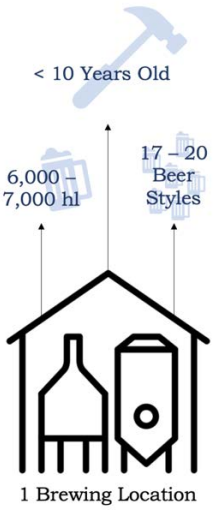


Figure 5.6. The Canada-wide craft brewery survey provides data towards Objective 1 (O1), Objective 2 (O2), Objective 4 (O4), Objective 5 (O5), and Objective 6 (O6) in the development of a spent grain upcycling framework for Winnipeg, MB.

Objective 1

Quantitatively determine if there is enough BSG in Winnipeg to render upcycling plausible.



The survey data resulted in the evaluation of an 'average' Canadian craft brewery, which was based on the responses of 168 breweries of a potential 1165. The average Canadian craft brewery has a single brewing location, was established within the past decade, and brews 17-20 beer styles for a total of 6,000-7,000 hl annually. A 6,500 hl (650,000 L) average results in 125 hl (12,500 L) of beer every week of the year. This then means an average of 5,511 lbs of spent grain on a weekly basis, per brewery. This further translates to 787 lbs of spent grain per brewery/day of varying characteristics.

The data provided towards Objective 1 with this analysis is that if Winnipeg breweries are comparable to the Canadian average, it's then assumed that the age, production volume, and number of beer styles of Winnipeg craft breweries are not the/a limiting factors to the potential of upcycling. As the survey was distributed across Canada, the data acquired is not specific to the Winnipeg case study and framework, but instead helps assess real potential.

Figure 5.7. Section 1 survey data conclusions visualization of the average Canadian craft brewery among the 168 survey participants.

Objective 2

Quantify and map what local breweries currently do with their spent grain.

While the literature review determined that animal feed, compost, and landfill are the most common waste routes for brewers spent grain, the Canada-wide craft brewer survey provided values to support that. It was found that among the participating craft breweries, 81.8% of spent grain goes to animal feed, 10.6% to compost, 3.1% to upcycling, 2.9% to other, and only 1.5% goes to landfill. If this is the average, we can reasonably expect the same ratios in Winnipeg.

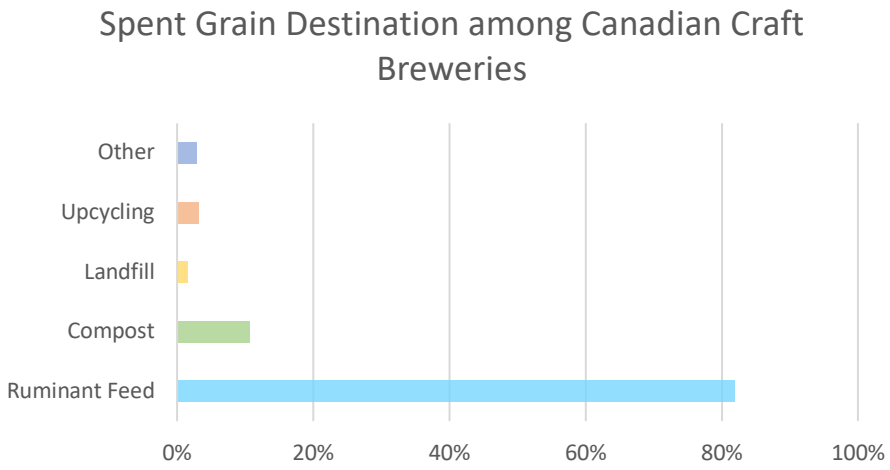


Figure 5.8. The final destinations of spent grain in Canada among survey participants (Total = 100%).

Objective 4

Determine if/which breweries are interested in BSG upcycling potential.

While the survey was anonymous, 4 breweries indicated they're located in Manitoba of a total 27 invited, representing 14.8% of the population. A variety of reasons could explain the low participation rate, but the topic of upcycling piqued the interest of some breweries meaning that it's of value to continue the research. If the survey data is comparable to Winnipeg, we might expect that 80% of craft breweries are considering upcycling but don't have a set timeline yet, suggesting that the interest level is much higher than represented in the survey participation rate.

Objective 5

Research and identify who the potential users are of BSG as an input in Winnipeg.

The survey participants identified a variety of products that is made with their upcycled spent grain including bread (most common), crackers and pizza dough (next most common), followed by cookies, biscuits, granola, flour, cake, brioche buns, bread kits, snack mix, dessert crumble, brownies, pretzels, and mustard. Of those, incorporation of BSG to cake, dessert crumble, and mustard were new possibilities to the research. The survey also revealed that some breweries upcycle at their own establishment via the restaurant and/or brewpub, indicating this option might also be available to Winnipeg craft breweries. While further research is needed, the data is valuable for equipment selection, product choices and process design for the Winnipeg upcycling framework.

Objective 6

Identify and evaluate the intermediate steps required to link BSG with potential users.

The survey responses provided some valuable information regarding the logistics of upcycling spent grain. The first conclusion made is that the measurement and/or tracking of spent grain is not of high importance. Most Canadian breweries don't track spent grain, and those who do typically use a dry weight conversion after emptying the mash tun. This could tie in with the second conclusion that 20% of breweries pay to have spent grain removed from their property with prices ranging from $250-1800/month or $12.50-900/container. A third conclusion is that most of the brewery's upcycling spent grain are able to upcycle 100% of it, meaning they don't need to find alternative options. However, some breweries are not able to upcycle spent grain from beers such as dark beers (Stouts, Porters), fruity styles, beers with rice husks, and styles where the grain mixture is not 100% barley. The data suggests that upcycling should/can be affordable and reliable for Winnipeg brewers.

Interview Data Conclusions

The fourth data collection method used in this research project was interviews which were conducted with Winnipeg craft brewers, Manitoba food companies of various scales, a Manitoba milling company, and North American companies currently upcycling brewers spent grain. The interviews were intended to generate data to meet all project objectives (Objectives 1-7). Each participant group's interview targeted varying objectives as follows: (1) Winnipeg craft brewer interviews addressed Objectives 1, 2, 3, 4, 5, 6, and 7, (2) Manitoba food company interviews addressed Objectives 1, 5, and 6, (3) the Manitoba milling company interview provided data towards Objectives 1, 6, and 7, and (4) North American upcycling company interviews addressed Objectives 1, 2, 3, 5, and 6. As shown in *Figure 7*, the combined interview data covers every aspect of the upcycling framework to further support and refine data from research stages 1-3.

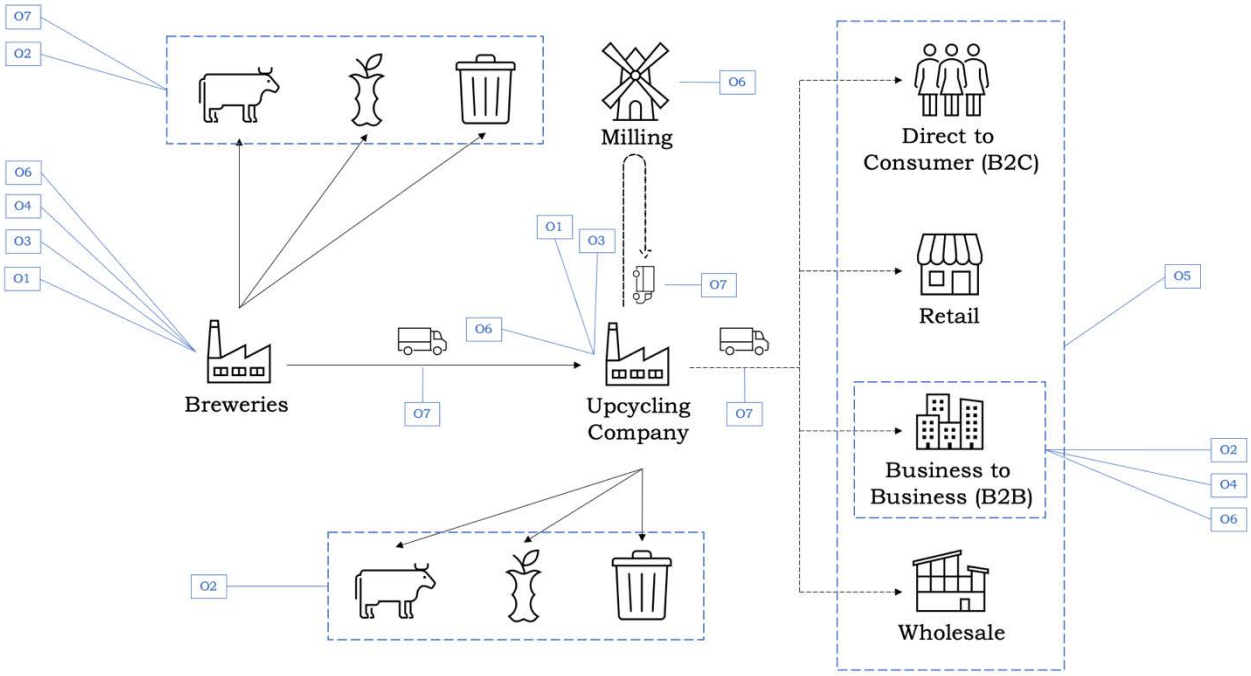


Figure 5.9. Interviews provided data towards Objectives 1 through 7 (O1, O2, O3, O4, O5, O6, O7) in the development of a spent grain upcycling framework for Winnipeg, MB as depicted.

Objective 1

Quantitatively determine if there is enough BSG in Winnipeg to render upcycling plausible.

The 'average Winnipeg craft brewery' with an interest in upcycling their spent grain was found to produce 2,725 hl of beer annually between 16 styles of beer with the 7 core styles making up 75% of the production volume. Among the breweries, there are 22+ core styles which introduce an opportunity for the Winnipeg upcycling company to offer a consistent product while the remaining 25% of spent grain supply offers opportunities for seasonal upcycled products depending on how the beer style was made. The data found that ¾ of breweries store their spent grain outside therefore the final framework needs to address indoor food storage to ensure food safety.

Two drying options were discussed with North American upcycling companies as potential options in Winnipeg. The first is a tray dryer with a capacity of approximately 1000 lbs/day or 200,000 lbs annually, and the second is a tunnel style dryer with a capacity of 800-1000 lbs/hr or 1,000,000-1,250,000 lbs annually. The final equipment decision is based on several factors and will be decided on following the focus group. The final data stage will also determine whether milling onsite or with an existing milling company will be the best option as both are currently in consideration and involve different operational and planning considerations.

While the majority of breweries don't measure their spent grain, an estimate of 20 kg of spent grain are obtained for every 100 L of beer brewed. The estimated volume of brewers spent grain among participants is 182,000 kg annually which equals approximately 51,016 kg dried spent grain (shown in the graph with an orange marker). In bakery products, brewers spent grain flour is best used at a 10% ratio in a wheat flour blend to minimize unwanted sensory characteristics. At a 10% ratio, individual food company demands can range from 0.055-0.082 lbs/day (20-30 lbs/year) to 6,613 lbs/day (3,000 kg/day) according to the data, suggesting that a wide variety and number of revenue streams are needed.

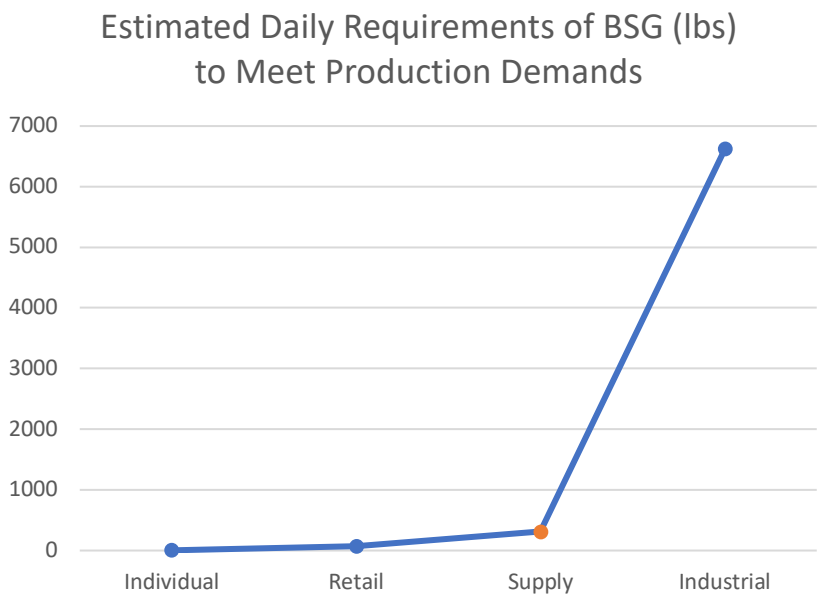


Figure 5.10. Daily Winnipeg BSG supply graphed among perceived daily demand of various consumer groups including individual, retail, and industrial.

Objective 2

Quantify and map what local breweries currently do with their spent grain.

Figure 5.11. The destinations of Winnipeg BSG are Elie, West St. Paul, Beausejour, and Anola (marked in red) (Google Maps).

Most breweries (75% of participants) experience free removal of spent grain while the other quarter takes on the cost of removing spent grain from their property. In total, 340 km are driven every week to move spent grain for ruminant feed, totalling approximately 17,680 km/year among 4 breweries. The distance of each destination is as follows (calculated from Downtown Winnipeg):

1. Beausejour: 61 km/way = 122 km total
2. Anola: 39 km/way = 78 km total
3. Elie: 46 km/way = 92 km total
4. West St. Paul: 24 km/way = 48 km total

An estimated 178,825 kg of spent grain is used as ruminant feed (98.14%), 3,000 kg as compost (1.64%), 374 kg goes to landfill (0.19%), and <187 kg goes to other uses (0.03%).

To keep spent grain in Winnipeg to be upcycled, the framework needs to consider that brewer schedules vary and can change daily. The data from North American upcycling companies also notes that a framework can be made to either upcycle 100% of grain supply or find alternative uses for non-core and non-light coloured beer style spent grains (eg. Fruit beers, wheat beers, dark styles, etc.) In Winnipeg, the excluded styles would account for a minimum of 25% of spent grain.

Objective 3

Document the barriers brewers face in using/moving/storing their spent grain.

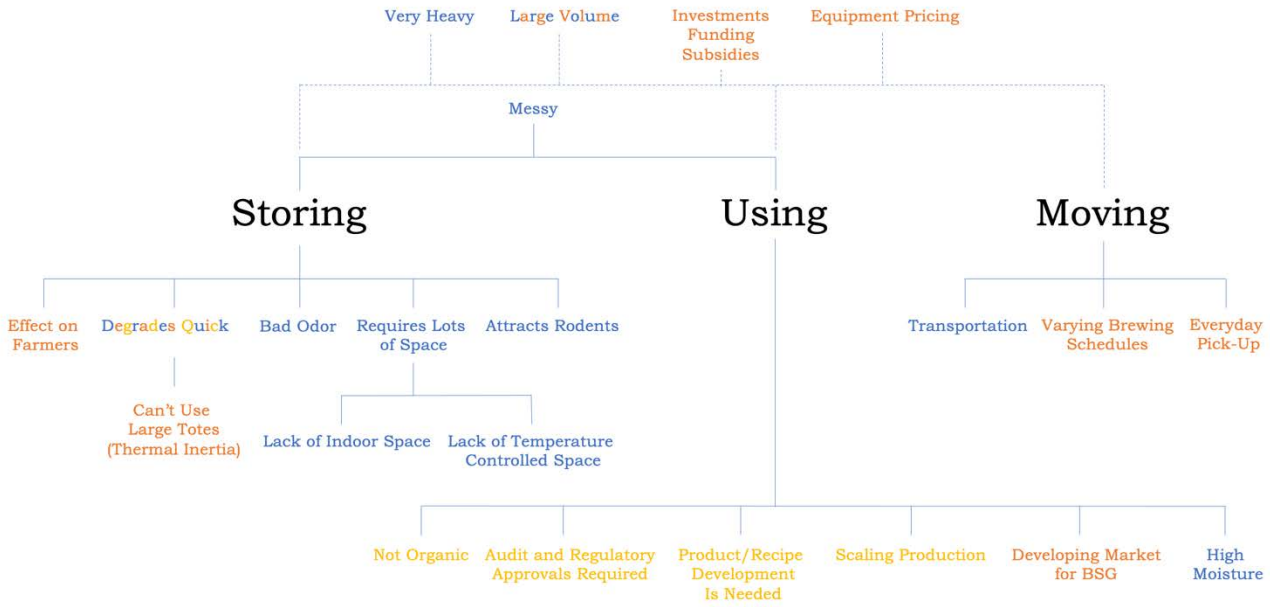


Figure 5.12. The combined barriers to upcycling brewers spent grain expressed during interviews by Winnipeg craft brewers (blue text), North American upcycling companies (orange text), and Manitoba food companies.

The preliminary research states that "The Boomerang CoOp in Montreal has identified the 4 most prevalent issues that brewers face with managing their spent grain as space, smell, flexibility and cost" (13). The interview data identified similar barriers and more, that can be divided into three main categories: storing, using, and moving spent grain. Brewery barriers are in blue type, upcycling company barriers are in orange, and food company barriers are in yellow.

The above *Figure 9* reveals essential considerations for the upcycling framework to make it convenient and possible for all affected parties. The colours alone suggest that brewers face the most issues with storing spent grain, food companies face issues with usage, and the upcycling companies have to work through logistics and financing to overcome their biggest barriers. As such, the final framework requires careful planning to reduce, or preferably eliminate, the above barriers.

Objective 4

Determine if/which breweries are interested in BSG upcycling potential.

The interviews found that all participants (breweries and food companies) had heard of upcycling prior to the interview and had some interest in the research objectives. All food companies and half the breweries are concerned with their environmental footprint and are looking for ways to operate more sustainably.

The data also found that all the brewery participants are willing to work together if upcycling spent grain in Winnipeg becomes available. This suggests that a variety of business structures for the upcycling framework/company are possible, such as (1) sole proprietorship, (2) partnership, (3) corporation, and/or (4) cooperative.

Objective 5

Research and identify who the potential users are of BSG as an input in Winnipeg.

The preliminary research identified several ways/products to upcycle spent grain including bread, breadsticks, tortillas, biscuits, crackers, snack bars, cookies, cakes, muffins, waffles and pancakes, doughnuts, brownies, extruded snacks, and frankfurters. As wet spent grain has a very short shelf life, it's commonly dried and milled to increase ease of use and convenience.

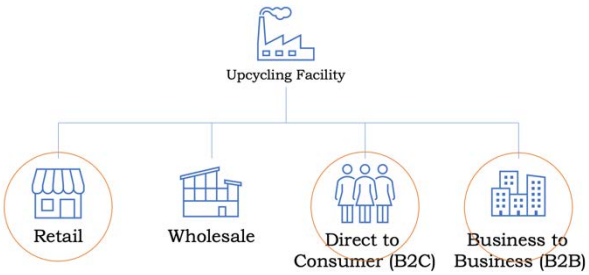


Figure 5.13. Most common revenue streams of existing interviewed BSG upcycling companies.

North American upcycling companies identified retail, B2C, and B2B as their current revenue streams as shown to the left, suggesting a variety of final products have potential for success in Winnipeg. Interviews with existing Manitoba food companies highlighted five primary food types as having the most potential for being able to use/incorporate upcycled brewers spent grain (B2B revenue) as follows: (1) cookies, (2) bread), (3) buns, (4) soups, and (5) take-home meals.

The most convenient form of upcycled spent grain is dried and milled as it offers the most versatility to all customers/consumers as a food ingredient. Spent grain flour also happens to have revenue potential among all possible streams including retail, wholesale, B2C, and B2B. Among the available options, an upcycling organization mentioned that participating breweries are a great opportunity for upcycled product sales, bringing awareness to the spent grain circular cycle, and can offer immediate education to potential customers through staff and product packaging. Not only can breweries act as a retail outlet, but the 50% in Winnipeg with restaurants can double as a B2B revenue stream for their own by-products.

Objective 6

Identify and evaluate the intermediate steps required to link BSG with potential users.

For the final upcycling framework to be realistic, it's essential that all aspects are addressed to connect brewers spent grain with the final consumers and to make it convenient for everyone.

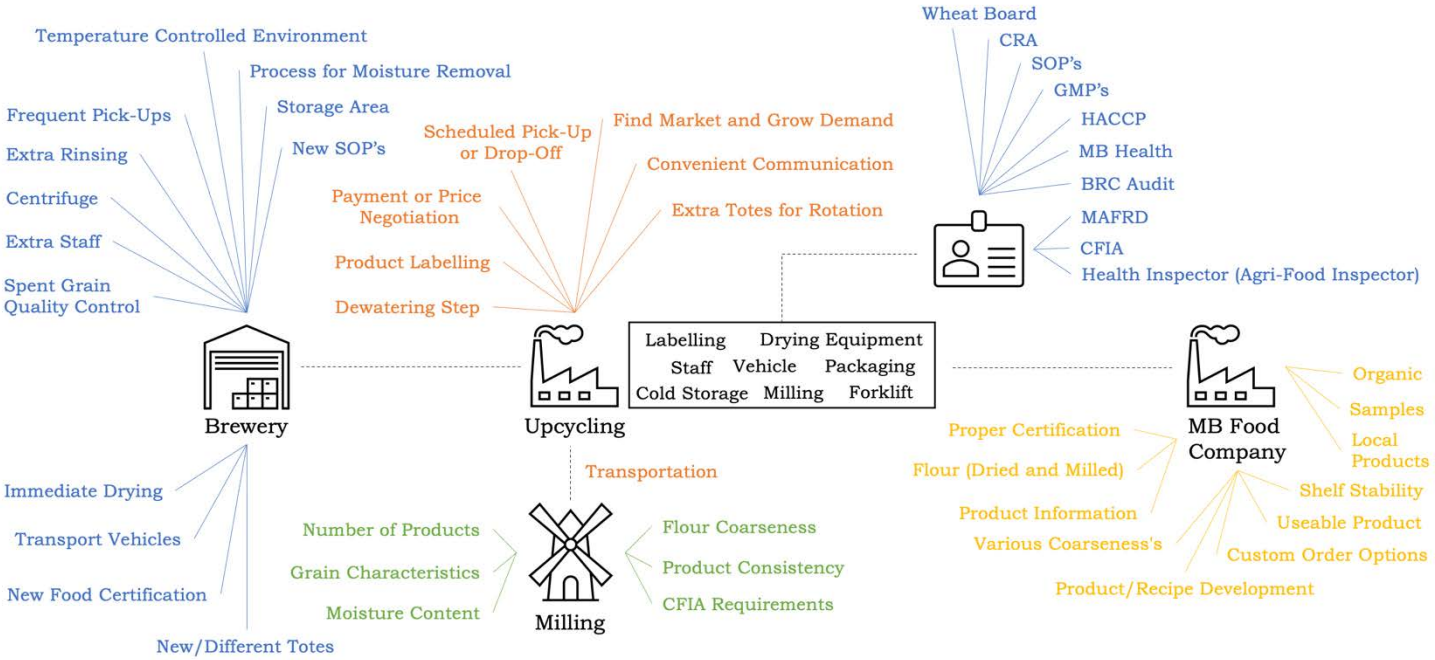


Figure 5.14. Required intermediate steps identified by all interview participants and organized by industry with brewery and regulatory steps in blue text, upcycling company in orange text, milling company in green text, and food company in yellow text.

Interview participants were asked to identify the intermediate steps required for their businesses to be able to upcycle spent grain. The combined suggestions are organized by industry in *Figure 10*. The considerations suggested by Winnipeg brewers are primarily associated around concerns of on-site and inside storage, as well as how current operations will be affected. In order for spent grain to remain a human-grade product, there are potential changes needed with the way it's stored and handled to ensure product quality and safety, especially with indoor brewery space being limited and valuable. The primary considerations to do with the upcycling operation have to do with transportation and the market demand. The development and introduction of a new food product involves a lot of planning to ensure success. As this is the research stage, thorough planning and realistic scaling options are a priority. Aspects to consider when evaluating the feasibility of milling grain off-site have to do primarily with the characteristics of the raw product and the desired final product(s) and will be compared with an option for on-site milling with emission and sustainability aspects as part of analysis. Food company considerations are centered around their ability to create a feasible and desirable final product.

Objective 7

Quantify the energy/CO_2 emission differences of current waste management strategies compared with the final framework.

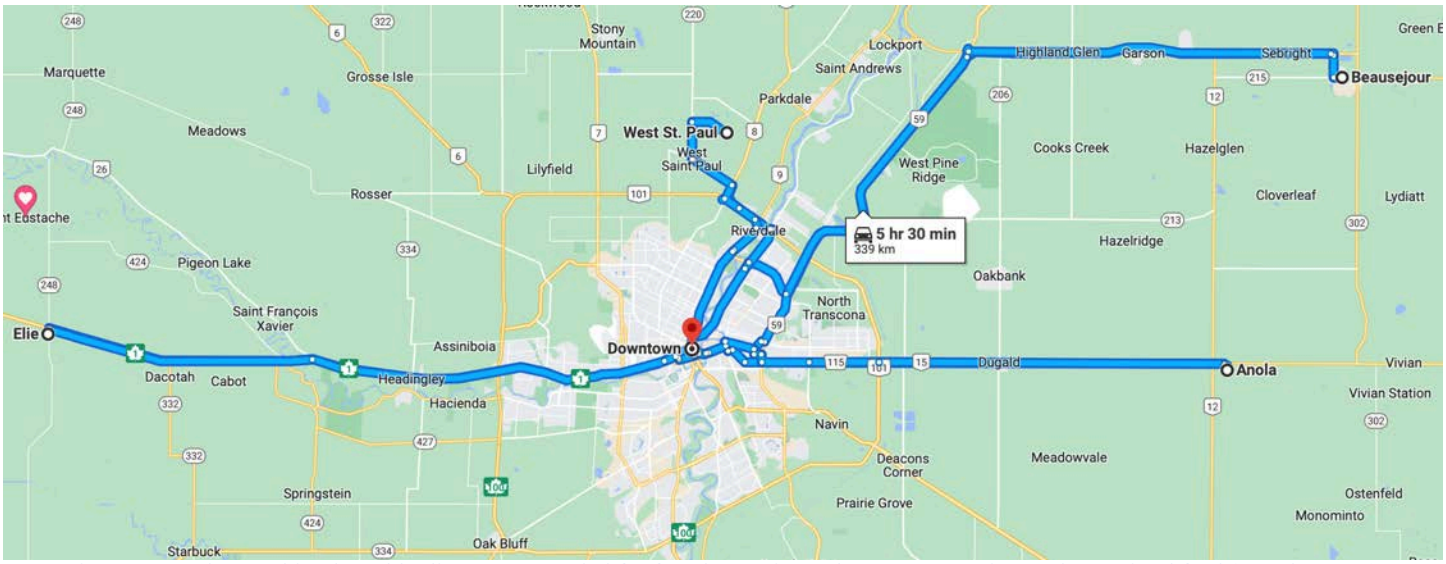


Figure 5.15. The combined weekly distances traveled for four breweries to have spent grain used as animal feed (Google Maps).

Interview data found that a combined 340 km are driven every week among 4 Winnipeg breweries to move an annual volume of 178,825 kg of spent grain to farms as cattle feed. This distance does not include the 3,000 kg going to compost or 374 kg going to landfill. As wet spent grain is extremely heavy and requires a lot of space, larger trucks are used for transport.

According to Natural Resources Canada, every litre of gasoline produces 2.29 kg (5.05 lbs) of CO_2 emissions, and every litre of diesel produces 2.66 kg (5.86 lbs) (14). The current combined weekly 340 km route costs $100.02 (at March 2023 gas and diesel prices) and emits 154.73 kg CO_2. Annually, this route costs $5,201.04 and emits 8,045 kg CO_2.

Route:

- Beausejour: ((47 km Highway x 2) x 14.5 L/100km) + ((14 km City x 2) x 18.9 L/100km) = 18.92 L (D)
- Anola: ((24 km Highway x 2) x 29.6 L/100km) + ((15 km City x 2) x 29.6 L/100km) = 23.09 L
- Elie: ((32 km Highway x 2) x 14.5 L/100km) + ((14 km City x 2) x 18.9 L/100km) = 14.57 L
- West St. Paul: ((13 km Highway x 2) x 14.5 L/100km) + ((11 km City x 2) x 18.9 L/100km) = 7.93 L

Costs

- Price: (18.92 L (Diesel) x $1.60/L) + (45.59 L (Gasoline) x $1.53/L) = $100.02/Week
- CO_2: (18.92 L (Diesel) x 2.66kg CO_2/L) + (45.59 L (Gasoline) x 2.29kg CO_2/L) = 154.73 kg CO_2/Week

Combined Research Data

The combined research data builds a framework supported by four research methods, used to support framework decisions and gradually refine framework functions to suit Winnipeg, MB specifically. As shown in *Figure 12*, each research method (differentiated by colour) supports and addresses multiple project objectives and results in decisions based on more than one source.

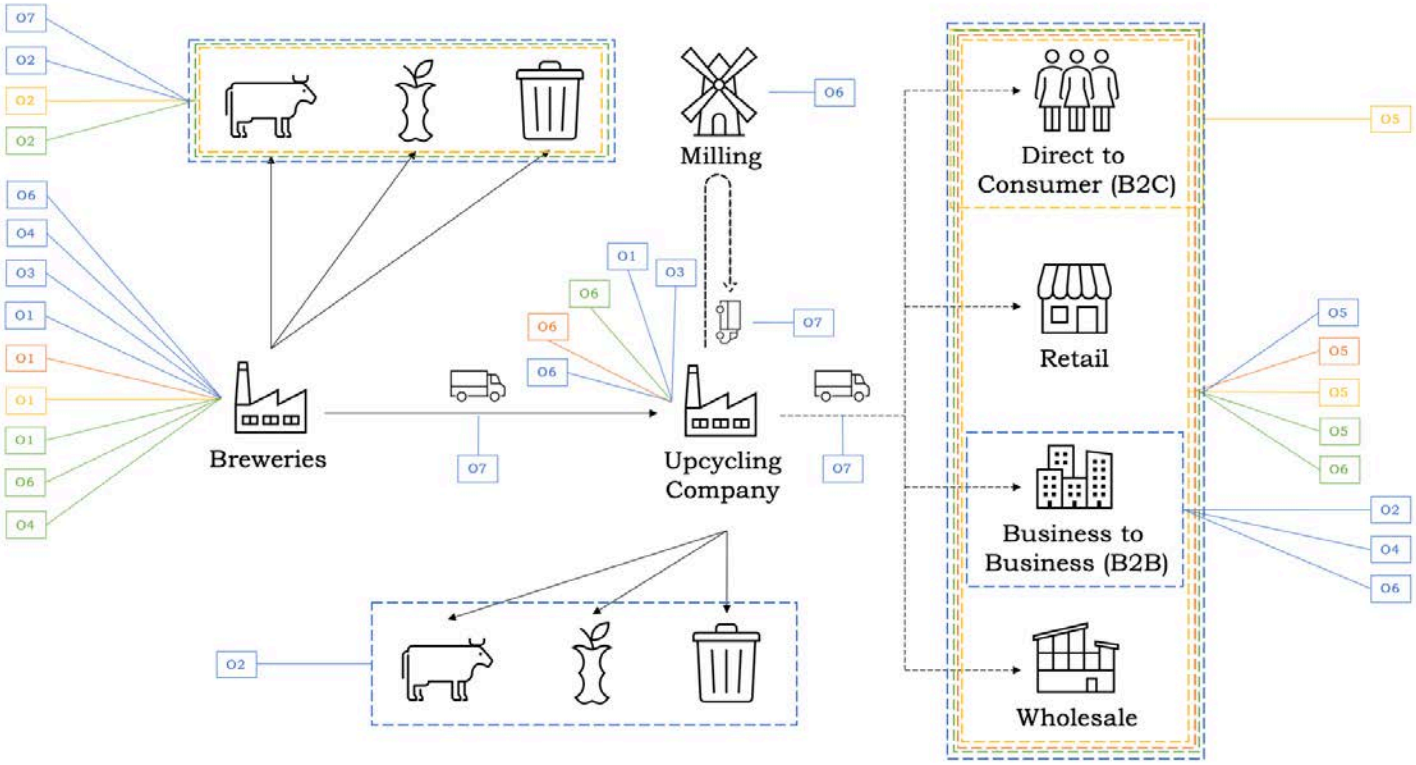


Figure 5.16. Visualization of the combined research stages with the colours indicating method of data acquisition (Yellow – Literature Review, Orange – Website Review, Green – Survey, Blue – Interviews) and a numbered box indicating the project objective addressed.

Proposed Framework Overall Operations

As outlined in the project methodology, interviews are the fourth research stage after a comprehensive literature review, a website review, and a Canada-wide craft brewer survey. The combined data was used to outline the framework pictured in *Figure 13*. The Winnipeg upcycling is established as a privately owned and operated business with a goal of being a zero-waste facility. The company will start by operating Monday to Friday, 8:00-4:00. Upon establishment, all participating breweries are provided with new spent grain storage totes (Uniform totes for proper stacking and storage at brewery and upcycling facility).

Stage 1: At the Brewery

The first framework stage happens at the brewery. After the mash step of the brewing process, spent grain will be emptied into the provided food-safe storage totes and stored inside the brewery in a food-safe area for spent grain to remain safe for human consumption. Totes are stored for approximately 24 hours to allow spent grain to drain and reduce the moisture content. Before 3:00PM on weekdays (Monday to Thursday), breweries will schedule their spent grain pickup for the following afternoon. Participating breweries will be encouraged to brew Monday to Thursday as totes filled on other days will sit for more than 24 hours and will no longer be human grade (likely be dried and available as ruminant feed or used wet/dry as compost).

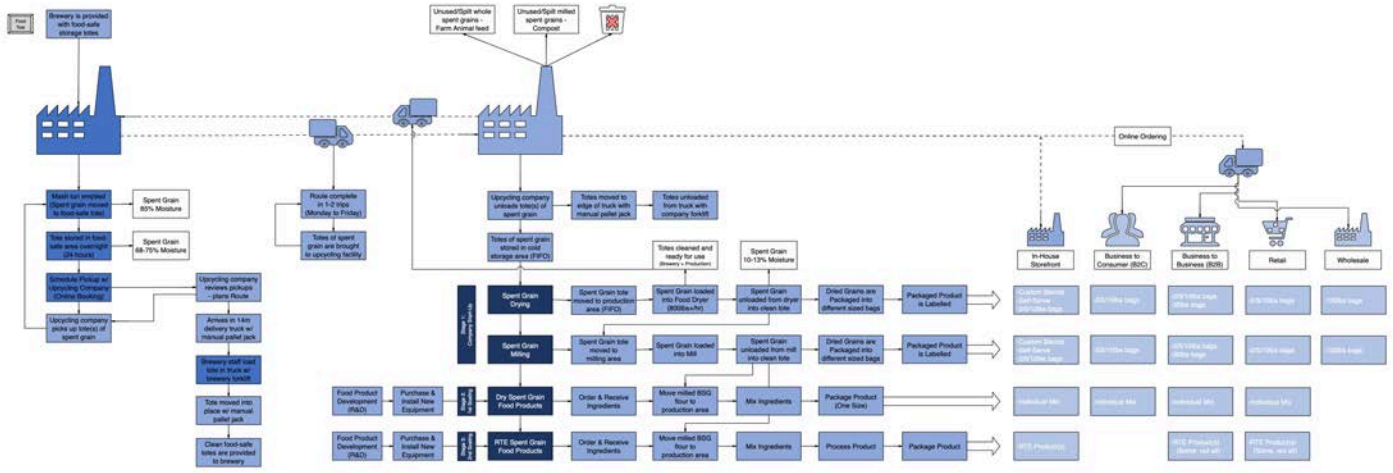


Figure 5.17. The proposed spent grain upcycling framework after combining data from the literature review, Canadian craft brewer website review, Canada-wide craft brewer survey, and all interviews.

Stage 2: Transporting Spent Grain

Starting from the corner of McGillivray Blvd. and Route 90, spent grain pickup from each individual Winnipeg brewery (route if all breweries participate) will be done with the above route once a day with a possible second round if the first round cannot move all the spent grain totes. Every weekday morning (by 10:00AM) the upcycling company will review the scheduled pickups and plan stops based on the above circular route. Pickups will be done every weekday afternoon (Between 12:00-4:00PM).

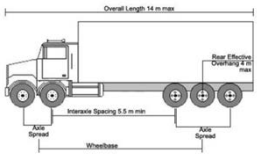
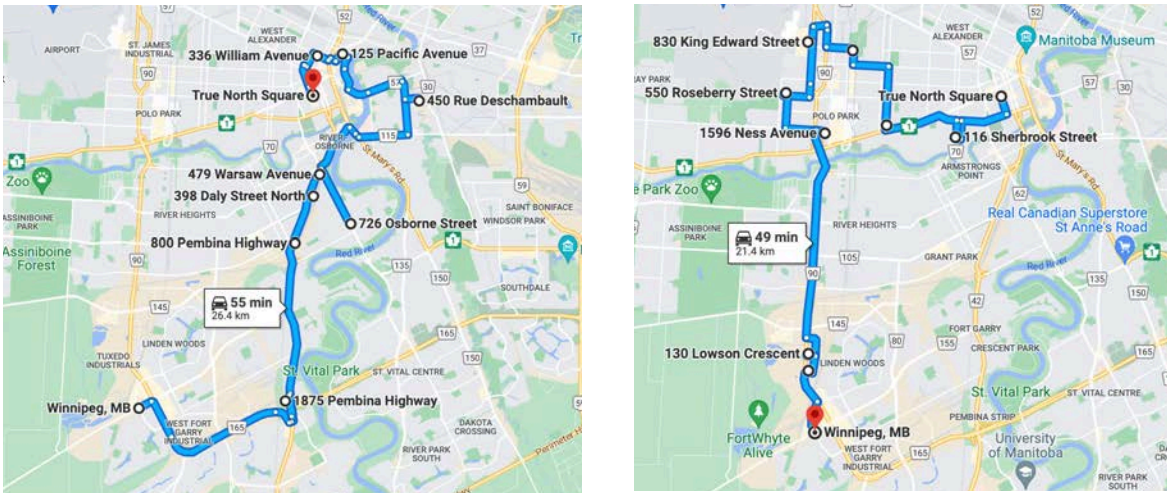


Figure 5.18. Tandem steer truck (14).

Spent grain pickup is done with a tandem steer/tridem drive straight truck (14m long), owned and operated by the upcycling company. Upon arrival at the brewery, a brewery employee will bring the tote of spent grain out with a brewery owned forklift and raise the tote into the truck. Once in the truck, an upcycling company employee will use a pallet jack (or similar device) to move the tote into place and label/date tote. Every full tote is replaced with an empty sanitized tote to keep production flow going and to minimize trips. Once all the scheduled pickups are complete and/or the truck is full, the totes of spent grain are brought to the upcycling facility.

Circular route for spent grain pickup (least driving distance):



Route: 1st half

Route: 2nd half

Figure 5.19. The proposed spent grain pickup route for the shortest driving distance starting from McGillivray Blvd. on Google Maps.

Stage 3: At the Upcycling Facility

3.a: Tote Unloading and Storage

Figure 15 is an example of the upcycling facility areas to allow for initial start-up and operation, as well as process expansion/scaling and a storefront. Upon arrival at the upcycling facility, the totes are moved to the edge of the truck with a pallet jack (or similar device). A forklift is used to lower the tote from the truck and move the spent grain to a cold storage facility. Totes are organized and brought out to be processed on a FIFO (First In, First Out) basis to avoid spoilage.

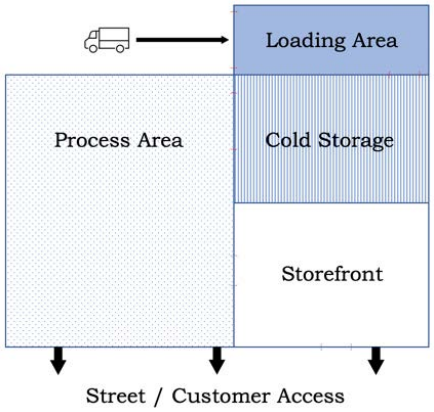


Figure 5.20. Example of upcycling facility operational areas.

3.b: Spent Grain Processing

The first processing step is drying. A spent grain tote (approximately 1,000 lbs) is moved to the process area in place to be unloaded into the dryer. The empty tote is removed and cleaned. The dryer is drum-style with a capacity of 800-1000 lbs/hr, or approximately 1 tote per hour. The moisture content of the spent grain will be reduced from 68-75% moisture to 10-13% moisture. Dry whole spent grain is removed from the dryer into a clean tote and moved to the milling area. (If possible, this movement of spent grain will be automated and direct.) A small portion of the dried whole grains will be packaged and labelled to fill orders. Next, the dried spent grain is loaded into the mill to be ground. Flour Coarseness may be chosen by the consumer and can range from fine to coarse. Milled spent grain is dispensed from the mill to a clean tote, then packaged and labelled in various packaging sizes to fill customer orders.

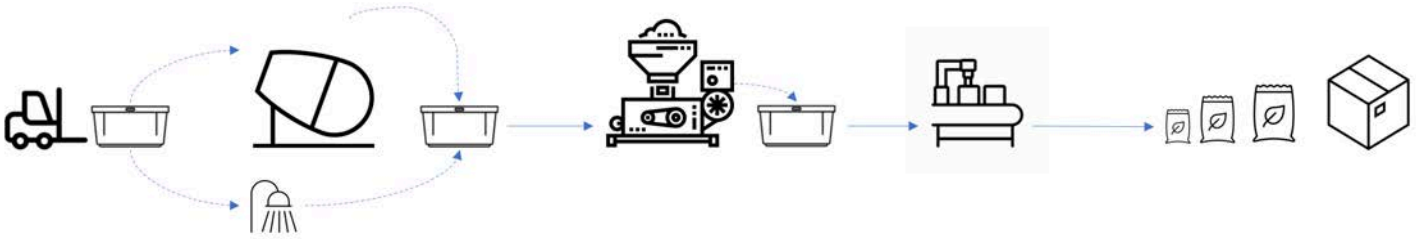


Figure 5.21. Visualization of the various processing stages at company start-up. The upcycling process starts with moving spent grain, drying, milling, packaging, and labelling, and storage of the final product.

3.c: Inedible and Spilt Spent Grain

Because the plant is a zero-waste facility, inedible and/or spilt spent grain will not be shipped to a landfill. Instead, spent grain that is no longer human grade will be made available to farmers and as compost in dry format by default. The dry form has a shelf life of approximately 24 months whereas the wet form is approximately 4 days. As the upcycling framework diverts a free feed from farmers, these forms will be available free on a first-come-first-serve basis.

Stage 4: Business & Production Scaling

4.a: Company Start-Up

The upcycling company start-up involves the most significant investment which the largest costs including land, a building, a delivery truck, forklifts, the drying equipment, milling equipment, packaging equipment, and a labeller. The first stage allows the company to offer dried whole spent grain and spent grain flour to consumers.

4.b: First Scaling

After successfully finding a market for spent grain flour and experiencing company profits, the first scaling would include large scale mixing equipment and the ability to source ingredients. This scaling would allow the company to make prepackaged mixes for consumers such as a cookie mix, pizza dough mix, bread mix, brownie mix, etc. Each mix will include enough product to feed a family of 4 people (Ex. Pizza dough will make 2 pizza's, cookie mix will make 24 cookies, etc.)

4.c: Second Scaling

The second scaling would include processing equipment that would allow the company to make RTE (ready-to-eat) foods such as crackers, breads, cookies, etc. Equipment could include ovens, extrusion machines, etc. to facilitate the desired RTE products.

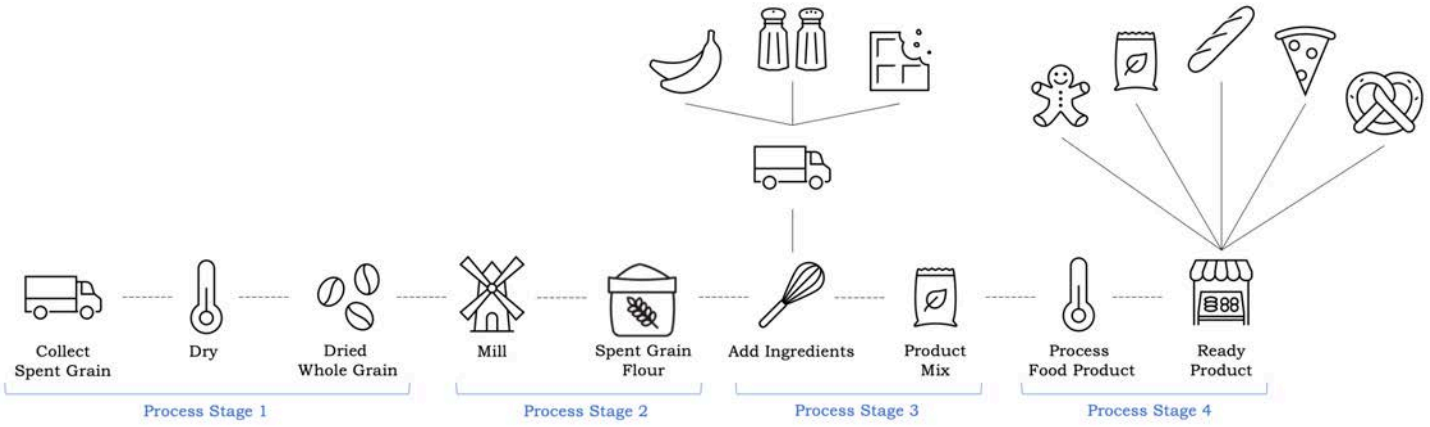


Figure 5.22. Depiction of the level of processing (Stages 1-4) required for increased upcycled spent grain product offerings.

Revenue Streams

The dried whole spent grain and flour will be sold in the facility's storefront (custom blends, 2/5010 lb bags), directly to consumers (2/5/10 lb bags), to businesses (2/5/10/30 lb bags), in retail outlets (2/5/10 lb bags), and wholesale (100 lb bags). The prepackaged mixes will be sold at the facility's storefront, directly to consumers, to businesses, and at retail outlets. The RTE products will be sold at the facility's storefront, to other businesses, and at retail outlets.

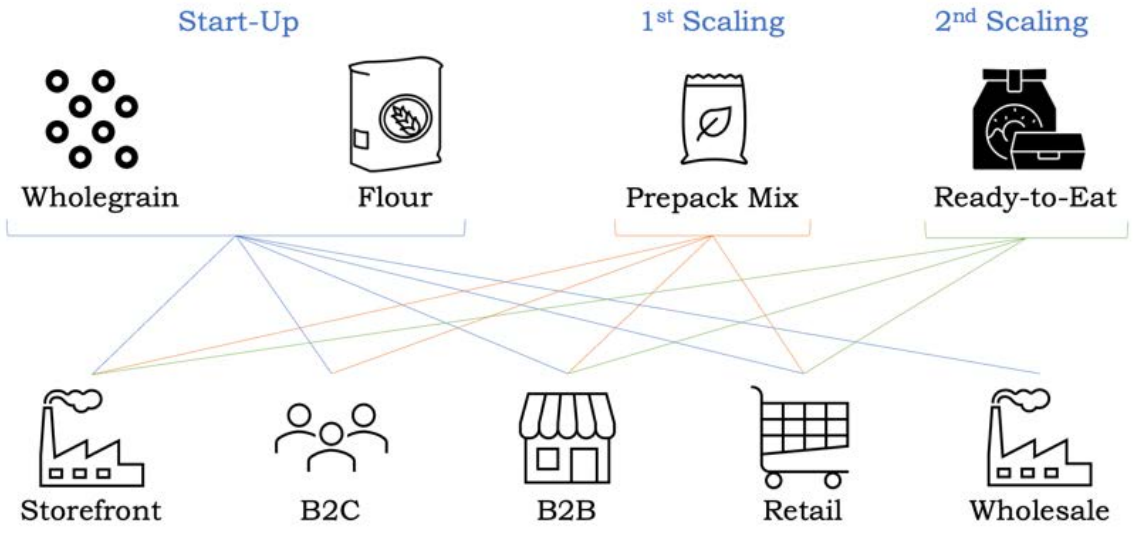


Figure 5.23. Representation of the potential revenue streams with each company scaling.

PART 2: Supporting Research

Discover Upcycling in Canada

Click on one of these Canadian company's logo to explore their exciting upcycled products or certification for upcycled products!

Figure 5.24. Linked map of BSG upcycling in Canada.

Upcycled Spent Grain Products

Above the identified products from the literature review, survey and interviews, the existing North American upcycling companies offer valuable information regarding the potential of upcycled spent grain as well as the products that are showing market success. *Table 3* summarizes some products made with upcycled spent grain in North America.

Table 5.3. Products offered by North American companies upcycling brewers spent grain, organized by the overall number of required materials, processing and equipment.

	Dried + Ingr..	Dried & Mill	Dried & Milled + Ingredients						Dried & Milled + Ingredients + Processed							
	Granola	Barley Flour	Cookie Mix	Pancake and/or Waffle Mix	Banana Bread Mix	Brownie Mix	Carrot Cake Mix	Pizza Dough Mix	Bread and/or Bagels	Pretzels	Pizza Dough	Cookies	Soft Snack Bars and/or Bites	Croutons	Crackers	Pasta (Dry)
Susgrainable (15)		X	X	X	X											
GroundUp (16)		X		X		X										
coRISE (17)	X	X	X	X		X								X		
Spent Goods (18)									X	X	X					
Boomerang (19)		X														
Regrained (20)					X	X	X	X					X			X
Loop (21)													X			
Rise NY (22)	X	X				X							X			
Upcycled Grain Project (23)															X	
Still Good (24)	X	X										X				
Saison 2 (25)															X	
Total:	3	6	2	3	2	4	1	1	1	1	1	1	3	1	2	1

As shown in *Figure 19*, the choice of final upcycled spent grain products needs to consider various factors to meet the project objectives while ensuring the framework can be successful and has scaling options. Each process stage is marked with the requirement of an additional processing stage, thus requiring additional equipment and materials to produce the final product but all products would require nutritional testing, packaging, and labelling.

- Stage 1 is defined here as the drying stage and results in a whole dried spent grain.
- Stage 2 requires the extra milling step and results in a spent grain flour.
- Stage 3 processing is a significant investment and/or leap in final product as these consumer products required importing/obtaining other ingredients and the purchase of additional processing equipment and results in a consumer product-mix.
- Stage 4 is defined as the additional processing step to make a product that is ready to consume (Apart from the dried pasta in *Table 3*) which requires additional processing equipment.

The project's overall goal is to 'think global and act local' in considering the environmental impacts of food waste and growing food for an increasing number of people. Apart from the financial investment of food manufacturing equipment, the final framework considers the environmental impacts of the product choices. The final products affect framework decisions in every way including (but not limited to) supply and demand requirements, resource requirements (financial, material, human), and transportation.

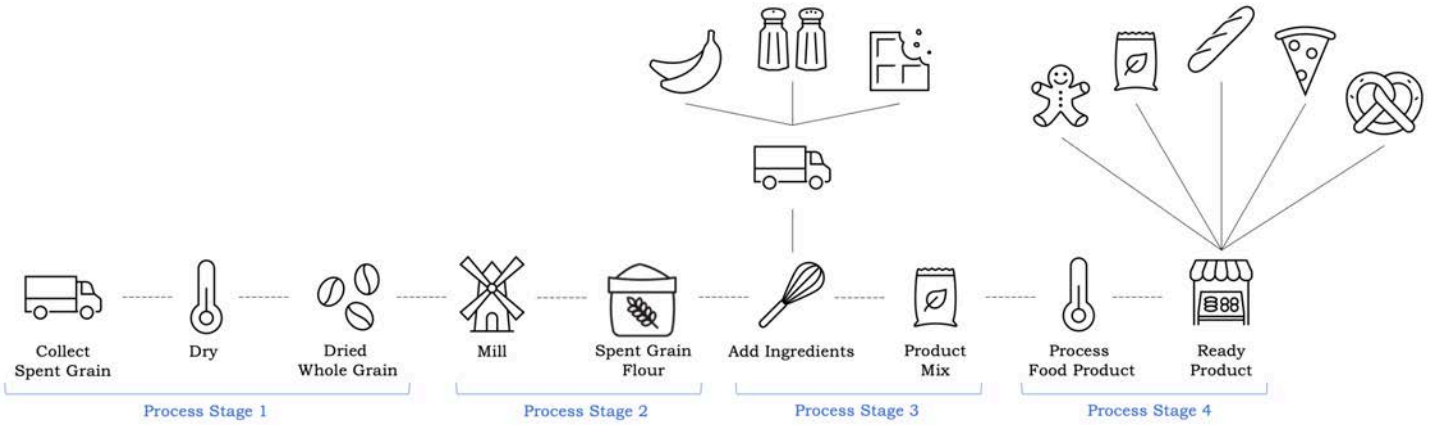


Figure 5.25. Depiction of the level of processing required for upcycled spent grain products.

Table 3 reveals that spent grain flour is the most common consumer product offered which requires two overall stages of processing and the least amount of investment. Considering the other upcycled spent grain products offered (apart from granola), a flour is the required spent grain format which allows for various options. The first option is to have the upcycling company take on 'Process Stage 1' and produce a whole dried upcycled spent grain as the final product. In this case, the grain would be sold and milled off-site or contract out the milling stage and have the spent grain returned to the upcycling company. The second option is to invest in the milling equipment and have the upcycling company dry and mill the upcycled spent grain on-site and offer a whole dried spent grain and flour product. Option three is to invest in the processing equipment required to make a consumer product mix, which also requires importing/obtaining other ingredients. The fourth option is to invest in all the equipment required to make a ready-to-eat product for consumers which adds a whole new set of processing requirements. The projected pro's and con's of taking on each processing stage is listed below, in *Table 4*.

Table 5.4. The anticipated pro's and con's of incorporating each processing stage into the upcycling framework.

	Pro's	Con's
Stage 1	• Smallest level of investment to upcycle spent grain to a shelf-stable product (financial, human, material)	• Product is not ready for most consumer or business use (likely requires further processing)
Stage 2	• The least amount of investment and processing for the most versatile/useable product	• Flour would likely exclude 10-20% of spent grain supply in creating a consistent product • Requires a separate demand for excluded spent grain beer styles
Stage 3	• Introduces the opportunity to create a consumer-ready product and market to a new group of customers • Provides opportunities to offer products to all revenue streams • Introduces opportunities to upcycle other ingredients • Offers opportunities to use the spent grain beer styles that cannot be included in the flour	• Requires a higher investment of resources (financial, human, material) • Increases the reliance of transportation to acquire ingredients • Decreases the percentage of upcycled ingredients in the final product • May reduce the frameworks sustainability potential
Stage 4	• Results in a product that consumers can try without committing to a large portion/amount • Offers opportunities for customer education of upcycled spent grain	• Increases opportunities for spoiling product or below-grade for sale • Requires fast product movement • The highest investment required

Upcycled Product Ingredient Review

The following is a review of the ingredients used in the five most common packaged upcycled spent grain products offered by North American upcycling companies as shown in *Table 3*. The ingredients of products reviewed will be as follows: (1) Barley Flour (6 Products), (2) Brownie Mix (4 Products), (3) Pancake/Waffle Mix (3 Products), (4) Granola (3 Products), and (5) Cookie Mix (2 Products). The review is intended to determine what is most commonly done among companies already having success with upcycling spent grain to use as consideration within the final framework.

According to the Canadian Food Inspection Agency (CFIA) (26), in Canada the core labelling requirements are: (1) Bilingual Labelling, (2) Common Name, (3) Country of Origin, (4) Date Markings and Storage Instructions, (5) Name and Principal Place of Business, (6) Irradiated Foods, (7) Legibility and Location, (8) List of Ingredients and Allergens, (9) Net Quantity, (10) Nutrition Labelling, (11) Sweeteners, (12) Food Additives, (13) Fortification, (14) Grades, and (15) Standards of Identity. In terms of listing ingredients, "All prepackages products with more than 1 ingredient must declare their ingredients and components in a list of ingredients… Ingredients must be declared in descending order of proportion by weight, as determined before they are combined to make the food" (27). This means that by examining a nutritional label of a prepackaged food product, we can roughly determine the ingredient volumes and the potential for different types of upcycling certification through the Upcycled Food Association (28).

The Upcycled Food Association is on a mission to 'reduce food waste by growing the upcycled economy and educating consumers about upcycled products' and offers 'the world's first certification program for upcycled food ingredients and products' (29). There are four steps to certification (30):

5. Scoping: Connect with UFA and the certifying body (CB) to determine scope of audit.
6. Audit: Submit documents for an audit which can be a desk audit for 95% of companies.
7. Licensure: Update your packaging and marketing assets with the Mark.
8. Launch: Celebrate your impact with your consumers!

Food and beverage products are eligible for certification and can be (1) Upcycled Ingredient(s) (UI), (2) Product Containing Upcycled Ingredient(s) (PUI), and (3) Minimal Content PUI(s) (31 p. 9). A UI is ≥95% upcycled input, a PUI must be ≥10% upcycled input, and a minimal content PUI is <10% upcycled input (31 pp. 12-13). Based on these definitions, the products chosen for production in the Winnipeg upcycling framework will be eligible for some sort of upcycled certification as an added labelling consideration and marketing strategy.

Barley Flour

Barley flour is the most common consumer product offered among the North American upcycling companies listed in *Table 3*. It also happens to be the most versatile product option and requires the least number of resources (financial, material, and human) to produce.

Table 5.5. The listed ingredients of upcycled spent grain flours offered by various North American upcycling companies.

	Ingredients
Susgrainable (15)	Spent Grain (Barley)
GroundUp (16)	Brewer's Saved Grain (Upcycled from Craft Micro-breweries in Alberta)
coRISE (17)	coRISE Supergrain+ (whole spent grain hulled barley)
Boomerang (19)	Spent Grain (Barley)
Rise NY (22)	Malted Barley
Still Good (24)	Spent grains (barley, oats and/or wheat)

As evident in *Table 5*, the six companies offering upcycled spent grain flour all have only one ingredient: upcycled spent grain. Among the labels, four companies list the spent grain as 'barley' meaning that the company could not include spent grain from beers that have had other grains or ingredients added for flavour as the nutritional label would no longer be accurate. One company does not specify the grains, and the last states "barley, oats, and/or wheat", indicating they may have more flexibility with the spent grains they can include in their product.

Relating back to the interview data analysis, a consistent product like a flour requires fairly consistent ingredients so customers know what to expect from the product. While it appears that one or two of the companies include some variation in grains, the variation is likely limited to adhere to the nutritional label as too much variation would require new packaging. It's also likely that flour would only use spent grain from lighter coloured beers and would therefore require different uses for seasonal and dark coloured beer spent grain.

Brownie Mix

According to *Table 3*, a packaged brownie mix is the second most common upcycled spent grain product. As opposed to an upcycled flour, a brownie mix would require more resources such as additional equipment, sourcing other ingredients, and additional packaging/labelling.

Table 5.6. The listed ingredients of upcycled spent grain brownie mixes offered by various North American upcycling companies.

	Ingredients
GroundUp (16)	Organic Cane Sugar, Saved Grain Flour (100% Brewer's Barley), Organic Cocoa Powder, Coffee Flour, Salt, Vanilla Powder, Xanthan Gum
coRISE (17)	Cane sugar*, coRISE Supergrain+ (whole-grain hulled barley, wheat*), cocoa*, espresso grounds+, sea salt
Regrained (20)	Cane Sugar, Organic Semi-Sweet Chocolate Chips (Organic Cane Sugar, Organic Chocolate Liquor, Organic Cocoa Butter, Organic Vanilla Extract), ReGrained SuperGrain+® (Barley, Wheat, Rye), Cocoa Powder (Processed with Alkali), Sea Salt, Natural Vanilla Flavour
Rise NY (22)	Cocoa powder, RISE Stone Ground Whole Barley Super Flour made by hand from upcycled grain, all-purpose flour, sugar, sea salt, chopped semisweet chocolate

Among the four companies currently offering a brownie mix, ¾ have cane sugar as the largest weight ingredient meaning the product is not a UI (31 p. 9) according to the Upcycled Food Association but could be a PUI for certification. All the mixes include upcycled spent grain, cocoa powder, salt, ¾ contain vanilla, and ½ contain chocolate chips.

We know that brownies are a dark brown chocolatey dessert. The GroundUp version contains upcycled coffee flour and the coRISE product has upcycled espresso grounds. Due to the nature of brownies, the incorporation of these dark coloured products seems a good fit and suggests that darker coloured spent grain would also be a good fit in a brownie mix. Depending on the dark beer recipe, a core style dark beer could provide the Winnipeg upcycling company consistency within a more conventional product while a seasonal dark beer might require nutritional testing and a new label if different grains were used in the brewing process.

While it's likely that ingredients used for flavouring aren't added until after the spent grain is removed, it's possible that some ingredients might be added with the barley. The partner brewery, **LOW**LIFE Barrel House, has a 'Dark Mild' in which the description states "Toffee and biscuits dominate the aroma, light taste of bakers chocolate, dark fruit & nuts. (4.4%)" (32), and also has a 'Dark Saison' with a description of "Malty and rich. Coffee, vanilla & coconut at the forefront. Aged in foeder" (33). Both these beers would offer great complimentary flavours in a limited-edition brownie mix or similar product if the coffee and chocolate flavours are also present in the spent grain.

Pancake/Waffle Mix

A pancake and/or waffle mix is the third most common upcycled spent grain product offered by the North American upcycling companies listed in *Table 3*. As with the brownie mix, this type of prepackaged consumer product requires more resources such as additional equipment, sourcing ingredients, and additional packaging/labelling requirements above those needed to offer a finished flour product.

Table 5.7. The listed ingredients of upcycled spent grain Pancake/Waffle mixes offered by various North American upcycling companies.

	Ingredients
Susgrainable (15)	Enriched Unbleached Flour (Wheat flour, Malted Barley Flour, Niacin, Iron, Thiamine, Riboflavin, Folic Acid), Spent Grain (Barley), Sugars (Cane Sugar), Baking Powder (Cornstarch, Sodium Bicarbonate, Monocalcium Phosphate), Salt
GroundUp (16)	Saved Grain Flour (100% Brewers Barley), Egg White Powder, Milk Powder, Corn Starch, Baking Powder, Butter Powder, Organic Cane Sugar, Pea Fibre, Vanilla Powder, Xanthan Gum
coRISE (17)	coRISE Supergrain+ (whole-grain hulled barley, wheat*), cane sugar*, baking powder, pea protein isolate, sea salt, spices*

Of the three companies offering a pancake and/or waffle mix, two (Susgrainable, coRISE) have mixed their upcycled spent grain flour with a wheat flour, two (GroundUp, coRISE) have included pea protein, and only one (GroundUp) has included the dairy ingredients.

Susgrainable produced a mix with 5 common ingredients and sells a 504 g bag for $11.99, equalling $2.38/100g. The *Pancake and Waffle Mix* requires the consumer to add ¾ cup milk, 3 tablespoons butter, and 1 egg (34). For the consumer, this product is the most expensive mix as it's almost the same price as GroundUp's version but still requires the purchase of other ingredients whereas the later likely does not. From the company side, this product will likely generate the most revenue of all three as it does not appear to include expensive ingredients.

GroundUp's *Better Breakfast High-Protein Pancake Mix* does not clearly indicate product directions, but the ingredient list would suggest that no additional ingredients apart from water are needed (35). A 450g package sells for $10.99, equalling $2.44/100g. For the consumer, this product is the most convenient as the dairy ingredients are already included and there's no additional purchases required to prepare the mix. A downfall is that the mix is not and cannot be made vegan and people with dairy allergies cannot use this product. From the company's side, this version is likely the most expensive to produce as it requires 10 ingredients and dairy can be pricey.

The coRISE *Cinnamon Pancake & Waffle Mix* requires the consumer to add water, vegetable oil, and eggs to the packaged product (36) after spending $9.99 for 510g, or $1.96/100g. This packaged mix is the most affordable up front and requires additional ingredients. However, the ingredients required to prepare the mix are relatively low cost which likely makes the coRISE mix the most affordable overall. The mix has 7 ingredients, most are common, therefore the company cost to produce the mix is likely mid-range among the three options.

Overall, a pancake and/or waffle mix appears to be a relatively simple product to offer and upcycling companies appear to have success with this option whether the dairy is included or not. In considering the Winnipeg upcycling framework, it appears that the addition of dairy products can be considered but is not necessary to a successful prepackaged product, leaving the decision to be based almost completely on finances and sourcing options/availability. A pancake/waffle mix can also offer versatility in the spent grains used as consumer options could include a conventional product made with the lighter-coloured core beer styles, a darker and more flavourful mix made with core style dark beer styles, and potentially unique flavours made with the limited-edition and seasonal beer styles. In this case, nutritional testing and custom labels need to be readily available.

Granola

Granola is the next most popular consumer-ready product offered by the North American spent grain upcycling companies listed in *Table 3*. This type of product requires more resources such as additional equipment, sourcing ingredients, and additional packaging/labelling requirements as with the other prepackaged products but does not require milling.

Table 5.8. The listed ingredients of upcycled spent grain granolas offered by various North American upcycling companies.

		Ingredients
coRISE (17)	Chocolate Hazelnut Granola	Rolled oats*, rye flakes*, coRISE Supergrain+ (whole-grain hulled barley), hazelnuts*, sunflower seeds*, chocolate chips (chocolate liquor, sugar, soy lecithin), canola oil*, cocoa*, cane sugar*, coconut MCT oil*, sea salt
	Chocolate Coconut Granola	Rolled oats*, rye flakes*, coRISE Supergrain+ (whole-grain hulled barley), coconut*, sunflower seeds*, chocolate chips (chocolate liquor, sugar, soy lecithin), canola oil*, cane sugar*, coconut MCT oil*, sea salt
	Protein Seeds Granola	Rolled oats*, rye flakes*, coRISE Supergrain+ (whole-grain hulled barley), sunflower seeds*, hemp seeds*, pumpkin seeds*, chia seeds*, flaxseeds*, cane sugar*, canola oil*, coconut MCT oil*, sea salt
Rise NY (22)	Brewers Spent Grain (Malted Barley), Rolled Oats, Maple Syrup, Sugar, Vegetable Oil, Cinnamon	
Still Good (24)	Oat (rolled oats, flour) Sugars (unsweetened applesauce, maple syrup, brown sugar), Sunflower seeds, Canola oil, Spent grains (barley, wheat), Dried blueberries (blueberries, sugar, sunflower oil), Dark chocolate (unsweetened chocolate, sugar, soy lecithin, natural vanilla extract), Coconut flakes, Pumpkin seeds, Puffed rice, Salt, Spices	

There are three companies currently offering upcycled spent grain granola, all of which include spent grain, rolled oats, and a form of sweetener. coRISE offers three unique varieties that all start with the same 3 ingredients. The version offered by Rise NY is made with 6 ingredients and appears to be the most 'conventional' or 'standard' option with spent grain. The granola offered by Still Good is a *Blueberry Dark Chocolate Upcycled Granola* and is shown in *Figure 20*. This product offers consumers with a unique and distinct flavour in a beautifully and professionally packaged product.

The primary benefit of the coRISE granolas are that the product base is consistent, allowing the company to change flavours relatively easily, but may limit the variety of spent grain that's able to be incorporated. The Rise NY product offers a more widely-appealing product, while the packaging used by Still Good limits them to consistently offering the same product.

Granola could present the upcycling company with a unique opportunity to use whole dried spent grain in a consumer-ready product that's not restricted to a conventional flavour and/or appearance if planned for. As is evident with the products listed in *Table 8*, granola flavours can be as unique as desired indicating unique seasonal and/or limited-edition small batch grains can be used.

Figure 5.26. Blueberry Dark Chocolate Upcycled Granola offered by Still Good (80).

Cookie Mix

The fifth upcycled food item included in the review is a prepackaged cookie mix offered by two upcycling companies as shown in *Table 3*. As with other packaged mixes, a cookie mix requires spent grain drying, milling, additional equipment, sourcing ingredients, and additional packaging/labelling materials/abilities.

Table 5.9. The listed ingredients of upcycled spent grain cookie mixes offered by various North American upcycling companies.

	Ingredients
Susgrainable (15)	Chocolate (Sugar, Unsweetened Chocolate, Cocoa Butter, Soy Lecithin (an Emulsifier), Natural Vanilla Extract), Sugars (Cane Sugar), Spent Grain (Barley), Oats, Baking Powder (Cornstarch, Sodium Bicarbonate, Monocalcium Phosphate), Baking Soda, Salt
coRISE (17)	Rolled oats*, cane sugar*, coRISE Supergrain+ (whole-grain hulled barley, wheat*), chocolate chips (chocolate liquor, sugar, soy lecithin), baking soda, sea salt, spices*

Figure 5.27. Chocolate Chip Cookie Mix offered by Susgrainable (78).

Cookies come in all shapes and flavours which offers a company upcycling spent grain some versatility in what type of spent grain is used. The products shown could potentially be made with a consistent flour made with spent grain, offering a more conventional oatmeal chocolate chip cookie. As with the brownies, the decision to offer a double chocolate cookie would expand the uses for core, seasonal, and limited-edition dark style beer spent grain as well as providing consumers with additional purchasing options. Offering a healthier option in the sweet treats industry could potentially attract and ease consumers who are not yet familiar with eating upcycled spent grain.

Of the two ingredient lists shown in *Table 9*, both mixes contain upcycled spent grain, oats, chocolate, cane sugar, baking soda, and salt. They only really differ in the flavouring and spices used. In fact, the product directions for both require the consumer to add butter and eggs. The primary difference between the products lies in the ingredient list itself. The Susgrainable version lists chocolate first, meaning it's the largest ingredient by weight whereas coRISE lists Rolled oats first. The proportion of oats compared with other ingredients is visible below in *Figure 22*.

Figure 5.28. Oatmeal Chocolate Cookie Mix offered by coRISE (36).

Suggested Products for Winnipeg, MB

The choice of final products offered through the upcycling framework takes in several considerations including, but not limited to: (1) upcycled spent grain revenue streams, (2) ingredient sourcing, (3) common upcycled spent grain products, (4) likeliness of success, and (5) resource availability (financial, material (equipment, space, etc.), human).

The *Upcycled Product Ingredient Review* provided insights of the potential for spent grain of various beer styles, represented in *Figure 23* below. Interview data from Winnipeg craft brewers indicated that 75% of the total beer production among participants are core-style beers, leaving the other 25% as 'expected variable product'. The review indicates that an upcycled spent grain flour is the most common product offered among the North American upcycling companies listed in *Table 3*, followed by brownie mix, pancake and/or waffle mix, granola, and cookies. A typical bakers flour is light coloured and would be the primary flour in light-coloured bakery products as a dark flour would change the final product colour and/or flavour. In the upcycling framework, the desired colour consistency of flour is most attainable through the lighter coloured core beer style's spent grains. Spent grains from other beer styles (seasonal, limited-edition, one-off, and contract brews) have potential and use in other consumer prepackaged products. *Figure 23* shows how 100% of spent grain supply could be used among the five most common upcycled spent grain consumer products.

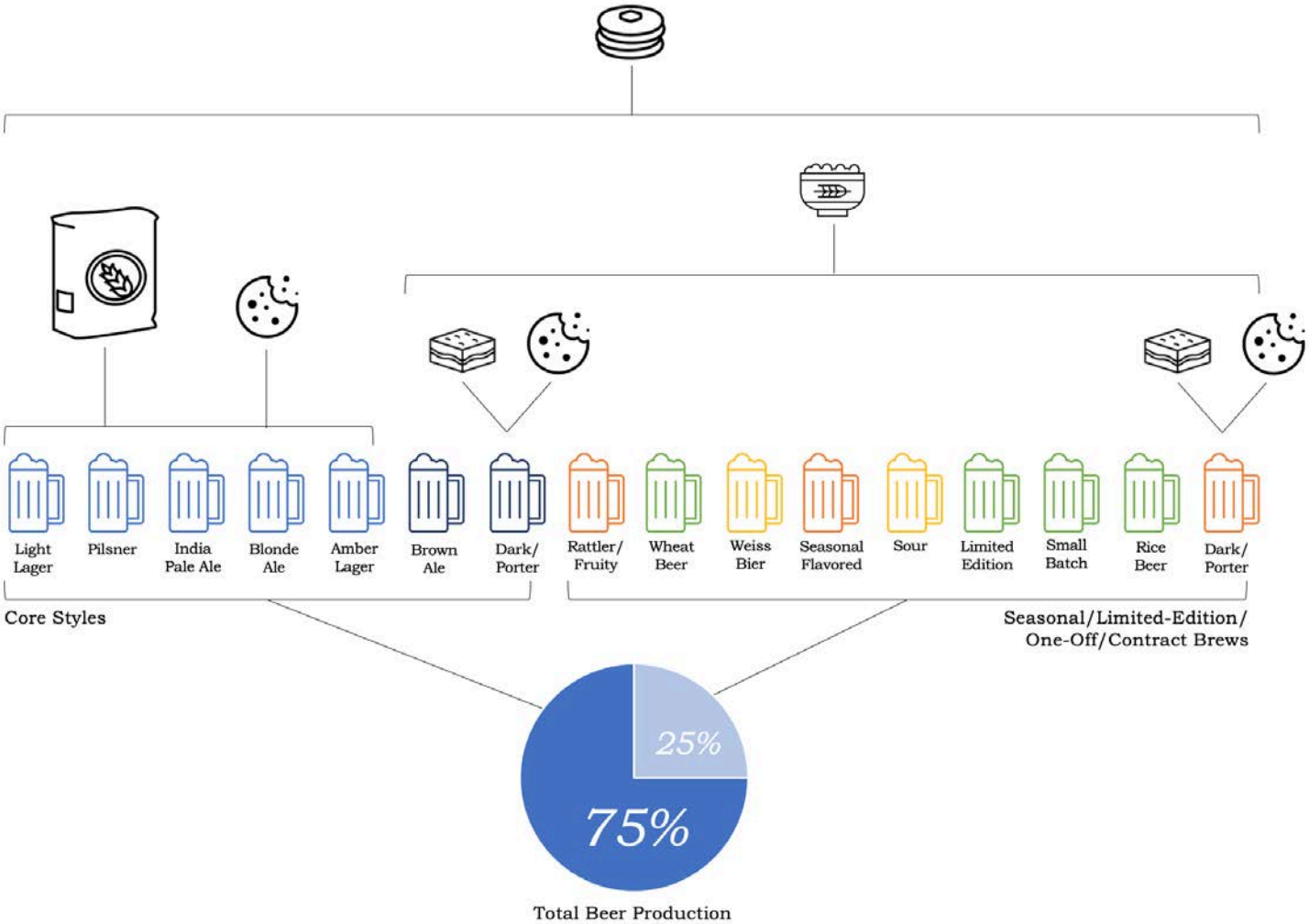


Figure 5.29. Representation of the proportion of beer styles and the potential final products for associated spent grain incorporation/use. The proportions (75% core styles, 25% other) were determined from Winnipeg craft brewer interviews and is only applicable to this case study. The beer styles listed are for examples only and is not an exhaustive list.

As upcycled spent grain products would be new to Winnipeg, it's important to consider that the framework needs to account for company growth and scaling as processing equipment can be very expensive, especially if product success is not guaranteed. Based on the common upcycled spent grain product ingredients and ingredients of other potential products listed in *Table 10,* company product offerings are suggested in the order shown in *Figure 24*.

Table 5.10. The listed ingredients of upcycled spent grain products offered by various North American upcycling companies.

		Ingredients
All Companies	Flour	Spent Grain (Barley)
Susgrainable (15)	Pancake /Waffle	Enriched Unbleached Flour (Wheat flour, Malted Barley Flour, Niacin, Iron, Thiamine, Riboflavin, Folic Acid), Spent Grain (Barley), Sugars (Cane Sugar), Baking Powder (Cornstarch, Sodium Bicarbonate, Monocalcium Phosphate), Salt
Regrained (20)	Pizza Dough	ReGrained SuperGrain® Blend [wheat flour, malted barley flour, ReGrained SuperGrain® (barley, wheat, rye)], vital wheat gluten, salt, instant yeast (sorbitan monostearate, ascorbic acid)
Regrained (20)	Banana Bread	ReGrained SuperGrain® Blend [wheat flour, malted barley flour, ReGrained SuperGrain® (barley, wheat, rye)], banana flakes, cane sugar, non-aluminum baking powder (sodium acid pyrophosphate, sodium bicarbonate, corn starch, monocalcium phosphate), cinnamon, salt, baking soda, spice
coRISE (17)	Cookies	Rolled oats*, cane sugar*, coRISE Supergrain+ (whole-grain hulled barley, wheat*), chocolate chips (chocolate liquor, sugar, soy lecithin), baking soda, sea salt, spices*
Rise NY (22)	Brownie	Cocoa powder, RISE Stone Ground Whole Barley Super Flour made by hand from upcycled grain, all-purpose flour, sugar, sea salt, chopped semisweet chocolate

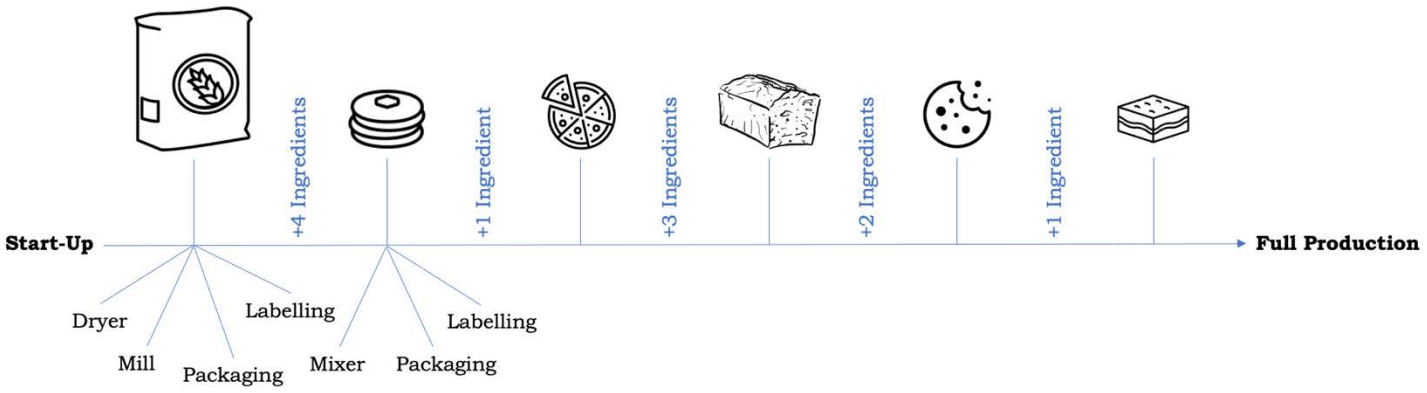


Figure 5.30. The basic requirements of additional consumer prepackaged products by the upcycling company through company scaling.

The basic equipment requirements of starting the upcycling company and producing flour are (1) the dryer, (2) a mill, (3) packaging equipment, and (4) a labeller. This first stage of company existence must generate a strong consumer base (most likely local businesses (B2B sales) and individual consumers) and grow consumer product knowledge. The first suggested consumer prepackaged mix is a pancake/waffle mix which requires a large increase in resources including (1) mixing equipment, (2) potentially more packaging and labelling capabilities, and (3) sourcing 4 more ingredients (wheat flour, cane sugar, baking powder, salt). The subsequent product additions are relatively easy compared with the first. Sourcing 1 more ingredient (yeast) allows the upcycling company to make a pizza dough mix. Sourcing another 3 ingredients (banana, spices, baking soda) provides the ability to make banana bread. Sourcing oats and chocolate chips can then make cookies, and sourcing 1 last ingredient (cocoa powder) allows the company to produce a prepackaged brownie mix. Overall, if the company wants to expand to offer the five products shown in *Figure 24* after the first stage, it requires sourcing 11 ingredients total, a mixer, and potentially packaging/labelling.

Upcycled Products Price Review

Pricing of any consumer product is a vital consideration as it needs to be appropriate and/or reasonable for both the company and the buyer. If the upcycled products are priced too high, consumers may be more inclined to purchase the products they are familiar with, but if priced too low, jeopardizes the company's ability to profit. With that said, the following section offers some pricing suggestions based on upcycled product pricing compared with common grocery store flour products pricing. All upcycled product prices were obtained from their respective websites on June 6, 2023, and grocery store prices were obtained from The Real Canadian Superstore the same date. The price analysis is done on consumer products as the information is readily available and individual consumers will likely make up a significant revenue group.

Barley Flour

As the most common product offered by upcycling companies and requires the least amount of processing, barley flour offers an affordable and versatile product for new and repeat customers to enjoy at home in a variety of recipes.

We see in *Table 11* that upcycled barley flour ranges in price from $0.90-2.65/100g, with the average being $1.96/100g. Other flours offered at the grocery store range from $0.25-3.56/100g averaging at $1.33/100g, with wheat flours on the lower end and specialty/alternative flours on the higher end. The variation in price is a result of many factors that are also considered in pricing barley flour. First off, barley contains gluten and cannot be used in gluten-free diets and is therefore more relatable to wheat flour than gluten-free alternatives. Second, production costs associated with growing and acquiring the product need to be incorporated into the final cost. As the framework is based on a no-money exchange with breweries, the costs of acquiring the ingredient include a vehicle and fuel, but no product purchase. Third, the processing costs need to be considered but are not comprehensively covered in this report. Fourth, the company should consider a competitive edge associated with pricing upcycled barley flour. With those primary considerations, the product should land within the range of $1.20-1.80/100g.

Table 5.11. Upcycled Barley Flour Price Review.

	Price	Unit Volume	Volume Price per 100g	Servings	Price per Serving
Susgrainable (15)	$9.99	400g	$2.50	---	---
GroundUp (16)	$8.99	1000g	$0.90	---	---
coRISE (17)	---	---	---	---	---
Rise NY (22)	$60.00	2268g	$2.65	---	---
Still Good (24)	$8.99	500g	$1.80	---	---
Average:	$21.99	1042g	$1.96	---	---

Table 5.12. Grocery Store Flour Price Review (37).

Product	Brand	Use	Price	Unit Volume	Volume Price per 100g
Wheat Flour	No Name	All Purpose	$2.49	1000g	$0.25
Wheat Flour	Robin Hood	All Purpose	$4.99	1000g	$0.50
Whole Wheat Flour	Robin Hood	All Purpose	$6.49	2500g	$0.26
Quinoa Flour	PC Organics	---	$11.49	454g	$2.53
Brown Rice Flour	PC Organics	---	$4.29	454g	$0.94
Coconut Flour	Robin Hood	---	$7.99	500g	$1.60
Almond Flour	Robin hood	---	$17.79	500g	$3.56
Oat Flour	Quaker	---	$6.49	700g	$0.93
		Average:	$7.75	888.5g	$1.33

Brownie Mix

An upcycled brownie mix is the second most popular product offered by other spent grain upcycling companies and is a good use for dark spent grain. We see in *Table xxx* that the average price of upcycled brownie mix is $1.68/100g, while the grocery store average is $1.24/100g. The majority of brownie mixes are a single-pan portion of 450-550g, suggesting that this range is effective for a dessert product and fits standard bakeware. As the average price of upcycled and conventional brownie mixes are relatively similar, a price between $1.24/1.68/100g is reasonable and wouldn't affect the overall price of a 450-550g box significantly.

Table 5.13. Upcycled Brownie Mix Price Review.

	Price	Unit Volume	Volume Price per 100g	Servings	Price per Serving
GroundUp (16)	$8.99	450g	$2.00	---	---
coRISE (17)	---	---	---	---	---
Regrained (20)	$5.99	454g	$1.32	12	$0.50
Rise NY (22)	$19.00	1106g	$1.72	48	$0.40
Average:	$11.32	670g	$1.68	36	$0.45

Table 5.14. Grocery Store Brownie Mix Price Review (37).

Product	Brand	Use	Price	Unit Volume	Volume Price per 100g
Brownie	Betty Crocker	Mix	$4.49	550g	$0.82
Chocolate Chunk Brownie	Betty Crocker	Mix	$4.49	440g	$1.02
Gluten Free Brownie	Betty Crocker	Mix	$7.49	454g	$1.65
Epic Brownie	Duncan Hines	Mix	$7.99	585g	$1.17
Plant Based Brownie	Presidents Choice	Mix	$7.49	500g	$1.50
Brownie	Bobs Red Mill	Mix	$7.49	595g	$1.26
		Average:	$6.57	520g	$1.24

Cookie Mix

A cookie mix was the 5th most popular upcycled spent grain consumer item and unfortunately one company no longer had a website by the price review date. However, Susgrainable offers a cookie mix that sells for $3.24/100g, while the average of some grocery store mixes was $0.94/100g. The upcycled cookie mix is relatively expensive compared with the other mixes but could be justified. As the grocery store mixes do not exceed $1.39/100g, an upcycled cookie mix should not exceed $1.50-1.60 (half the unit price of the Susgrainable mix) to remain competitive but would also need to consider and incorporate company profits to be a viable product.

Table 5.15. Upcycled cookie mis price review.

	Price	Unit Volume	Volume Price per 100g	Servings	Price per Serving
Susgrainable (15)	$11.99	370g	$3.24	---	---
coRISE (17)	---	---	---	---	---
Average:	$11.99	370g	$3.24	---	---

Table 5.16. Grocery Store Cookie Mix Price Review (37).

Product	Brand	Use	Price	Unit Volume	Volume Price per 100g
Chocolate Chip Mix	Betty Crocker	Mix	$4.49	496g	$0.91
Oatmeal Cookie Mix	Quaker	Mix	$5.79	900g	$0.64
Oatmeal Cookie Mix	Presidents Choice	Mix	$3.99	900g	$0.44
Sugar Cookie Mix	Betty Crocker	Mix	$4.49	496g	$0.91
Chocolate Chip Cookie	Bobs Red Mill	Mix	$8.49	624g	$1.36
Gluten Free Chocolate Chip	Betty Crocker	Mix	$7.49	539g	$1.39
		Average:	$5.79	659g	$0.94

Pancake/Waffle Mix

Pancake and/or waffle mixes are the third most offered upcycled spent grain product by North American upcycling companies. They also happen to be common and abundant in grocery stores. The upcycled version sells for an average of $1.92/100g, while the grocery store options average $0.97/100g (approximately half the price). The most comparable upcycled option in price is the Still Good mix at $1.15/100g. As it seems pancake and waffle mixes already have a lot of competition, a local upcycled version should not exceed $1.30/1.40/100g if possible so the company can remain somewhat competitive and sell more volume. This price range would be comparable to the specialty-diet products such as plant-based and gluten-free, without choosing a price point that average consumers cannot afford or will not justify buying.

Table 5.17. Upcycled pancake/waffle mix price review.

	Price	Unit Volume	Volume Price per 100g	Servings	Price per Serving
Susgrainable (15)	$11.99	504g	$2.38	18-21	$0.60
GroundUp (16)	$9.99	450g	$2.22	---	---
Still Good (24)	$5.99	520g	$1.15	24	$0.24
Average:	$9.32	491g	$1.92	21	$0.42

Table 5.18. Grocery Store Pancake/Waffle Mix Price Review (37).

Product	Brand	Use	Price	Unit Volume	Volume Price per 100g
Old-Fashioned Pancake Mix	No Name	Mix	$2.99	905g	$0.33
Original Pancake Mix	Presidents Choice	Mix	$3.49	905g	$0.39
Buttermilk Pancake Mix	Presidents Choice	Mix	$3.49	905g	$0.39
Original Pancake Mix	Pearl Milling Co.	Mix	$3.79	905g	$0.42
Buttermilk Pancake Mix	Pearl Milling Co.	Mix	$3.79	905g	$0.42
Whole Grain Mix	PC Blue Menu	Mix	$3.49	905g	$0.39
Original Pancake Mix	PC Organics	Mix	$5.99	900g	$0.67
Plant-Based Pancake Mix	Presidents Choice	Mix	$5.29	400g	$1.32
Crepe Mix - Plain	Cora	Mix	$6.29	700g	$0.90
Gluten-Free Pancake Mix	Bobs Red Mill	Mix	$6.99	680g	$1.03
Gluten-Free Pancake Mix	Presidents Choice	Mix	$5.49	400g	$1.37
Protein Pancake & Waffle	Flourish	Mix	$9.49	430g	$2.21
Protein Pancake & Waffle	Bobs Red Mill	Mix	$10.99	397g	$2.77
		Average:	$5.50	718g	$0.97

Granola

Granola is the fourth most common upcycled product and has the added benefit of requiring minimal processing of the spent grain as it can be dried and whole within the granola. The upcycled granola's offered differ substantially with one at $2.99/100g and the other at $15.79/100g. The grocery store granola options range from $0.84-2.29/100g with an average of $1.59/100g. The upcycled granola price is higher than any of the specialty brands offered at the grocery store, therefore having a max price of $2.29/100g would allow the product to remain competitive. However, considerations of the desired target market would be needed in choosing a final price.

Table 5.19. Upcycled granola price review.

	Price	Unit Volume	Volume Price per 100g	Servings	Price per Serving
coRISE (17)	---	---	---	---	---
Rise NY (22)	$18.00	114g	$15.79	---	---
Still Good (24)	$8.99	300g	$2.99	---	---
Average:	$13.50	207g	$9.39	---	---

Table 5.20. Grocery Store Granola Price Review (37).

Product	Brand	Use	Price	Unit Volume	Volume Price per 100g
Granola	PC Blue Menu	RTE	$3.99	475g	$0.84
Protein Chocolate Granola	PC Blue Menu	RTE	$4.49	325g	$1.38
Honey Nut Granola	Presidents Choice	RTE	$3.99	400g	$1.00
Dark Chocolate Granola	Nature's Path	RTE	$6.99	325g	$1.54
Banana Nut Omega 3	PC Blue Menu	RTE	$4.49	325g	$1.38
Pumpkin Flax Granola	Nature's Path	RTE	$5.69	325g	$1.63
Apple Crumble	Harvest Crunch	RTE	$5.49	470g	$1.17
Raisin and Almond	Harvest Crunch	RTE	$5.49	510g	$1.08
Strawberry Granola	Made Good	RTE	$6.49	284g	$2.29
Chocolate Banana	Made Good	RTE	$6.49	284g	$2.29
Gluten-Free Organic Coconut Cashew	Nature's Path	RTE	$6.99	312g	$2.24
Gluten-Free Organic Honey	Nature's Path	RTE	$6.99	312g	$2.24
		Average:	$6.17	362g	$1.59

Considerations for Final Pricing

According to the Business Development Bank of Canada (BDC), when choosing a product price, considerations need to be made considering operating costs, scarcity or abundance of inventory, shipping costs, fluctuations in demand, your competitive advantage, and the perception of your price (38). Additionally, a pricing strategy should be considered and the five most common strategies according to the BDC are (38):

1. Cost-plus **pricing.** Calculate your costs and add a mark-up.
2. **Competitive pricing.** Set a price based on what the competition charges.
3. **Price skimming.** Set a high price and lower it as the market evolves.
4. **Penetration pricing.** Set a low price to enter a competitive market and raise it later.
5. Value-based **pricing.** Base product/service's price on what the customer believes it's worth.

While the grocery store price lists provided in the comparison analysis are nowhere near exhaustive, they touch on some of the considerations needed in choosing a final product price and offer some insight as to how the upcycled products are priced.

With a primary focus of this project being to provide sustainable upcycling solutions for local breweries and food companies, the sustainability advantages of buying an upcycled and sustainable product should be extended to consumers who are trying to minimize their environmental impact. That said, a combination of cost-plus pricing and competitive pricing should be considered. A cost-plus pricing strategy would protect the upcycling company and ensure profits are being made, while competitive pricing encourages consumers to try the product as well as appeal to a wider range of consumers. As shown in *Figure 25,* there is an ideal price where the company is profitable but priced strategically to remain competitive and appealing. In meeting global environmental initiatives and targets, it's important that sustainable and environmentally friendly products are accessible to all income levels so as to remove as many barriers as possible.

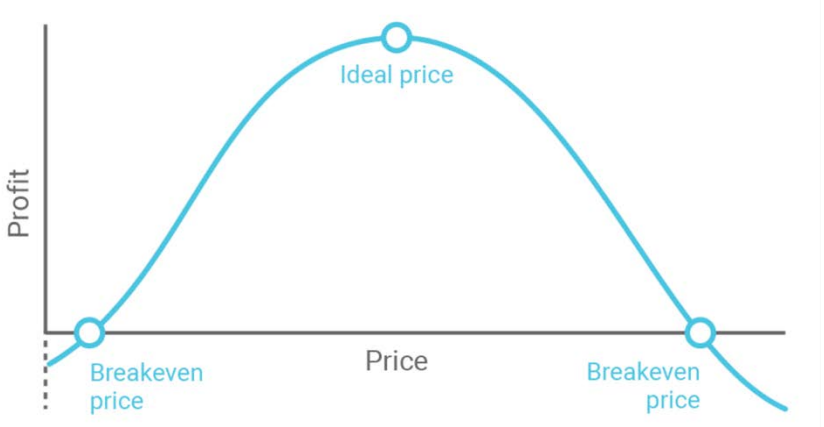


Figure 5.31. "As you raise your price (moving left to right), your profitability goes up—to a point. It's at the point where you've raised your price by too much that your profitability goes down" (38). *Source: Eric Dolansky*

Existing Upcycling Frameworks

There's a variety of framework options that would allow for upcycling in Winnipeg, but the goal is not just to upcycle spent grain. The final framework must be the best option for Winnipeg from a variety of factors including the consideration all affected parties, the environmental footprint of implementation and operations, and ensuring that it's realistic. As such, it's valuable to understand the upcycling frameworks from existing companies.

Susgrainable

Table 5.21. Susgrainable upcycling framework description (92).

Extraction	Collection	Processing	Products
Malted barley in the brewing industry is steeped in water to extract all the sugars but the rest of the grain is left behind.	As soon as the brewing process is complete, we collect the materials and send them for processing.	We process the grains into a high fibre, high protein flour which becomes our key ingredient in our products.	Our flour is turned into simple healthier baking mixes and customers benefit from better nutrition and creating a positive environmental impact.

Susgrainable is a Vancouver-based company that upcycles brewers spent grain into flour and mixes for cookies, pancakes, waffles, and banana bread. The above upcycling framework breaks their process down into three stages: (1) Extraction, (2) Collection, and (3) Processing. Based on the products they offer it appears their process requirements are Stage 3. Based on the framework and description, there is no indication that they upcycle out of more than one location/establishment, therefore assuming Susgrainable processes spent grain to a finished packaged product themselves after collection.

Figure 5.32. Susgrainable upcycling framework (39).

GroundUp

Table 5.22. GroundUp Upcycling framework description (112).

Brewing	Dehydrating	Clean Technology	Milling	Products
Brewer's grains are used to brew beer.	Grains are dehydrated, making them shelf-stable.	Advanced clean technology processes remove elements.	Grains and milled into a finer flour consistency.	100% barley saved-grain flour.

GroundUp is an upcycling company based in Okotoks, Alberta that makes an upcycled barley flour, brownie mix, and a pancake mix. The above framework breaks their upcycling process into five steps: (1) Brewing, (2) Dehydrating, (3) Clean Technology, (4) Milling, and (5) Products. Based on the framework and products offered, GroundUp upcycling is a Stage 3 process. The framework and description suggest that all upcycling activities are done at one location by GroundUp itself.

Figure 5.33. GroundUp upcycling framework (112).

Boomerang Coop

Boomerang Coop is a Montreal-based upcycling company that upcycles spent grain to a barley flour in four steps according to their website framework: (1) Collection, (2) Drying, (3) Milling, and (4) Flour. Based on the image, their process is a stage 2. The upcycled flour is said to have a "roasted taste", bring "chocolate/caramel notes", and add a "golden/caramelized" colour to the products you use it in (13). From the interview conducted with Boomerang Coop, we know their entire process happens in an 800 sqft space from storage to packaging and labelling.

Figure 5.34. Boomerang upcycling framework (45).

coRISE

Table 5.23. coRISE upcycling framework description (113).

Upcycling Process
We rescue & upcycle these grains from local breweries and distilleries to reduce food waste & environmental impact. We transform them into prebiotic coRISE Supergrain+ -sustainable wheat & grain replacement for all products ranging in baked goods, cereal, snacks, pasta, dietary supplement & more.

This upcycling company makes several products including croutons, 3 types of granolas, 3 consumer mixes, and offers barley flour. Their upcycling process is not provided online, but based on their products and image, coRISE likely has a Stage 4 process, needed for croutons and granola. The framework description suggests that upcycling is done at a single location.

Figure 5.35. coRISE upcycling framework (113).

Spent Goods

Table 5.24. Spent Goods upcycling framework description (114).

Upcycling Process			
We enable *any* food producing business to cost effectively incorporate viable food by-products that are typically discarded, turning them into "upcycled" foods (aka spent goods) while addressing food safety, consumers' emotional needs as well as business financials, as a(n):			
Product Innovator	**Ecosystem for Business**	**Sales and Distributor**	**Educator**
We focus on industrial food by-products (not household) in urban areas and find innovative ways to transform them into value	Through relationship building and online tools, we are building an ecosystem where outputs from certain businesses become inputs for others	We curate food producers that incorporate viable food by-products to highlight their delicious foods to the foodie masses.	We assure Canadians that upcycled food is delicious and food safe, while nudging behaviour that directly reduces food waste and climate change.

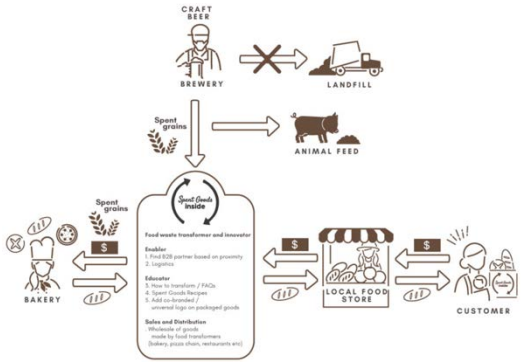


Figure 5.36. Spent Goods upcycling framework (114).

The Spent Goods company upcycles spent grain and offers a variety of fresh bakery products (bread, pretzels, crackers). The framework suggests they rescue spent grains and use it in their own products therefore leading by example and offering education to consumers and other companies, but they also enable B2B sales with other proximate businesses to expand the impact of upcycling. Based on their upcycling framework depiction and description, it appears that the process of upcycling spent grain to fresh bakery products is done at one location and/or at least done by The Spent Goods Company itself.

Regrained

Table 5.25. Regrained upcycling framework description (115).

Patent Process		
ReGrained rescues food safe ingredients that manufacturers traditionally consider "spent." By saving this food, we can introduce products with no additional land use, fertilizers, and other inputs.	Our patented technology developed in partnership with the USDA unlocks what is otherwise a challenging supply chain in a scalable, energy-efficient way. Our pioneering process is the gold-standard of food safety and quality.	These new upcycled food supply chains reduces systemic demand on virgin resources, lowers carbon footprint and feeds people clean nutrition!

ReGrained is a California-based company that makes prepackaged mixes from upcycled spent grain, as well as upcycles other ingredients for B2B customers. The exact process is not provided online, but based on their products and the framework, they likely have a Stage 3 process. In terms of upcycled spent grain products, there's no indication that more than one location is needed for their upcycling activities.

Figure 5.37. Regrained upcycling framework (115).

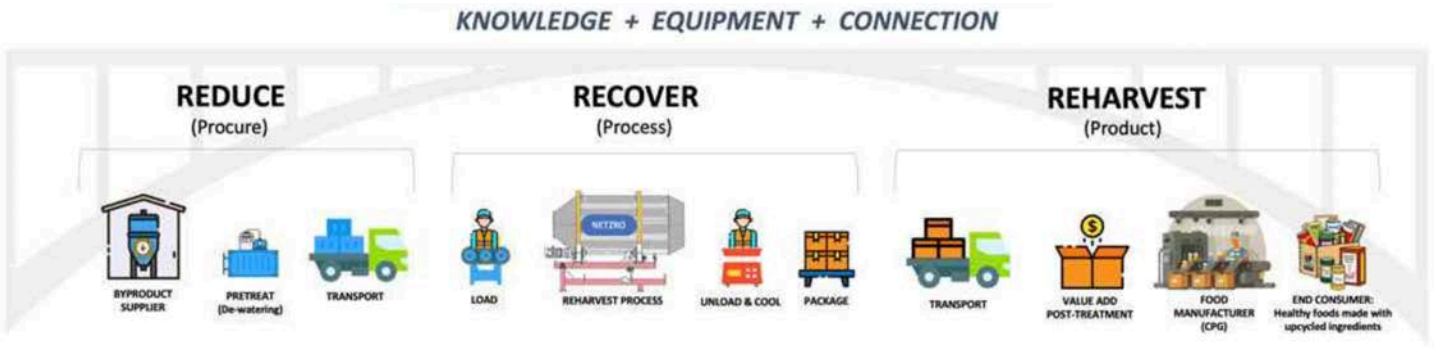


Figure 5.38. NETZRO upcycling framework (116).

Table 5.26. NETZRO upcycling framework description (116).

Upcycling Process
NETZRO connects all sides of the food supply chain to create a sustainable circular upcycled food economy. The platform was built with transformational change in mind and to connect the food supply chain. NETZRO technology involves upcycling by-products into new upcycled ingredients but also connects different sides of the food chain that are generally not bridged. We want to use our platform to further connect people to address the root causes of the broken food system. **NETZRO is a bridge to connect the entire food supply chain.**

NETZRO is a Minneapolis-based company that has developed equipment capable of removing moisture from delicate spent goods, allowing them to be upcycled in other products. They "connect all sides of the food supply chain to create a sustainable circular upcycled food economy" (44). The available upcycling figure and description clearly indicate that the upcycling process happens in various locations with NETZRO handling the 'Recover' portion and offering a whole, dried spent grain.

Suggested Upcycling Process for Winnipeg, MB

Of the seven upcycling companies that described their brewers spent grain upcycling framework and/or processes online, six of the companies appear to have all upcycling activities/processes done at a single location, while one company is a 'connection' or an 'intermediate' step in upcycling. The companies upcycling 'on-site' also have a variety of their own branded products made with upcycled spent grain. The perceived popularity of on-site upcycling suggests that this might also be the best option for the Winnipeg upcycling framework as well for various reasons.

- To start, the transportation of anything emits a lot of greenhouse gasses and the upcycling framework is intended to be the most sustainable option available therefore on-site processing of the raw product to a finished consumer product is the least travelled distance for spent grain. It's beneficial to make the facility as productive as possible to not waste space/resources.
- Second, having the upcycling activities/processes produce a flour product instead of a whole-grain dried product eliminates the need for a potential user to need additional processing equipment (for example a mill or an at-home food grinder) to use the product.
- Third, having full control of the process schedules and scaling options with on-site processing allows the upcycling company to make informed and necessary decisions regarding growth and business finances, and allows the company to pursue growth opportunities.
- Fourth, on-site processing allows the upcycling company to truly operate with a zero-waste goal at the forefront of all decisions as a primary focus is to reduce food waste.
- Fifth, processing on-site allows the upcycling company to accept special consumer requests regarding the finished product at a higher rate. For example, this could be providing a finer flour coarseness or making a particular spent grain blend.
- Sixth, keeping all production activities at a single location limits contamination opportunities.

Due to the popularity of a single site for spent grain upcycling and the above reasons, it's recommended that upcycling brewers spent grain in Winnipeg also be done at a single establishment.

Identifying Market Demand

As an emerging food trend, a new upcycled food product in Winnipeg requires identifying and creating market demand. A variety of revenue streams and product options are possible and creating excitement and value can be done in many ways and will be discussed in this section.

BSG Nutritional Profile

The nutritional profile of brewers spent grain has been studied and documented in various countries and has been found to be a nutritious food product/ingredient. As shown in *Figure 26*, BSG is generally comprised of 30-50% fibre, 19-30% protein, 12-28% lignin, 10% lipids, and 2-5% ash. Although BSG is largely composed of fibre, proteins and minerals, spent grain can vary in chemical composition due to a number of factors including barley variety, harvesting time and conditions, malting and mashing techniques used by the craft brewery, and other cereals added to the brewing process. However, overall, brewers spent grain is rich in proteins, sugars, and minerals, and samples remain fairly consistent across breweries (10 p. 1264). A complete analysis of brewers spent grain nutritional profile is provided in the Background Information Report.

The current version of the Canada Food Guide suggests making "half your plate vegetables and fruits", and to "choose protein foods that come from plants more often" (45). "Plant-based protein foods can provide more fibre and less saturated fat than other types of protein foods. This can be beneficial for your heart health" (46). Brewers spent grain is high in protein (20-30%) and fibre (up to 50%) (7), making it a valuable addition to food products to increase protein and fibre content to support a healthy diet.

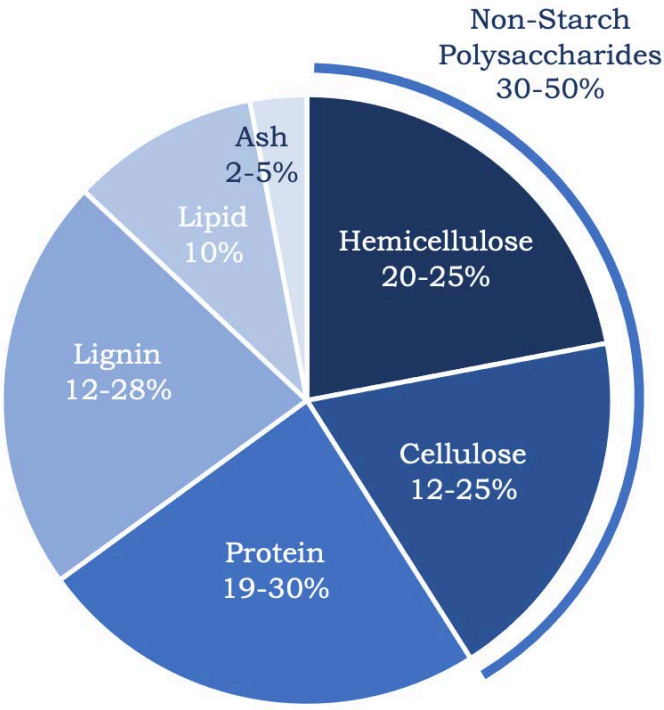


Figure 5.39. Typical barley BSG composition. Graph replicated from (7 p. 555), adapted from (8) and (9).

Additionally, Lignans are classified as natural products with many studied and reported biological activities including antiviral, anticancer, cancer prevention, anti-inflammatory, antimicrobial, antioxidant, immunosuppressive, hepatoprotective, and prevention against osteoporosis (47 p. 370). Not to mention that of the total spent grain protein content, approximately 30% is essential amino acids and Lysine represents 14.3%. Lysine is generally a limiting amino acid in other cereals, which makes BSG valuable (48).

Brewers spent grain has mostly been studied in bakery products. As a flour product, BSG is usually dried and then milled. Sieving has also been studied as various fractions of the milled product can be separated (7 p. 561). Upcycling BSG to bakery products has been tried with breads, biscuits, cookies, muffins, cakes, waffles, pancakes, tortillas, snacks, doughnuts and brownies. BSG can increase the protein, fibre and amino acid contents while decreasing the overall calories in a food product. BSG incorporation increases water absorption and decreases fat absorption but is best incorporated in coloured products to not alter the final products appearance. It's been found that up to 100 g kg^{-1} in food formulations, or 10% has the best results (10 p. 1267) to minimize any unwanted textures in final products.

Large-Scale Brewing and BSG Upcycling

Anheuser-Busch

Anheuser-Busch is the world's leading brewer (49), operating many breweries around the world including 8 in Canada (50) and 12 in the United States (51). ABInBev created a company called EverGrain (52) that upcycles the company's spent grain.

"Brewing beer creates a by-product called brewer's spent grain (BSG), which the industry has historically sent to landfills or animal feed. As the world's largest brewing company, we sustainably source about three million metric tons of the highest quality malting barley every year. That means a lot of BSG – about 1.4 million metric tons annually" (52).

EverGrain has a line of products, EverPro, which are soluble barley protein products made from upcycled spent grain. They boast "quality nutrition, lower carbon footprint, faster absorption and digestibility, and unparalleled taste and texture". Products include (1) Original - A protein isolate powder, (2) Neutral – an isolate that enables plant-based milks, and (3) Clear - a protein isolate resulting in a clear solution (53).

With a global leader upcycling brewers spent grain, two thoughts regarding upcycling BSG in Winnipeg BSG arise. First, if the world's leading brewer has invested extensive resources to upcycle spent grain, it's likely a very valuable and profitable endeavor, and second, EverGrain by ABInBev could be a key player in making upcycled products mainstream with such a global brand backing it.

Figure 5.40. EverPro product lineup (53).

"The Best Protein for the Planet
Upcycled BSG is one of the most sustainable proteins on the planet. It uses less water to grow, prevents food waste, and doesn't require transportation to our facility. This means lower GHG emissions, a reduced carbon footprint, and less impact on the environment" (54).

Molson Coors

Another large-scale brewing company, Molson Coors, is upcycling spent grain in a different way. While the company's 2022 ESG report (55) does not mention what they do with their spent grain from a multitude of brands, the Sustainable Development Goals Impact Report 2021 and 2020 states that "1,200,000+ tonnes of spent grain and yeast are sent to farmers and other businesses for beneficial reuse" (56) (57).

The company has however made their entrance into the plant-based milks market with GoldenWing (58), but unfortunately the product is not made with upcycled spent grain and instead requires a fresh supply which in turn increases demand for barley growth/yield. "Golden Wing is a barley milk made with the highest quality barley from the Coors Barley Program" (59). The Coors Barley Program is a series of "partnerships with growers across the Rocky Mountain region" which gives "the brewery exclusive access to good quality, high-yield barley" (60).

Figure 5.41. GoldenWing barley milk by Molson Coors (58).

"Milk from the mountains.
Uniquely grown in the spirit of the Rocky Mountain West by generations of barley farmers, we're a barley milk that invites people to step outside their everyday comfort zone" (58).

BSG in the Plant-Based Industry

The current version of the Canada Food Guide suggests making "half your plate vegetables and fruits", and to "choose protein foods that come from plants more often" (45). Since the release of the new food guide, several new "plant-based" products have become available, shown in *Figure 29* (61 p. 17).

"A plant-based diet consists of all minimally processed fruits, vegetables, whole grains, legumes, nuts and seeds, herbs, and spices and excludes all animal products, including red meat, poultry, fish, eggs, and dairy products. (62)", while plant-based alone is defined as "(of food or a diet) consisting largely or solely of vegetables, grains, pulses, or other foods derived from plants, rather than animal products" (63).

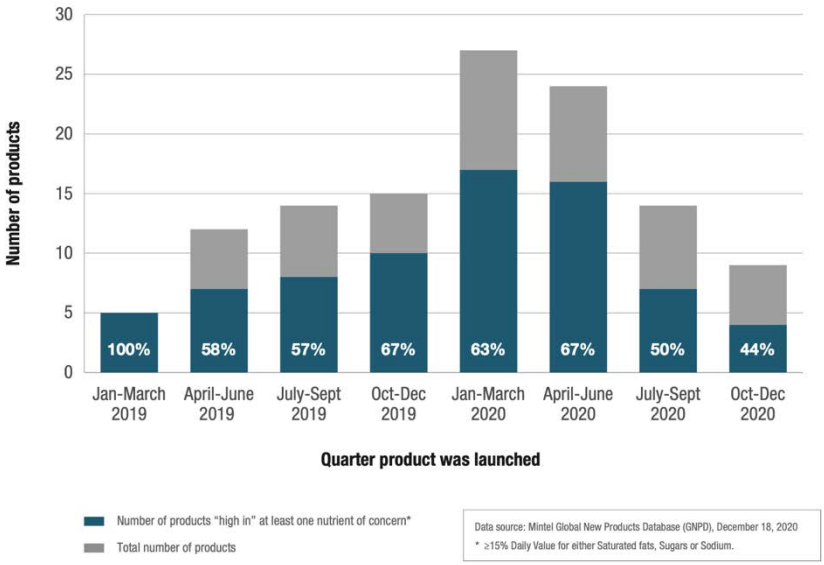


Figure 5.42. Number of new plant-based products in Canada since Canada's food guide launch in January 2019. (61 p. 17)

Plant-based proteins fall in the category of *alternative proteins* and are expected to represent up to a third of the entire protein market by 2024 (64). The primary drivers of this industry's growth are: (1) an increasing awareness about the benefits of protein-rich diet and plant-based alternatives, (2) rising world demand for protein due to rapid population growth, (3) growing consumer interest in foods that promote health and well-being, and (4) adoption of environmental stewardship and protection of animal welfare (64). Among a population of 40.1 million (65), 40% of Canadians "are actively trying to incorporate more plant-based foods into their diets (64). The upward trend suggests that there is growing demand and high potential in this sector for upcycled BSG.

"In Canada, outdated regulation, labor training and infrastructure continue to remain a challenge for the plant ingredient industry. Another current barrier for manufacturers seeking to position plant-protein foods domestically and abroad is that regulatory methods for measuring protein quality differ across regions. As the Canadian value-added industry expands, the finite resources used in food processing such as water and energy would also pose a significant threat to long-term environmental sustainability.

Producers and manufacturers in the sector have identified at least four venues to take advantage of the growing market of plant-based food: (1) starting new plant-based companies, (2) launching a plant-based product line or altering ingredients, (3) pursuing acquisitions to enhance their brand and product offering; and (4) expanding, diversifying or adjusting product offerings to ensure alignment with the current market through R&D. Some of the major global players in the sector are undertaking major expansions of their existing facilities and operations in Canada" (64).

The above excerpt from the *Plant-Based Protein Market Global and Canadian Market Analysis (March 2019)* outlines that as a relatively new industry, there are challenges but there are opportunities that can be taken advantage of during the plant-based industry's growth with upcycled BSG. First, as the research suggests, starting a new plant-based company is feasible and has large potential in Winnipeg, MB. Second, the launch of a new company introduces new plant-based products to the local market, especially with the scaling options presented. Third, the new products offered by the upcycling company would simultaneously offer other companies the opportunity to enhance their own products and market to new and existing customers. The report states that "most plant-based protein sources are at an early stage of development and require continued innovation to succeed" (64). BSG is a reliable ingredient and upcycling is an innovative process.

The 2019 report indicates the plant-based industry is "currently dominated by soy protein products" but "demand for pulse ingredients is growing". With that said, "the Canadian prairies are currently on their way to become a hub for pulse fractionation, a relatively new processing technology used to select and extract proteins for use as food ingredients" (64).

> "With an enormous capacity for growing and processing plant-based proteins, the Prairies have the potential to become the world's "protein basket". International firms have already shown interest in the Prairies' potential by investing in facilities and equipment in western Canada" (64).

Industry Trends

According to the Institute of Food Technologists, the top ten food trends of 2023 are: (1) Resizing the restaurant/retail gap, (2) Morphing meal patterns, (3) Sustainable superstars, (4) Everyday self-care, (5) Gourmet convenience, (6) Wraps and rolls, (7) Urgent care, (8) Technical Difficulty, (9) Event Makers, and (10) The parent trap. Upcycled foods fall into the #3 category *Sustainable Superstars*, and Upcycled Certified claims have the highest penetration in the jams, jellies, and fruit spreads category, followed by baking mixes/flours, plant-based milks, pet treats, and snacks (66). Upcycling was among the top food trend predictions in 2022 (67).

Focusing on the plant-based industry, in January 2023 Unilever published an article reporting *Five trends that will take plant-based eating mainstream in 2023*. The listed trends are: (1) Hassel-free plant-based solutions, (2) Climate considerations influencing purchasing decisions, (3) Innovative flavours and formats, (4) Exciting out-of-home options, and (5) Favourite brands offered in plant-based choices (68). Of those, Upcycling brewers spent grain as described in the report appeals to several (if not all) of the expected plant-based food trends, but primarily to *Climate Considerations influencing purchase decisions*. The sustainability of upcycling spent grain locally, along with the necessary advertising/education of such, is predicted to draw consumer interest.

Plant-Based Meats and Dairy

In 2021, Nielson data showed that meat and dairy alternatives became an industry worth over $1 billion (69). "Meat analogue research and development focuses on the production of sustainable products that recreate conventional meat in its physical sensations (texture, appearance, taste, etc.) and nutritional aspects" (70). Meat alternatives come in various forms, including minced products, muscle-type products, and emulsion-type products.

Emulsion-type plant-based products (sausages) are typically formulated with soy protein, gluten, pea proteins, or potato proteins because they are known to have water binding functionality and will stabilize emulsions/gels (70 p. 3). Minced plant-based products (burger patties, nuggets) typically use soy, wheat, or pea protein (or a mix) to create a textured vegetable protein (TVP) to give a "meaty and chewy texture" (70 p. 4). Muscle-type plant-based products (chicken, steak) are usually made with soy protein and take on the shape of the equipment used (70 p. 5). While this type of plant-based product demand was not identified within Winnipeg through this research, among the common types of meat analogues upcycled barley flour may develop a demand in emulsion-style products as a source of gluten, or in minced products with local industry growth in this sector.

Take Two unfortunately shut down production sometime during this research but used upcycled brewers spent grain to produce barley milk in Portland, Oregon. The ingredients of the unsweetened version were "Barleymilk (water, barley and rice protein), coconut cream, organic sunflower oil, pea protein. Contains less than 1% of calcium carbonate, dipotassium phosphate, natural flavour, sea salt, organic locust bean gum, gellan gum, vitamin B12, organic sunflower lecithin" (71). The exact reason for this company's closure is unknown, but the launch of Molson Coors barley milk suggests that there is growing demand for plant-based milk alternatives and could be a consideration for the upcycling framework's scaling options.

While the research shows that barley (new and upcycled) can be used to make barley milk and that gluten is a common meat analogue ingredient, the project data suggests that the most immediate opportunity and demand for upcycled spent grain lies within the bakery industry as a fibre and protein component within a flour mixture. As with the product recommendations provided with this report, upcycled spent grain can be used in everyday staple foods such as breads, in breakfast items such as pancakes, waffles and granola, in dessert products such as cookies and brownies, and in snack items such as energy bars and extruded snack products. Further research and innovation can be utilized to identify other opportunities with company expansion within the plant-based industry.

Upcycled Certification

Highlighting the 2023 food industry trends (66) and making plant-based food popular in 2023 (68), predictions and trends suggest that the sustainability aspects of upcycled spent grain products will offer the highest opportunity of success for the Winnipeg BSG upcycling company.

Upcycling in any industry has environmental, social and economic, and personal benefits. The environmental benefits include (1) saving materials from landfill, (2) reducing what goes to landfill, and (3) minimizing use of natural resources. The social and economic benefits of upcycling include (4) celebrating work, (5) supporting local and rural industry, and (6) reducing manufacturing costs. The personal benefits include (7) doing your part for mother nature, (8) craft repair skills, and (9) one-of-a-kind items (72). Upcycling food specifically reduces global greenhouse gas emissions, reduces deforestation, and limits the pressures an increasing population puts on the environment through food systems (73).

The Upcycled Food Association (28) is on a mission to 'reduce food waste by growing the upcycled economy and educating consumers about upcycled products', and offers 'the world's first certification program for upcycled food ingredients and products' (29). Labelling food products with the upcycled logo obtained through certification with the Upcycled Food Association is a universal way of highlighting the environmental benefits of the company's operations and products. 2022 was a big year for the association with certifying 324 products and ingredients, having an increase of 118% upcycled products, having diverted 1.6 billion pounds of food since May 2021, achieving 60% consumer awareness, and experiencing 21% growth of upcycled food products (74). There are four steps to certification (30):

1. Scoping: Connect with UFA and the certifying body (CB) to determine scope of audit.
2. Audit: Submit documents for an audit which can be a desk audit for 95% of companies.
3. Licensure: Update your packaging and marketing assets with the Mark.
4. Launch: Celebrate your impact with your consumers!

Food and beverage products are eligible for certification and can be (1) Upcycled Ingredient(s) (UI), (2) Product Containing Upcycled Ingredient(s) (PUI), and (3) Minimal Content PUI(s) (31 p. 9). A UI is ≥95% upcycled input, a PUI must be ≥10% upcycled input, and a minimal content PUI is <10% upcycled input (31 pp. 12-13). More information on The Upcycled Food Association and the certification process can be found at https://www.upcycledfood.org.

"The Upcycled Certified® Program is the world's first and only third-party certification program for upcycled food ingredients and products. Products bearing the Upcycled Certified® mark can be found throughout the grocery store, from pantry staples to snacks to personal care. At the same time, consumers are growing in their familiarity with upcycling and are willing to pay more for products that save food from waste. Upcycling is on the upswing!" (74)

Watch the Upcycled Food Association 90 second commercial: https://youtu.be/3OMeAo-Qtek

Scaling Options and Opportunities

When referring to scaling and/or growing the company, there are two primary ways in which upcycling can expand it's environmental benefits in Winnipeg. The first way, as discussed in the framework and outlined in *Figure 30*, is to expand production to allow for increased opportunity of brewers spent grain and would be more dependent on pricing and availability of industrial sized processing equipment and potential market demand. With this option, scaling is based solely on brewers spent grain and would likely require 1-2 dryers depending on the desired operation schedule. For the second option, we look to LOOP Mission.

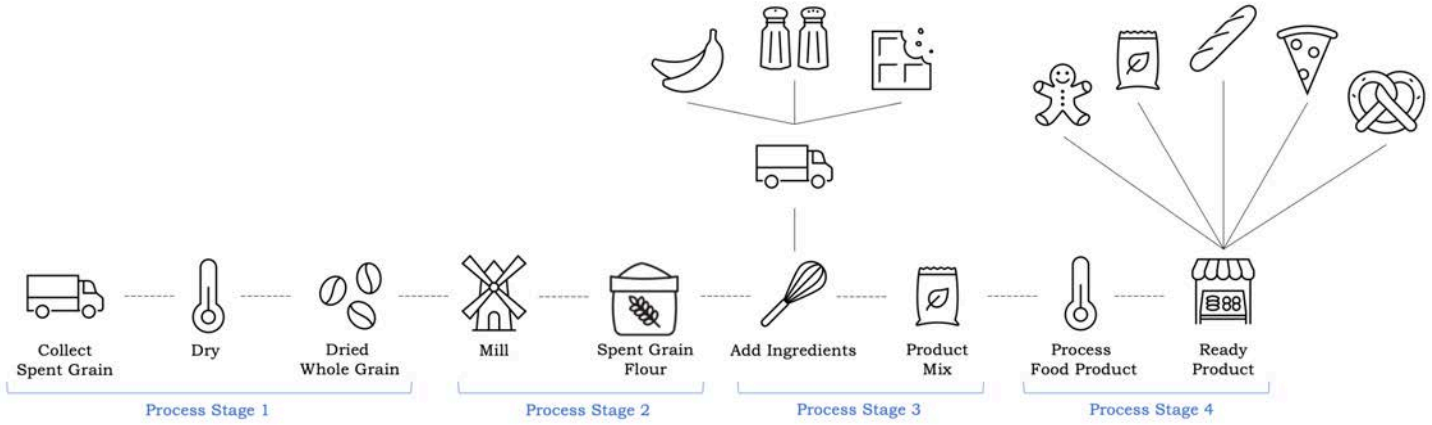


Figure 5.43. Depiction of the level of processing required for upcycled spent grain products.

LOOP Mission is a Montreal-based company on a rescue mission. "LOOP Mission is a circular economy project that aims to reduce food waste by repurposing the outcasts of the food industry. In a nutshell, we save fruits and veggies that are rejected because they don't have the proper shape, size, or a shelf life that is not long enough to survive the cycle of distribution. We transform them into awesome cold pressed juices. But we're not a juice company, we're a food waste fighting powerhouse. We have beers brewed with day-old bread, a gin distilled using potato cuttings from a potato chip factory, hand-crafted soaps made with rejected cooking oil… and that's only the beginning! There are so many exciting things still to come, all saving more food products from needless waste" (75).

As shown in *Figure 31*, the LOOP Mission upcycling process is able to upcycle a variety of food products to produce a variety of consumer products including juices, smoothies, sodas, beer, gin, soap, and energy bites (21). With multiple videos available on YouTube about the company, a lot can be learned about what goes into their process of rescuing food waste.

The patented upcycling equipment available from NETZRO is able to process a variety of products, providing future opportunity to expand into upcycling products other than brewers spent grain. This option is valuable if, for example, (1) not all Winnipeg craft breweries decided to be spent grain suppliers, or (2) spent grain upcycling was a huge hit and other upcycling opportunities were identified or presented themselves. LOOP Mission is a great example and motivator to think beyond one industry and make upcycling mainstream.

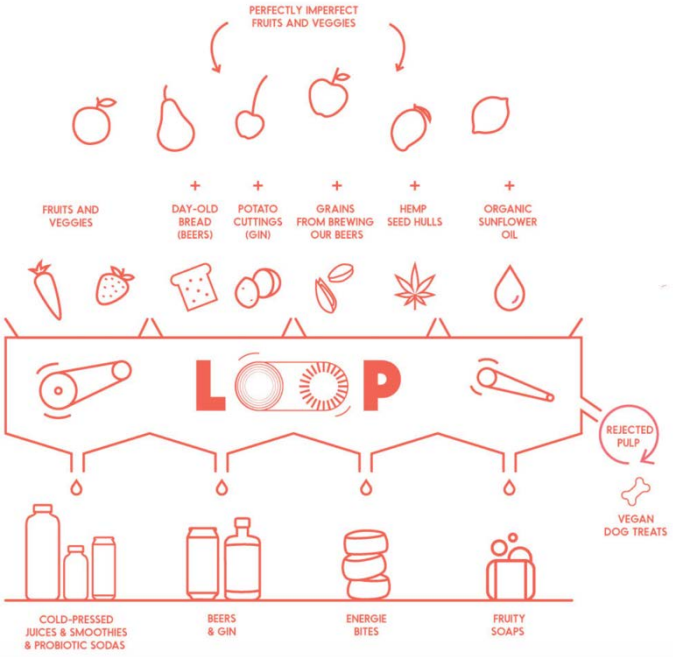


Figure 5.44. The LOOP Mission upcycling process (75).

Facility Location

Choosing a facility location is an important decision and will need careful consideration starting with the following five factors: (1) Local geography – A site may require additional land depending on local conditions such as topography, drainage, and governmental regulation, (2) Daily operations – Will the plant require rail or interstate access? Consider raw ingredient delivery, finished product distribution, and internal material movement, (3) Utility and water costs, (4) Distance to resources – Minimize total transportation costs by choosing a strategic location by identifying the locations of customers, distribution centers, and raw material sources, and (5) Environmental issues – Examine nearby industrial sites and environmental factors, neighbouring sites cannot pollute your products (76). With those in mind, a map of the preferred locations is provided in *Figure 32*.

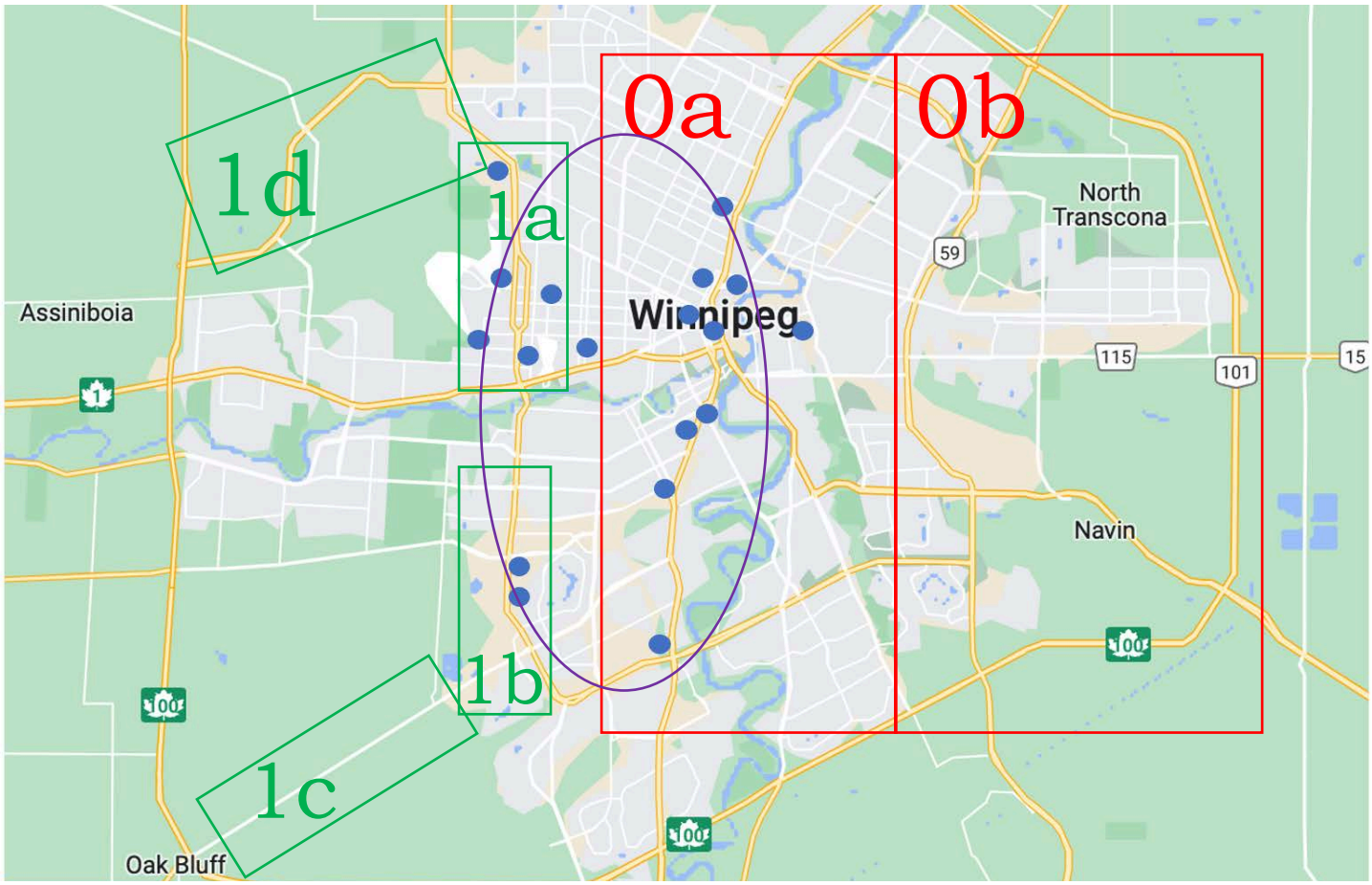


Figure 5.45. Map of Winnipeg showing the preferred (marked with green boxes) and non-preferred (marked with red boxes) facility locations. Most Winnipeg craft breweries are in the area marked with a blue circle for reference.

- Zone 1a: Area encompasses multiple breweries and has many industries/businesses within a short distance. This area offers the potential for convenient retail space to consumers and is moderately accessible with large vehicles.
- Zone 1b: Area encompasses 2 large breweries, offers room for growth/storage, and is surrounded by industries/businesses. This area offers the potential for convenient retail space to consumers and is accessible with large vehicles (e.g. delivery vehicles and farmers).
- Zone 1c: Area is increasingly developed and offers room for growth/storage and/or a large establishment with easy access for larger vehicles. Less potential for a successful retail space.
- Zone 1d: Area is increasingly developed and offers room for growth and/or a large establishment with easy access for larger vehicles. Not ideal for retail space.
- Zone 0a: Not desirable as the area is dense/busy and would be difficult to operate delivery vehicles in at certain times of day. Also not convenient for farmer access.
- Zone 0b: Not desirable as it's the furthest away from all brewing locations.

PART 3: Project Objectives

Meeting Project Objectives

To explore the potential of upcycling brewers spent grain in Winnipeg, MB, the project had three overall objectives that were further broken down into the seven guiding objectives driving the data acquisition and analysis. The objectives were met during project execution in the ways described in this section and contribute to the three overall project objectives:

1. Define and quantify current waste management strategies for BSG (Objectives 1, 2)
2. Understand the opportunities and barriers to upcycling BSG (Objectives 3, 4)
3. Recommend potential upcycling options (Objectives 5, 6, 7)

Throughout the project, the combined data contributed to building a case study that became increasingly specific to upcycling brewers spent grain in Winnipeg, MB. The increase in local data is shown with the progression of visualizations used in the reports and research. *Figure 33* was a general outline derived from the literature review (background information report) which was then refined to *Figure 34* after analyzing all project data. As the figures below suggest, the data contributing to each stage of the research was increasingly specific to allow for the most realistic and feasible option for upcycling in Winnipeg, MB.

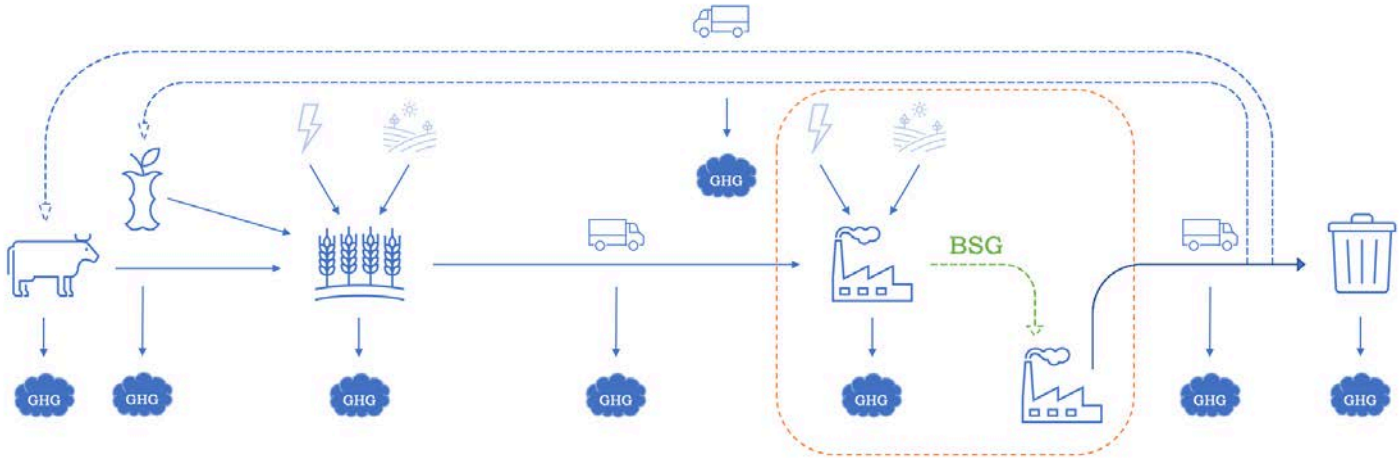


Figure 5.46. A general depiction of the potential upcycling framework in Winnipeg, MB used in the background information report after conducting the literature review, prior to conducting any local research.

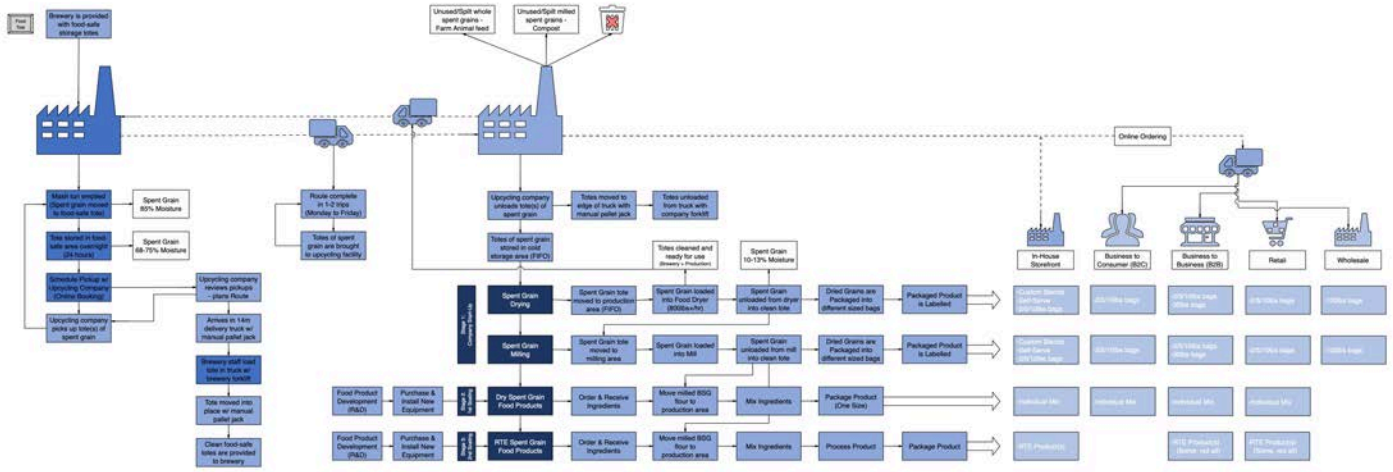


Figure 5.47. The final BSG upcycling framework recommendation for Winnipeg, MB resulting from four stages of research: (1) Literature Review, (2) Website Review, (3) Canada-wide Craft Brewer Survey, and (4) Local Interviews.

Objective 1: Quantitatively determine if there is enough brewers spent grain in Winnipeg to render upcycling plausible.

The first objective was originally planned to be met with the website review, the Canada-wide craft brewer survey, and interviews with Manitoba food companies and Winnipeg craft brewers; thus, supported by three forms of data. The though behind the research methods was to analyze the potential of upcycling through comparisons and local data as described below.

The website review was valuable in determining where upcycling was currently happening, which then provided a comparison to base the research on. It was found that upcycling BSG was currently happening in Vancouver, Kelowna, Calgary, Montreal, and Toronto. For the most part, the cities listed are much larger than Winnipeg, making it especially important to determine how Winnipeg is similar in potential to those cities in later research methods.

The survey data built on the knowledge that upcycling was possible in other Canadian cities and generated the comparison model needed to compare and preliminarily assess potential in Winnipeg. The idea was that if Winnipeg craft breweries were comparable to the average Canadian craft brewery, then upcycling would have some level of potential in terms of spent grain supply.

The interview data pertaining to objective 1 provided sufficient quantitative data to critically assess if there is in fact enough spent grain in Winnipeg to render upcycling possible. Comparing interview data with survey data concluded that individual Winnipeg craft breweries were in fact comparable to those in larger cities. Using a conversion formula obtained during the literature review, Winnipeg spent grain supply was estimated but among those who participated in interviews, there's not enough spent grain to supply industrial sized demand of upcycled spent grain without the participation of several more local breweries. This was determined with calculations stating that an annual supply of 182,200 kg of wet spent grain result in 51,016 kg of upcycled and dried spent grain. Upcycling equipment specific information was able to determine that a volume of 200,000 lbs (90,718 kg) or 1,000,000 lbs (453,592 kg) of spent grain could be upcycled annually dependent on the equipment chosen which further contributes to the ability to assess supply and demand models. Interview data also determined that approximately 75% of Winnipeg-made beers are core styles which produce a consistent ingredient base for the upcycling company with approximately 25% variation to consider in final product selection. Winnipeg does in fact have enough spent grain to upcycle.

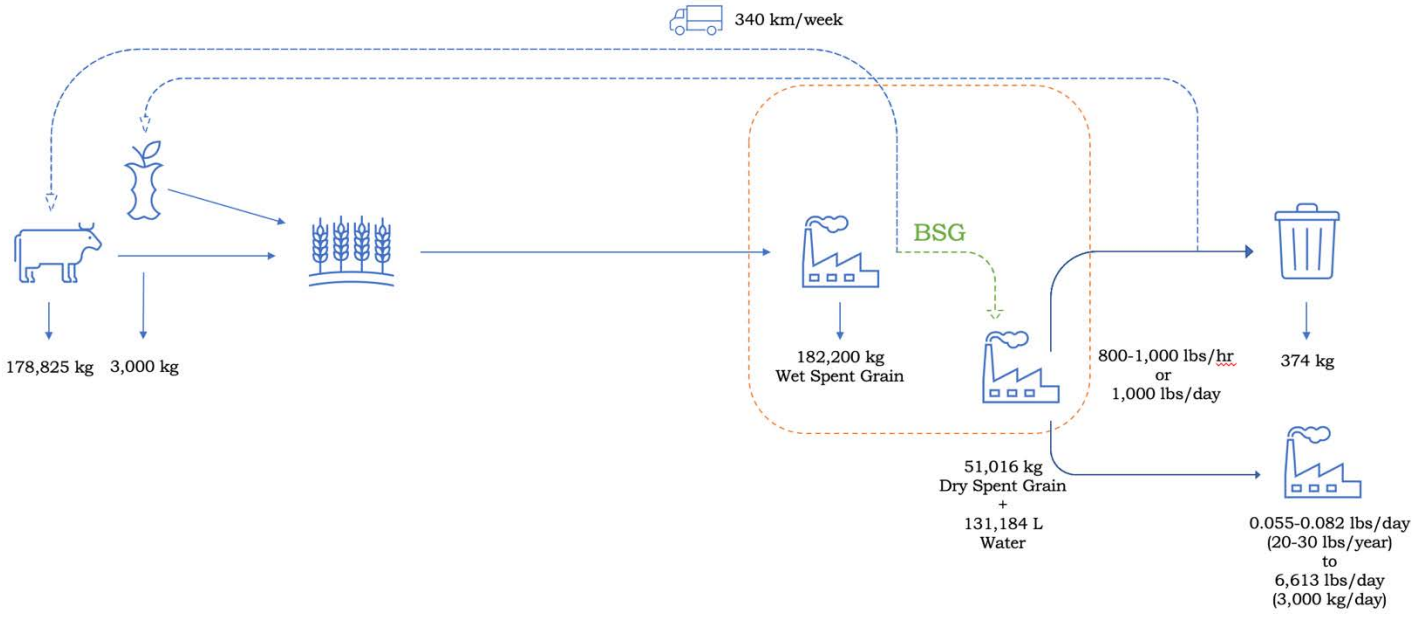


Figure 5.48. Visual of the basic mathematics determining spent grain supply, process volumes, and potential demand.

Objective 2: Quantify and map what local breweries currently do with their spent grain.

The second objective was originally planned to be met through interviews with Winnipeg craft brewers and was met as planned. Four Winnipeg craft brewers participated in interviews and provided data on how they manage spent grain. Represented in *Figure 35*, interview data determined that of a total 182,200 kg spent grain, 178,825 kg (98.15%) goes to animal feed, 3,000kg (1.65%) goes to compost, and the remaining 374 kg (0.2%) ends up in the landfill. The 178,825 kg of BSG going to animals as feed requires substantial effort and resources to coordinate to avoid disposing nutritious product. A combined 340 km are driven weekly by breweries and farmers to move this annual volume of spent grain to Beausejour (122 km round trip), Anola (78 km round trip), Elie (92 km round trip), and West St. Paul (48 km round trip).

The spent grain management data obtained from interviews reinforces what was determined in previous stages of research. The literature review conducted for the background information report listed ruminant feed as a primary method of spent grain waste management, while the Canada-wide survey determined that 81.82% of 168 Canadian craft brewers spent grain goes to animal feed. The 98.15% from Winnipeg going to animal is much higher than the average obtained and supports both the literature review and survey data.

Objective 3: Document the barriers brewers face in using/moving/storing spent grain.

The third project objective was planned to be met through interviews with Winnipeg craft brewers to determine the barriers they face in upcycling spent grain but was first assessed in the background information report. Preliminary research identified space, smell, flexibility, and cost as the primary barriers that brewers face. Interviews with Winnipeg craft brewers, Manitoba food companies, and North American upcycling companies confirmed the preliminary data and identified numerous other barriers that were considered in the framework as shown in *Figure 36*.

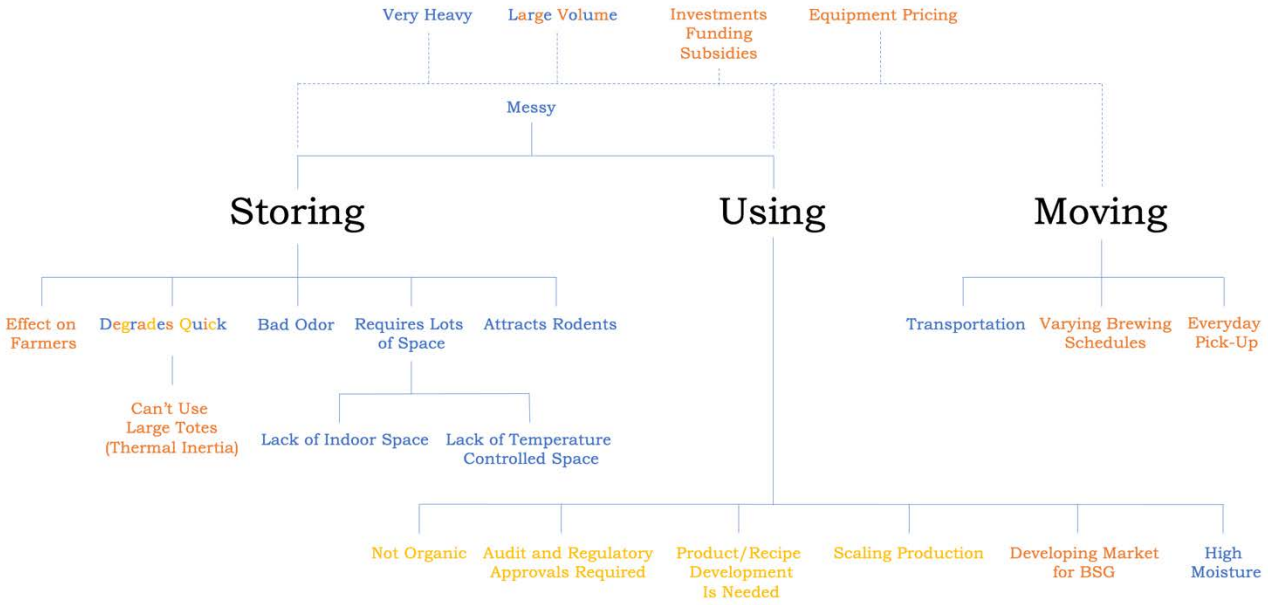


Figure 5.49. The combined barriers to upcycling brewers spent grain expressed during interviews by Winnipeg craft brewers (blue text), North American upcycling companies (orange text), and Manitoba food companies.

All barriers identified through the research were addressed to either minimize or remove the barrier for the affected party in the following ways. Storing spent grain is primarily an issue for brewers as it degrades quick and causes other issues. This was addressed in the framework with Monday-Friday spent grain pickup, so the brewery was dedicating minimal process area floorspace to spent grain storage, which in turn minimizes risk of rodents, reduces odor issues, and removes the

risk of spent grain degradation. As the spent grain is hot upon exiting the mash tun, a temperature-controlled space is not required until it reaches the upcycling company where it would be processed quick enough to allow use of large totes. As for the effect on farmers, the framework provides an opportunity for farmers to pick up non-human grade dried spent grain on a first-come-first-serve basis to reduce any negative impact this might have on them.

The barriers to using spent grain are mainly experienced by food companies with potential use for upcycled spent grain. Unfortunately, not having certified organic grains would affect some potential demand for the upcycled product but is accepted as the primary focus is to reduce existing food waste. The regulatory requirements associated with starting a food company are not directly addressed in this research but would be considered by those starting the company. Companies needing product to test recipes with would be provided with samples while other revenue streams (such as retail and B2C) would be pursued during company establishment. The issues with high moisture of spent grain are addressed through processing while developing a market is first addressed in the interviews through determining food company interest levels.

The barriers associated with moving spent grain were expressed by craft brewers and affect the upcycling company. The barriers of transportation and scheduling are addressed in various ways. First, the framework suggests online spent grain scheduling by the brewery upon emptying the mash tun to minimize any scheduling changes if brewing schedules change. Second, the upcycling company handles pickup to ensure the product remains human food grade and to minimize the required effort and resources required from brewers in obtaining the ingredient.

Brewers indicated that spent grain is messy to handle. Unfortunately, this barrier could not be eliminated, but is reduced with everyday pickup as it greatly reduces the number of stacked totes and associated risks of tipping or spilling, and the moisture drainage would only be from one day's worth of brewing as opposed to a week. This barrier is also minimized with the upcycling company handling transport instead of having breweries drop-off.

Four barriers were identified that relate to storing, using and moving spent grain: (1) Very Heavy, (2) Large Volume, (3) Investments, Funding, Subsidies, and (4) Equipment Pricing. Spent grain has a high moisture content and is therefore extremely heavy. This barrier is primarily addressed with the 24-hour dewatering stage at the brewery to reduce the transportation weight as much as possible within an appropriate amount of time, but the use of a forklift cannot be eliminated. The barrier associated with the large volumes of spent grain is addressed with everyday pickup as it minimizes the space required at the brewery for indoor storage and facilitates first-in-first-out (FIFO) at the upcycling facility. As the upcycling equipment operates by batch, everyday supply of spent grain reduces the amount of storage space required and will likely allow all spent grain volumes to be processed within 24 hours. Equipment pricing cannot be avoided but can be mitigated with the scaling options and adequate planning. The scaling options recommended in the framework are based on equipment needs of various products and are organized so that new equipment is strategically purchased with company growth and planned increase of product offerings, simultaneously considering company profits on existing offerings. Simply put, the company can expand when they can afford to, based on the success of existing product sales and revenue. The final barrier of investments, funding, and subsidies is outside the scope of this project but can be addressed at a later stage through the development of a comprehensive business plan, obtaining government grants and subsidies as there are environmental benefits to upcycling, and obtaining funding support from banks to aid in the start-up. There are likely other options and opportunities for implementing the framework, mitigating or minimizing the monetary barriers, and starting a company but are outside the scope of this project. As far as the identified barriers that are within the scope of the project, efforts to minimize or remove the barriers were considered in all framework decisions to increase the ease and convenience of upcycling to ultimately encourage breweries and food companies to be part of the solution to reduce global food waste.

Objective 4: Determine if/which breweries are interested in BSG upcycling potential.

The fourth project objective was planned to be met through the Canada-wide craft brewer survey and interviews with Winnipeg craft brewers. The objective was primarily met through interview participation rates as it's assumed that people wouldn't participate if they didn't have interest in the research. While interview participation rates were significantly lower than expected, many factors could have contributed to this outcome. The research was able to determine interest from some breweries and food companies, suggesting there could be an increase in interest with the development of a proper business plan that benefits both brewers and food companies, especially considering the expected increase in environmental concern related to food choices in 2023.

Objective 5: Research and identify who the potential users are of BSG as an input in Winnipeg.

The fifth project objective was planned to be met through four stages of research including a literature review, Canadian craft brewer website review, Canada-wide craft brewer survey, and interviews with Manitoba food companies and Winnipeg craft brewers. The preliminary research identified several uses for upcycled spent grain (mainly used in a flour mixture) which was used to identify potential users for upcycled BSG in Winnipeg, MB. The Canada-wide craft brewer survey further identified potential upcycled products that supported what was found in the initial research, which was further supported with the survey and interview stages. Each research stage reinforced that spent grain has the most potential in bakery products. Each stage of research also identified innovative and uncommon uses for upcycled BSG such as frankfurters (literature review), mustard (survey), and in cooking (such as soups and take-home meals) (interviews). Further consideration of BSG potential was identified in the supporting research of this report which identified popular and innovative uses for spent grain currently offered by upcycling companies. This objective was also met through consumer and revenue research to expand the potential user scope. While initial project ideas focused on industrial scale uses, individual consumers and retail options are valuable to the success and environmental impact of the company. This objective was ultimately met by expanding the scope of upcycled BSG uses, products, and potential customers/consumers.

Objective 6: Identify and evaluate the intermediate steps required to link BSG with potential users.

Objective 6 was originally planned to be met with the combined data from the Canadian craft brewer website review, the Canada-wide craft brewer survey, and through interviews with Manitoba food companies and Winnipeg craft brewers.

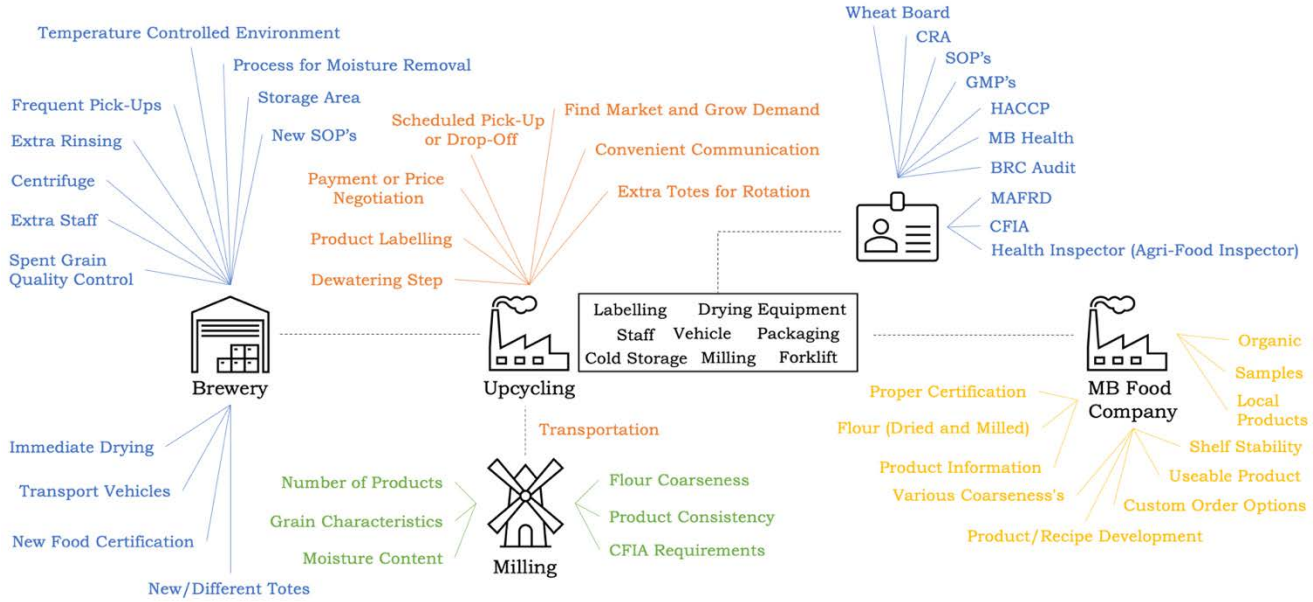


Figure 5.50. The intermediate steps linking BSG with potential users as identified through interviews.

To start, the website review didn't directly identify the intermediate steps of BSG use but provided some names of the upcycling companies they deal with that allowed for some data acquisition of their upcycling frameworks and operations. The Canada-wide craft brewer survey provided some information related to who moves spent grain and if/what the financial exchange is related to the ingredient (it's most often the brewery that pays if there's a financial exchange). The bulk of the data identifying intermediate steps was acquired through interviews with Winnipeg craft brewers, Manitoba food companies, and North American upcycling companies; shown in *Figure 37*.

Through careful consideration and research, the suggested intermediate steps were assessed and considered within the framework based on several factors. The final framework suggests that the brewery have a 24-hour dewatering period within the brewery to eliminate the need for a centrifuge and extra staff. Frequent pick-ups were chosen over having breweries build a temperature-controlled environment, and new totes are provided by the upcycled company and rotated upon pick-up of full totes. The resource requirements of the brewery are minimal but may require obtaining an additional licence and/or developing new SOP's. The primary consideration at the brewery is that being a spent grain supplier should be virtually effortless to justify a $0.00 exchange for the spent grain to use as an ingredient elsewhere.

The location of milling is suggested to be at the upcycling facility primarily to contain processing to one location and not be dependent on multiple parties for products. The steps required at the upcycling facility are largely dependent on the final products offered but will likely include storage, drying, milling, packaging, labelling, a store front, transport, food certifications and marketing. Various considerations of required certifications and/or procedures were suggested and would be addressed with a full business plan as it's out of the scope of this project.

Finally, the steps required to link upcycled BSG with the food company are primarily to do with use and convenience. The food companies require a product they can use and would therefore need options for custom ordering and coarseness selection. The companies also require final product and time for their own research and product development prior to commitment. As addressed in Part 1 and Part 2 of this report, other revenue streams have opportunity and potential along with securing large-scale contracts. The preliminary considerations related directly to the framework development were addressed to identify the required steps to meet this objective, but additional research regarding regulatory bodies and certification is needed upon pursuing company start-up.

Objective 7: Quantify the energy/CO_2 emission differences of current management strategies compared with the final proposed upcycling framework.

The final objective was planned to be met through a combination of literature review and interviews with Winnipeg craft brewers. The proposed pick-up route is circular to transport BSG the shortest distance possible. The total route is 47.8 km and is driven by a 14 m tandem steer delivery truck with an approximate fuel consumption of 29.6 L/100km. Assuming the route is driven once every day and every Winnipeg brewing location is participating as a spent grain supplier, the following calculations are applicable:

- Distance: 47.8 km x 5 days = 239 km weekly x 2 = 478 km weekly
- Fuel Consumption: 239 km x (29.6 L/100km) = 70.74 L x 2 = 141.48 L
- Fuel Price: 70.74 L x $1.53/L = $108.24/week x 2 = $216.48/week
- CO_2 Emissions: 70.74 L x 2.29 kg CO_2/L = 162.00 kg CO_2 x 2 = 324.00 kg CO_2

In the framework scenario, a total of 239 km is driven weekly to service approximately 17 breweries removal of spent grain. The circular route uses 70.74 L of gasoline costing the upcycling company $108.24 and produces 162.00 kg of CO_2. Some Winnipeg breweries are quiet a bit larger than others suggesting their participating could result in two daily routes on average. If doubled, the route is 478 km weekly, would use 141.48 L gasoline, costing the upcycling company $216.48 and emits 324.00 kg CO_2.

Table 5.27. Per capita company and environmental cost of using current spent grain waste management strategies (based on interview data) and using the preliminary upcycling framework route.

Value Description	Value (per Route) (Weekly Sum)	**Current Waste Management Strategies (Weekly Values)** 4 Breweries: Average per Brewery	**Upcycling Framework: 1 Daily Route (Weekly Values)** 17 Breweries: Average per Brewery	**Upcycling Framework: 2 Daily Routes (Weekly Values)** 17 Breweries: Average per Brewery
Distance	340 km	85 km	---	---
Fuel Volume	64.51 L	16.13 L	---	---
Fuel Price	$100.02	$25.00	---	---
CO_2 Emissions	154.73 kg	38.68 kg	---	---
Distance	239 km	---	14.06 km	28.12 km
Fuel Volume	70.74 L	---	4.16 L	8.32 L
Fuel Price	$108.24	---	$6.37	$12.74
CO_2 Emissions	162.00 kg	---	9.53 kg	19.06 kg

If the documented waste management strategies are representative, the total of all breweries managing their spent grain in this way would equate 1,445 km driven to move spent grain, 274.21 L of gasoline consumed costing $425.00, and 657.56 kg of CO_2 released weekly. Annually this equals 75,140 km driven, consumes 14,258.92 L of gasoline, costs breweries $22,100 combined, and releases 34,193.12 kg CO_2.

Compared with current waste management strategies, the proposed route shown in *Figure 38* (operating once daily) is 1/6 the distance (16.5%), uses 1/4 of the fuel (25.8%), and emits 1/4 of the CO_2 emissions (24.6%) per brewery. Operating the proposed route twice daily results in 1/3 of the distance traveled (33.1%), 1/2 the amount of gas used (50.4%), and 1/2 the CO_2 emissions (49.3%) per brewery if all breweries supply their spent grain towards upcycling. Not only does the proposed route cost the brewery and the environment less, but the food product stays in human food steams and eliminates the time and effort required of brewery owners to manage their by-product.

The intention of this objective was to evaluate the emission differences of the entire supply chain in the scenario of continuing production as-is compared with upcycling. The data provided is instead related to the CO_2 emissions of transportation that would alter with the establishment of the upcycling company. The objective could not be fully met for several reasons. First, methane emission data proved to be difficult to obtain and did not result in complete and comparable data for analysis. Second, GHG emissions of the upcycling equipment was not available as the equipment was not yet on the market and protected by a patent. Third, the entire supply chain was not of concern as we were not proposing to change the entire process, just the waste management of spent grain, therefore anything leading up to the waste management methods wouldn't have changed in either case. Despite the difficulties encountered with Objective 7, the data calculations show that upcycling locally would cost less and emit ¼ - ½ the emissions of breweries individually transporting their spent grain outside of Winnipeg, MB for use as animal feed.

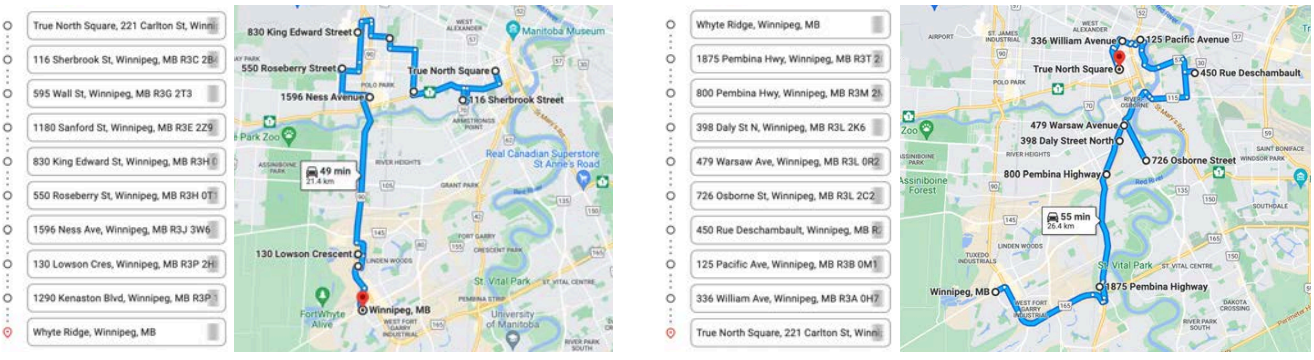


Figure 5.51. The proposed daily spent grain pick-up route (Google Maps).

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Chapter 6: Critical Reflection

Chapter Synopsis: This chapter details the skills and competencies I acquired during the M.N.R.M. program, what I learned about myself as an individual, the outcomes of project decisions, my contributions to research and what I'd do differently if I could start over, and the practical applications of this research to the brewing industry.

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Introduction

Prior to starting the Masters of Natural Resource and Environmental Management degree at the Natural Resource Institute (*University of Manitoba*), I was concentrated on the food manufacturing industry. I obtained my bachelor's in food science in June 2018 during which I worked two jobs, traveled 2-3 times each year, enjoyed time with friends, and achieved good grades in my courses. I developed excellent time management skills throughout this time and was able to perform highly in multiple efforts. My education allowed me to obtain a packaging supervisor position at an industrial food manufacturing plant where I learned how to prepare for the unexpected and be adaptable with plans. I considered myself to be extremely organized and capable of learning anything I needed to be successful at the goals/tasks I was working towards. Despite the skills I had, I quickly needed to develop new skills to be successful in my research/project and learnt some invaluable lessons throughout the project execution.

Figure 6.1. Marika Boryen, photographed in Selvatura Park, Monteverde Cloud Forest, Costa Rica, May 2017.

Program Selection

As someone who must live with the consequences of a changing climate, the decision to apply for a Master's of Natural Resource and Environmental Management was essential to me. With the overwhelming climate crises we're experiencing, I've made it my life's mission to be part of a/multiple solution(s) rather than to simply work for money. With that in mind, the decision of whether to complete a thesis or practicum was obvious to me.

Above all the knowledge I acquired throughout the courses I took; I learned that the role of managing natural resources is more about coordinating and influencing the right people as opposed to understanding every scientific aspect behind the decisions (as that would be someone else's focus). As such, it seemed apparent that based on the roles of the environmental organizations that I was keen to work with, project management skills would increase my job-specific skills to achieve my life's mission. As such, I chose the practicum stream to gain the skills and experience needed to be positively impactful towards global sustainability initiatives as experience writing a thesis can be done if/when I complete a PhD.

The Government of Canada's *Employment and Social Development Canada* department defines the 'Skills for Success' in *Figure 2* as "the skills needed to participate and thrive in learning, work and life" and "include skills that are foundational for building other skills and knowledge and important for effective social interaction" (1). The 9 *Skills for Success* and the 5 skills (Foundational, Analytical, Technical, Resource Management, and Interpersonal) of the *Skills and Competencies Taxonomy 2022* (2) encompass the potential I had for developing and refining valuable skills. The following pages outline the lessons I learned throughout my practicum and the skills I developed to achieve success with my project.

Figure 6.2. Government of Canada, *Skills for Success* (1).

M.N.R.M. Coursework Skills Development

The *Masters of Natural Resource and Environmental Management* degree has a course component as well as a thesis or practicum component; both are required for degree completion. I completed a variety of courses including a course in Project Management.

Project Management Course

My first (and most naïve) assumption about project managers was that they were simply people who were organized. I figured I would be a great project manager as I was already organized yet I faced multiple difficulties and setbacks throughout the course.

The freedom of choosing a research topic was initially overwhelming and felt impossible. At times when I did generate an idea, it wasn't one that drew upon the knowledge and skills I already possessed. It took many meetings with my advisor (Dr. Iain Davidson-Hunt) for me to finally decide on a topic that drew upon both my degree's and was relevant. Overcoming that initial hurdle 'opened the floodgates' of creativity in the sense that a focus allowed me to be innovative and strategic with how the project would be planned. I learned that while I'm skilful at conducting research on my own, my most innovative/unique ideas flow best in casual conversations or 'bouncing ideas' with others.

Lesson 1: Seeing the 'whole picture' *(AKA Long Term Planning)*

Prior to the course, I assumed that the development of an Integrated Project Plan (IPP) was going to be easy. I thought "I'll just do *this*, *this* and *this*, and then *this* will lead to *that*, and I'll be done". Realistically, it was a challenging task for me as I found myself planning 10 steps ahead of finalizing the general/base ideas. The original thought was to create a finished food product from brewer's spent grain, hence combining my background in Food Science with a Masters of Natural Resource and Environmental Management. I completed several assignments, ignored the fact that companies have entire departments for product development, and came to two realizations at the work breakdown structure assignment late in the course: (1) My project would take much more than a year to complete, and (2) I would need a lot of external resources to complete my practicum.

In terms of learning how to plan long-term, I work visually, and the work breakdown structure (WBS) is the most effective tool and skill I acquired, and I've used it many times since. Seeing the WBS allowed me to make a concrete decision to focus my practicum on the initial product research stage for a number of reasons: (1) The research portion of the WBS could be completed in an appropriate time frame (approximately 12 months), (2) I could complete the research stages on my own with very few external resources (human, material, and financial), and (3) It made sense to commit to the first stage of product development prior to expending resources on 'uncertainty'. This decision set me back in the course as I went back to re-complete the majority of assignments to reflect the new focus, but ultimately resulted in a realistic practicum document that I was excited to pitch to real people: Winnipeg craft brewery owners.

Having a clear goal for the overall practicum further allowed me to refine my writing skills through the formal development of the IPP, specifically my ability to communicate detailed and clear information. In anticipation of proposing the IPP to a potential partner, comprehensive writing took the project from "I'd like to research brewers spent grain and hopefully find use for it." to "The background research indicates *x* which is important to you because of *y*, as well as the environment due to *z*. I've developed a project plan that will research the potential of upcycling in Winnipeg and provide you with a realistic framework by [date] and will require no financial investment on your part. We'll complete the project in *x* stages … The data will be used to … [etc.]." The written information within the IPP communicated confidence in the project goals as the level of detail ensured that the processes had been thoroughly thought through and all potential diversions had been anticipated.

Background Information Report

The Background Information Report (BIR) I wrote cited 137 sources in 27 pages and took approximately two months to write with having two babies at home. It became the most comprehensive document I've ever written. Conducting the background research for my project and authoring the report allowed me to develop three skills in particular:

(1) Reading Skills: Your ability to find, understand, and use information presented through words, symbols, and images (1).

The document required reading and understanding many data sources including peer-reviewed research papers, trustworthy websites and company websites, and textbooks. The data necessary to document the need and potential for upcycling required extensive sourcing and drew on my background in food science. At this time, I had much experience with researching food related topics, but developed the above skills in relating food production to environmental issues/topics.

(2) Writing Skills: Your ability to share information using written words, symbols, and images (1).

After reading and re-reading many sources, I was faced with the task of writing the BIR to communicate the information to a variety of audiences. I had already developed my technical and scientific writing skills during my science degree, whereas I was now working on communicating complex data in ways that people without the same background knowledge as me would understand. But not only did the audience need to understand, they needed to see the potential and care to be part of the solution. As opposed to writing in a strictly technical manner, I used common language and added emotion to highlight the environmental issues and potential solutions associated with 'upcycling' to develop this skill.

(3) Numeracy: Your ability to find, understand, use, and report mathematical information presented through words, numbers, symbols, and graphics (1).

I've always considered myself to be 'good with numbers' and as a visual learner, I developed many graphs/visuals throughout my research to picture my data. Taken from my BIR, *Figure 3* was the most significant representation of the importance of looking to food waste as a possible solution to feeding a growing population. As I was trying to piece together and understand several numerical values from different sources, I developed a skill for representing this type of information in a similar manner as my new writing skills; in a way that most audiences would understand without the same educational background as me. I'm very conscious of the fact that for people to care and want to make a change, they need to understand the message.

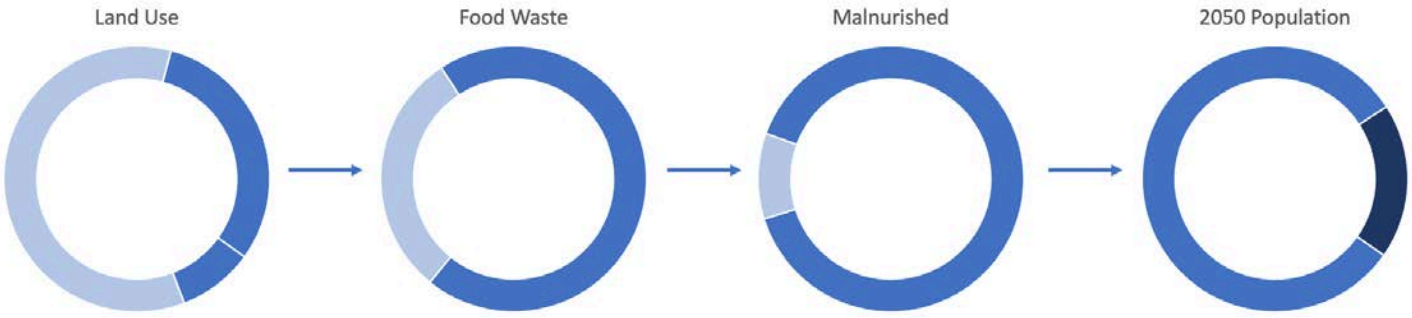

Figure 6.3. Depiction of the projected global population of 2050, highlighting the current number of citizens who are malnourished off modern agricultural production and food waste percentage. Land use is shown as 40% agricultural (23% grazing (lightest blue) and 77% croplands (light blue), while 60% is non-agricultural (dark blue) (3 p. 468). Food waste is shown as approximately 30% of global production wasted (light blue) with 70% consumed (dark blue) (4 p. 4). Malnourishment is shown as 820 million people malnourished globally (light blue), while 7.05 billion are not (dark blue) (3 p. 447). The 2050 global population is shown as a current 7.87 billion (dark blue), with a projected 9.7 billion in 2050 (darkest blue) (5).

M.N.R.M. Practicum Skills Development

I'm generally described by my peers as loud and outgoing, but I've never liked public speaking. My nervousness tends to overshadow the hard work I've put into a presentation. I'm meticulous about my work but lack confidence to share it in front of a crowd of strangers. Upon some self-reflection, I've realized that I have very high expectations of myself which I've portrayed onto others, which in turn left me highly self-critical and shying away from public speaking. Over the course of the entire practicum, I developed multiple skills and learned valuable lessons:

Lesson 2: To always have confidence in myself

I'm meticulous with my work and am confident in my abilities when communicating with people I know and trust, however, I experienced a lot of nervousness leading up to the initial meeting with Brian Westcott (LowLife Barrel House, Project Partner). The idea of presenting my work to someone new in hopes of gaining support in my endeavor felt mortifying. To my surprise, he was interested in the research and contributed some suggestions for the objectives of the project.

Confidence is defined as "Full of conviction: certain. Having or showing assurance and self-reliance" (6). Throughout the project execution, I learned to stand behind my research whether others cared or not, and to be confident in the objectives and outcomes. In other words, my confidence shifted from being dependent on the praise of others to being self-reliant and internal. This shift in confidence was likely a result of realization that not everyone has the time or energy to participate as opposed to not caring. I kept myself focused on my objectives and continued to seek out potential participants who were interested in the research. As with the initial meeting with the project partner, the people who participated were extremely knowledgeable and helpful, which added the confidence I needed to keep going. Knowing that other people were thinking about upcycling and sustainability reinforced the reality that I was researching a topic that has potential to be positively impactful on the way humans utilize food products. At some point during the project execution, I landed on the fact that business comes down to money, so I decided that I was going to create such a convenient and profitable framework that becoming a supplier or customer wouldn't even be a question.

(1) Communication Skills: Your ability to receive, understand, consider, and share information and ideas through speaking, listening, and interacting with others (1).

The project required multiple forms of communication, primarily through email but also included phone calls and in-person meetings. Face-to-face communication was the most effective form of communication for making vital decisions regarding the project and outcomes but is simultaneously the most difficult to plan if parties are not in the same space. As the project was planned during the Covid-19 public lockdowns in 2021, most verbal communication was done through Zoom. Virtual meetings were scheduled when important decisions needed answers beginning with the initial project proposal to the project partner, changes to project objectives, all the way through to signing off on satisfactory project completion. The importance of these meetings coupled with the professionalism required forced me to develop my communication skills through a variety of ways. First, being prepared was essential to sharing relevant information and ideas to receive the necessary feedback to continue my work and not get stuck waiting for an answer. For example, the initial meeting required clear objectives and methods (presented through the Integrated Project Plan) to convince the then-potential-project-partner that I was able to complete the project as proposed, whereas other meetings required projecting outcomes of various proposed project changes and being prepared with a list of questions to clarify new expectations. Being prepared allowed me to verbally present my idea, listen to the feedback, and interact with the project members to develop/expand on ideas to satisfy everyone's needs. Second, I kept written/typed notes to record the information and ideas I'd received from project members during meetings. After each zoom meeting, I'd send an email outlining what was discussed and decided upon during the meeting to (a) reinforce that I'd listened and understood the information, and to create a written record to later refer to for idea generation.

(2) Collaboration Skills: Your ability to contribute and support others to achieve a common goal.

The primary purpose of the practicum stream is to develop and execute a project with a project partner to acquire project management skills and experience. As such, my role as a student was to gain experience in an industry relevant to my study but as a project manager it was my job to coordinate and complete a project. I was in a unique position where I'd developed a project plan and presented it to the project partner in hopes of support. Brian was receptive to the idea and made some suggestions, putting me in the position where I was now collaborating with him to achieve the project objectives as opposed to simply executing orders.

Collaboration on the project happened in multiple ways. First, Brian was interested in obtaining energy data that I hadn't considered in the initial planning which would complement and add depth to the project overall. Initial project conversations centered around how the data would improve the sustainability of brewing and food operations, to which all project members held valuable experience and education from various backgrounds. Initial collaboration resulted in more comprehensive research results as opposed to a project with 'data holes'. Realizing the value and accepting suggestions from other team members of my original plan allowed me to execute the project with leadership, not dictatorship. A secondary form of collaboration happened through sharing contacts for potential data acquisition. The educational and experience backgrounds of our team members resulted in a wider network than any of us had on our own, which increased the volume, range and quality of data obtained. Third, the planned activities did not always execute as planned and required changes in schedule or activity. Project changes required the approval of team members and collaboration happened through discussions of possible changes, outcomes of changes, pro's and con's of associated changes, and how changes affect meeting project objectives.

(3) Decision Making Skills: The capability to analyze information among a set of alternatives, to evaluate potential outcome and choose the most appropriate solutions to achieve a predetermined objective (2).

While collaborating on the project with the project partner increased the quality of data, deliverables and outcomes, there were times that as the project manager, I had to make concrete decisions and keep moving forward. Starting the project, I was hesitant to make any project-related decisions without the approval of team members. As this sometimes compromised my timeliness waiting for approval on somewhat meaningless questions, I developed my ability to make decisions.

I'd made several small project decisions over the course of execution, but I really developed my ability to make executive and concrete decisions relatively late in the project. After trying to plan an in-person focus group with food and beverage industry folk (a very busy group of people), the confirmed attendance was 2 out of an invited 42. With the project team, I'd decided to change the event to a virtual event to increase attendance but failed to increase attendance. Every effort to reschedule the focus group required a potential change in ethics, coordinating schedules with the project team, and booking time off work. After three consecutive try's and knowing that food and beverage production is often a 24-hour endeavor, I began to consider the consequences of trying to reschedule several more times in terms of project completion. I had to accept that the invited participants are very busy people and made the decision that a group event was not the best option for this industry. It was time for me to execute my role as project manager with confidence. Equipped with the knowledge that participants are too busy to meet as group and having experienced the consequences of this reality throughout the interview stage, I made the decision to change the focus group to a feedback survey as this was the most convenient and appropriate solution to meet the predetermined objectives and would most likely generate a higher volume of data. With the project team still leaning towards a focus group, I presented my alternative solution and supported the decision with my experience throughout the project. With this new skill, I can confidently approach such conversations in the future with project objectives at the forefront of decision making, supported with evidence unrelated to individual 'feelings' towards changes.

Methodology

The project was developed during Covid-19 public lockdowns while not knowing when/if social restrictions would lift to do any sort of in-person research activities, so all research stages were designed to adhere to social distancing apart from the focus group. The choices I made for the research methodology allowed me to develop multiple skills while structuring activities with two primary focuses: (1) the research/data need to be as complete as possible, and (2) the data needs to be as specific as possible to Winnipeg brewers and food companies.

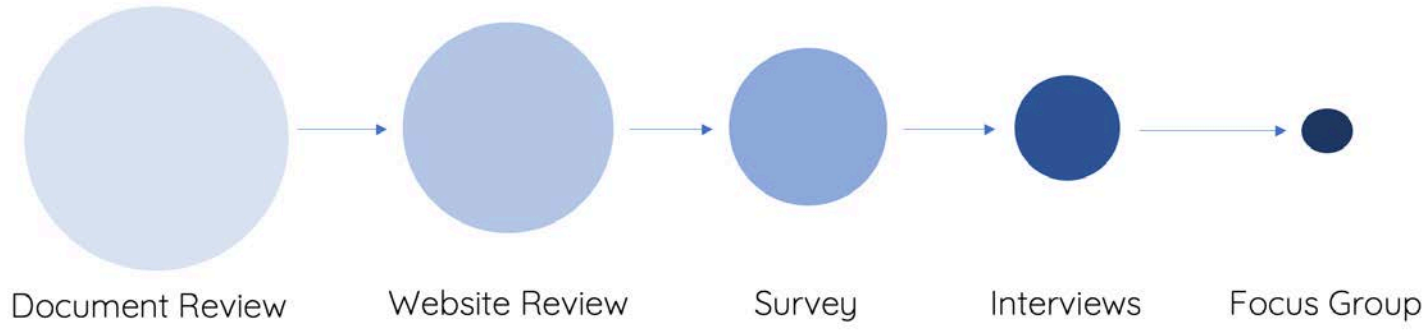

Figure 6.4. Visual representation of how the project methodology choices become increasingly specific to documenting the case for upcycling Brewers spent grain in Winnipeg, MB.

(1) Digital: Your ability to use digital technology and tools to find, manage, apply, create, and share information and content.

Planning a completely online/virtual research project gave me the opportunity to enhance my computer skills and develop new digital skills. Convincing people to trust me and take time out of their schedules to participate in my research would be challenging given they've never met me. Assuming that business owners already receive a lot of emails/requests, my intention was to make participation as convenient as possible. To me, this meant providing as much information up front to minimize confusion and communication, as well as using tools that were accessible.

I organize my personal life with a series of sticky notes, highlighters, and a calendar. A professional research project needed something more structured, which led me to Monday.com. The online program allowed me to create groups (the research stages), list to-do items by group (individual tasks), and list sub-items (task breakdown). Where my work benefitted most is that I could create task dependency within the lists, which appear on a Gantt chart in order. The program took my organization to the next level and became the first 'checklist item' of every day.

The default communication method was email (MS Outlook) for a variety of reasons but primarily for its versatility. The first benefit was the ability to create and manage contact lists. The website review included 1165 email addresses, whereas the list function allowed me to manage 19 lists per email as opposed to 1165 individual addresses. I'd never had the need to learn or use this function prior, but the ability to do so sped up the email composition step and allowed me to remove people that requested not to be included easily. A secondary tool I learned was the BCC (Blind Carbon Copy) function to protect the identification of potential participants as this was a requirement and promise of the consent forms. A third MS Outlook tool I used frequently was the 'scheduled send' function. This tool was critical to me staying focused on other tasks instead of 'going old-school' and having to remember to send emails on certain dates. Choosing email for participant communication, especially recruitment emails, enhanced my ability to share information and content. For example, all recruitment emails included a script, an attached PDF outlining study information and data requested from the participant, and a link to a consent form. The versatility of email allowed me to include short email script to not overwhelm the individual, have supporting information attached if they were interested, and provide a means of participation with 'the click of a button'.

The website review involved searching for 6 key terms related to the research on 1165 Canadian craft brewery websites, a total of 6990 searches. The intention was to generate an idea of the importance of sustainability to Canadian craft brewers through their public websites. As I couldn't read 1165 full websites in two months, I searched for an easier way and discovered the following google search tool: site:[enter URL] "[insert key word]". The tool allowed me to identify key terms within a domain without having to read the entire website. The ease and convenience of this tool got me thinking that there must be all sorts of tricks for remote work and research.

The anonymous portions of the project required some way of separating identifying information from the data collection. MS Forms was an obvious choice as it was already included with the MS Office program. I chose this program for the consent forms as the data analysis option was not as detailed as I'd needed but was sufficient for selecting yes/no and providing contact information. I used Google to identify other survey creation platforms and watched YouTube demonstration videos on 3 platforms before choosing SurveyMonkey. I decided to use this platform because the question-and-answer structure could accommodate both qualitative and quantitative data, the data analysis was comprehensive, and the survey layout for the participant was simple and easy to use. The combination of the two programs resulted in automatic participant anonymity and controlled survey responses as I was able to use MS Forms (consent form) as a pre-requisite to SurveyMonkey (survey completion). I accomplished this by only providing the consent form link in the recruitment email, marking the questions within the form as 'required', and provided the survey link in the "Thank You" script of the consent form thus requiring participant consent prior to participation without having to communicate back and forth with an individual to adhere to ethics requirements.

The interview stage introduced the need for new types of digital technology to encourage participation, starting with scheduling itself. As the recruitment group are people with busy schedules, convenience was essential. As such, I used Calendly.com to schedule interviews for a variety of reasons. First, participants could view my availability and schedule a time without having to communicate back and forth through email to find a time. It was equally convenient for them to reschedule if needed. This was equally convenient for me as I was able to link the program with my calendar and meetings would automatically appear/disappear, so I wasn't managing changes in multiple locations. I was also able to link the program with my Zoom account so that meetings were scheduled with the links provided automatically. The ability to automate the scheduling process allowed me to simply 'show up' for meetings after creating the process. After having used Zoom for online classes through the University of Manitoba, I was accustomed to the program features and was able to develop interview schedules that involved some of the features. As the 4th research stage, this was the first time I was meeting participants 'face to face' and having detailed discussions regarding data. As interview participants were given the option to review/edit their transcripts, the recording function and automatic transcript generation were highly useful and gave me the ability to be present in the interview without concentrating on writing notes; the conversations flowed more naturally without interruptions. Although transcripts were thoroughly edited before sharing with the respective participant, the automatic process saved me several hours of repetitive work.

(2) Creativity and Innovation: Your ability to imagine, develop, express, encourage, and apply ideas in ways that are novel, unexpected, or challenge existing methods and norms (1).

My focus on producing complete and increasingly specific data through a completely virtual workspace forced me to expand my imagination to adjust to the 'new normal' of social distancing. As I couldn't meet participants in person, my primary persuasion technique was 'convenience through accessible digital technology'. Accessibility was important as recruited individuals would likely have varying experience with digital and online technologies. While developing the methodology, I spent many hours working through processes and evaluating how easy it would be as a participant to develop continuous workflows, which led to the digital technologies discussed above. I developed links to use different platforms seamlessly and in tandem to create a novel process for participants, completely remote, that adhered to ethics in separating data and protecting participants identities.

(3) Adaptability: Your ability to achieve or adjust goals and behaviours when expected or unexpected change occurs, by planning, staying focused, persisting, and overcoming setbacks (1).

The initial decision to host an in-person focus group introduced a potential expected change in the project's methodology as the social distancing restrictions a year from planning were unknown. To my surprise, the final research stage required a lot of adaptability unrelated to Covid-19. I underestimated how busy participants really were and experienced difficulties in scheduling a group event. After trying to coordinate an event date three times and experiencing setbacks due to coordination logistics, I adapted the feedback process to accommodate and adjust for busy schedules and a need for convenience. Without changing the data objectives, the method of data collection was changed to a survey to meet participant and project requirements as the workflow I'd developed had worked well in the months prior.

Interviews & Feedback Survey

Referring specifically to the interviews and feedback survey portions of the research, I learned specific skills and learned two valuable lessons.

(1) Communication Skills: Your ability to receive, understand, consider, and share information and ideas through speaking, listening, and interacting with others (1).

I was able to develop my communication skills, primarily through sharing information and ideas with the interview participants. With previous research data supporting my initial ideas and questions, and having worked in food production prior, I was nervous for the first interview but quickly became comfortable for a variety of reasons. First, as this endeavor is complimentary to my education and work experience in the food industry, speaking with participants about food production details and understanding what they were referring to allowed me to have productive and professional conversations and obtain the appropriate data to make meaningful conclusions. Second, having completed comprehensive background research (BIR) including the environmental effects of food waste as well as the science of brewing beer, I was able to effectively consider specific aspects of brewing to share ideas on how the process could be done with upcycling spent grain. As I'd increased my knowledge of brewing and the properties of spent grain, overall I was able to receive feedback, understand the information, consider it within the overall upcycling process, and either incorporate the feedback or suggest an appropriate alternative idea. Third, I'd strategically prepared myself for the interviews. The interview schedule I'd prepared would easily steer an hour conversation but could stretch to two if the participant desired. As most participants dedicated an hour, the essential questions were asked first. I'd also worded questions in a way that would generate data needed for more than one objective with a single answer in case time ran short or participants wanted to skip something. Consciously knowing that I was prepared and didn't have to 'pull a conversation out of thin air' with a stranger allowed me to stay calm, actively listen to participants, and follow-up with conversation/questions relevant to what they'd said.

Lesson 3: Organizing myself versus organizing other/multiple people

(1) Time Management: The capability to manage one's own time and the time of others (2).

I'd spent years perfecting my own time management but was faced with difficulties in managing others. I assumed that if I was organized and timely then others could be too but was not what I'd experienced. Despite making processes easy and convenient for others and developing a project that was mostly reliant on my own abilities, I found myself waiting on others to proceed at times. As the project progressed and timelines were pushed, I learned to encourage response through increased communication and gentle reminders as opposed to quietly waiting. The confidence I gained in managing others time more effectively came after (1) a reminder that they'd agreed to participate and (2) they might have been busy and missed the email.

Framework Research & The Final Report

As a Food Science graduate, most of my scholarly work to date included writing extremely detailed laboratory reports outlining scientific processes and experiment outcomes. As such, I'd already developed a habit of thoroughly detailing all information that might and/or could be important to the topic. While useful in scientific writing, this skill edged on daunting while writing the final recommendation report. While writing the final report, I developed an additional skill required to execute my project and research with the upmost quality.

(1) Critical Thinking: The capability to use logic and reasoning to question, discern, interpret, and analyze various types of information to form an evidence-based conclusion or judgment (2).

The final proposed framework and associated full report was a compilation of the 5 research stages and required additional research to add quality/depth to the data and detail the case for Winnipeg, MB specifically. With varying types of data relating to an entire food process, the report required a high level of critical thinking which I was able to achieve because of my undergraduate degree, work experience in the food industry, and as an experienced researcher.

The project research stages were developed in a way that each stage produced increasingly specific and detailed data relating to the potential of upcycling brewers spent grain in Winnipeg, MB. I developed my ability to think critically with the same overall method: start with a general idea of the required steps/processes that I learned from Food Science, add the industry knowledge I've acquired, and work at refining the framework with increasingly specific data from the research. Simply put, I started with outlining the general steps/processes required, moved on to the next data stage to add details and remove unnecessary information, and did so until the framework was suited to Winnipeg.

The bulk of my critical thinking skills development took place after assessing the research data; during the framework research stage. At this stage, the framework lacked the detail required of a high-quality case study. I needed to use my logic to question and interpret the 'holes' in the framework. As such, I was able to visualize and imagine the framework by making flow charts in a program called VisualDesigner. The charts allowed me to 'walk through the process' as a brewer and food company to identify missing information/steps. I literally developed my critical thinking skills by thoroughly thinking through each step of the process. For example, the interview data identified upcycled products that other upcycling companies make but further research was needed to identify which products were made in Winnipeg/Manitoba and what scaling options were feasible. The interview data identified the pick-up vehicles that other upcycling companies used, but the framework needed further research to determine if those were too big/small for the framework needs. After identifying the gaps and missing information, I conducted location-specific (For example, transport routes) research and analysis to add the level of data required for a high-quality framework.

Overall Development of Project Skills

(1) Problem Solving: Your ability to identify, analyze, propose solutions, and make decisions. Problem solving helps you to address issues, monitor success, and learn from the experience.

After completing all project stages, I can confidently say that I developed my overall problem-solving skills in various ways. To start, food waste in itself is a huge global issue and addressing an innovative solution required a lot of data analysis, multiple solutions/ideas, and concrete decision making based on the evidence of multiple research stages. Second, the issue can't be solved by simply adding a type of food production to the city; the proposed solution needs to be sustainable and energy efficient. Third, problem solving happened prior to participant recruitment (For example, addressing workflow issues and links prior to sending recruitment emails) and throughout various stages of the methodology (For example, participants requesting alternative forms of participation during project execution) from which I learned how to develop easy and effective workflows for my next project.

What I Learned about Myself

Throughout the course of completing my Master's in Natural Resource and Environmental Management not only did I acquire the skills necessary to complete the courses and practicum, but I learned a lot about myself as an individual.

I struggled when I was faced with the task of selecting a research topic because I felt there were so many important issues I could have devoted my time and energy towards. The endless possibilities were overwhelming at first, but I grew to love the freedom of scholarly research. To date, if given the choice in a career with defined tasks versus one with increased independence, I would confidently choose the career with freedom and autonomy, specifically due to the development of my creativity and innovation skills as well as that of critical thinking. I learned that my mind is incredibly active and creative if given the opportunity. Over the course of this program, I can't name a single waking moment that my mind wasn't thinking about how upcycling would work in Winnipeg, and I'm confident I would perform at high levels on topics of interest to me.

Opposed to my initial thoughts on an open work schedule, I learned that I work really well independently and am very good at staying on track despite unexpected setbacks. I would go as far as saying that I work better in my own home than in any other location I've ever worked. I adored my days at home, undistracted at my own perfectly-set-up desk. I excelled with having control of my individual days and overall scheduling, and am highly skilled with time management. Having the authority and independence to assess task importance and freely move tasks around allowed me to appropriately prioritize and work effectively. The ability to work independently gave me the freedom to take care of myself when needed which likely avoided a burnout.

The decision to settle on addressing brewery waste through upcycling unleashed a side of me I'd never known. The topic brought my passion for sustainability together with my background in Food Science and addressed a pressing issue in a favourite beverage industry of mine. Having the opportunity to research a topic so perfectly suited to my interests gave me a high sense of responsibility to take the opportunity seriously and make a real difference with my time. But, the sense of responsibility didn't end with the project partner and my advisors expectations, I constantly feel a sense of duty to make a positive impact globally instead of being a materialistic being. I didn't want to just pass, I wanted to create something useful that actually worked and gave humans hope and work for in a time of climate and environmental crisis. I have the undying need to be part of the worlds adaptation to a changing climate.

In terms of my research style, now that I've acquired qualitative research skills, I much prefer quantitative forms of data within science-driven research topics. I can appreciate there is a time and place for qualitative research but find that numbers and numerical and statistical analysis answer questions more definitively within my research interests. I enjoy representing numerical data graphically, I value the importance of an average, and details matter. As I structured my research to include both types of data, I found myself dragging through transcripts and theme identification and frantically (and excitedly) searching for the numbers that would answer my questions. I imagine the qualitative experience will come in handy one day, and I might learn to love it, but as it stands, I find value and satisfaction in numerical analysis.

As may be noticed throughout this document, I learned that I'm a visual learner. Throughout my undergraduate degree, numbers seem to have served as the visual representation I needed to understand data and concepts. Face with qualitative data, I found myself drawing charts, graphs, and illustrations for everything to try and make sense of the data (and placing quantitative data to support wherever possible). What I further learned is that not only do the graphs help me make sense of the data, but they support my explanations when words just aren't enough. I thoroughly enjoyed creating visuals and representations of my research. I'm eagerly looking for an opportunity to research global environmental and food issues in the future.

Project Decisions and Outcomes

The integrated project plan (IPP) was developed in Spring 2022 and projected all activities and meetings to be done by December 2022. It's obvious that I'm writing my critical reflection in June 2023 that there were some decisions and changes made throughout the project execution. Three of the largest changes were related to scheduling, and the fourth was due to low participation.

The first change made in the project was to push back the start of all research activities requiring ethics approval by 4 months, from June 2022 to September 2022. This was a requirement as the ethics application had taken longer than anticipated to be submitted and approved, especially while finishing coursework and finalizing the research topic. The change in start date was beneficial as I'd overlooked the fact that breweries are extremely busy throughout the summer and I would have likely gotten a lower response rate had I been on time with the IPP. This change also gave me more time to identify potential users of upcycled BSG.

Figure 6.5. Original proposed timeline for completing research on *Exploring the potential of upcycling brewers spent grain in Winnipeg, MB.*

The second significant change to the project schedule was to extend the 6-week interview period to include 3-weeks after the winter holidays/Christmas. The decision was made as some participants had indicated that the weeks leading up to the holidays were too busy to participate but would be interested after the holidays. Initially I was upset that the change would push the already-changed schedule back another 5 weeks, but I was ultimately happy with the decision as I was able to conduct interviews with more participants and have a large data set to work with. Had this not happened, I believe the interview data would have been insufficient to make any concrete decisions or analyses.

The third significant change to project scheduling was done during the focus group planning and happened 3 times. The focus group required me (project manager), Brian (project partner), and Iain (committee member and academic advisor) to be in attendance as hosts. Coordinating three schedules and confirming a date was difficult to start with and proved to be more challenging when choosing a time suitable for a 2.5-hour focus group. After three separate dates resulted in only 2 participants, it was evident that the focus group was not going to work so we cancelled the focus group and submitted an ethics amendment. This worked out to be a good decision as each effort to plan a focus group date took approximately 2-3 weeks, thus delaying the project's schedule by quite a bit each time. Deciding to cancel the focus group saved us from wasting more time trying to plan and execute a meeting that participants didn't seem interested in.

The fourth significant project change was made due to low participation rates of the focus group. It was decided that instead of trying to host a group event and coordinate schedules with multiple people, we would amend the project plan to have a feedback survey in lieu. Preparing the documents for an ethics amendment was a lot of work up front to ultimately have an automated process for the following three weeks. I was happy with this decision for two reasons: (1) I found myself not looking forward to hosting a focus group as I don't enjoy public speaking, and (2) I was extremely happy with how the focus group questions were re-worded to yes/no or multiple choice survey questions; if there was significant responses, they would have generated meaningful data.

Formal Plans and Outcomes

Developing a full integrated project plan helped me develop skills and learn new ones to achieve the project objectives. However, the experience was also useful to learning how the formal plans execute in real life. Following is an outline of what worked well and didn't, and why.

Scope Changes

As was made obvious in the previous section, the majority of changes to the project were related to scheduling. While planning the project to finish in time with a June-2023 graduation, I made two vital mistakes. First, I overlooked how businesses might have prepared and planned their production around holidays and busy seasons. For example, breweries in particular are busier in the summer than winter, so planning interviews for July and August was a miss to begin with. I'd also planned some activities leading up to the winter holidays/Christmas in which I'd overlooked the fact that businesses are preparing months in advance and would likely not have time for a student's research. Second, I overestimated how interested and dedicated participants would be, specifically to the amount of time I dedicated to the interview process. To be exact, I'd dedicated 3 weeks for interviews and assumed to be busy each day when the reality was that I was having a busy week if I'd scheduled two interviews. The overestimation resulted in extending the interview period to a total of six weeks to generate a larger data set. Overall, the six weeks went well, but they would have gone better had I considered that holidays apply to businesses, not just individuals.

Resource Plans

After executing the project, I can confirm that the IPP *Resource (Skills and Knowledge) Needs Assessment* was correctly planned. This is ultimately due to the fact that the bulk of research activities were conducted by me and I was accurate in my assumptions of the skills I would acquire, particularly my digital skills development throughout the project. This was also due to conducting a meeting with committee members regarding their skills and knowledge and how they would/could contribute to project execution. The IPP *Resource Needs (Materials, Supplies, and Equipment) Assessment* also worked out as planned apart from changing the in-person focus group to a online survey. Prior to writing the document, I'd carefully planned the digital resources I was going to use and was happy with the program/application's performance throughout execution.

Managing Relationships

Looking back at the *Managing Relationships* section of the IPP, I believe that I planned communications effectively to (1) focus on the project, and (2) be aware of parties with potential interest in the research either now or in the future. I found the communication methods worked out well for communication with the project team for a few reasons. Email as the primary method of communication was effective for asking multiple questions and providing various updates/attachments in one place, and the flexibility to answer when convenient. Email also provided a transcript of communications for reference when needed. Knowing the team members better now, I could have suggested a group text or WhatsApp chat for matters requiring a quick response. While the communication plan worked out well for this type of project, had this project been a later stage of food product development, a more modern (texting, WhatsApp, social media) and less traditional (Strictly Email) communication method should have been chosen for daily communication. As this was a research stage of a potential product development, there was no need to contact or communicate with people outside of the research as long as the impacts of implementation were considered to all those affected and therefore the *External Interested Party Register* communication plan felt appropriate and worked out well for the project. Again, if this project had been a later stage of food product development, the communication methods and frequencies would have been different as affected parties would have been consulted and informed of the project activities.

Risk Management

The project itself, considering the required resources and overall cost, was not a risky investment to begin with. I believe the potential benefit of the project outweighed the potential risk by a long shot, especially considering that the project partner was not asked to invest financially for the research. I found that the risk response plan worked out well for the associated risks, but the most significant risks to the project were not identified well to begin with. The method of estimating the risks worked well, but I'd underestimated some significant risks and overestimated others. For example, "Personnel – Less than 50% of Canadian breweries complete online survey due to missed email or lack of interest, leading data to not be representative of Canada." was estimated to be a significant risk but had I done my research on survey's, I would have known that a 50% response rate was grossly overestimated to begin with and not a significant risk to the quality of data. Another example, "Schedule – The products with BSG incorporated in literature are not manufactured in Manitoba leading to a small group of potential users." was also identified as a higher risk which is absurd as Winnipeg produces a lot of food products, is host to many bakeries, and had I expanded my thinking, I would have realized that chefs and home cooks would have made an excellent interview group. Upon reflection, I believe that this plan was based more so on my personal fear of somehow not being able to produce quality data resulting in a focus on minor risks, leaving the major risks either unidentified or looked over. Future development of a Risk Management plan will involve a comprehensive assessment of project risks as opposed to identifying 'project fears'.

Quality Management

Upon reviewing the *Quality Management Procedures* with the project complete, I stand by what I outlined as it worked out well for the project overall. However, I believe there was an important component missed in identifying risks to project quality that resulted in lower-than-anticipated interview data: interview participation. While survey participation was addressed, interview participation wasn't and led to a lesser-than-required effort to recruit participants. Unfortunately, this risk to quality management was realized too late in the project, after already conducting six weeks of interviews with low participation and was not corrected. While the data acquired provided concrete primary data for a more quantitative data analysis (Such as calculating production volumes, equipment capacity, supply and potential demand, etc.), the data lacked supporting/secondary qualitative information (Such as relating to customer acceptance, willingness to pay, etc.) that would have resulted in a higher quality data set and larger volumes for numerical analysis.

Budget

The budget was mostly comprised of digital platform/program subscriptions and hosting an in-person focus group. As the in-person event was changed to an online survey and the project costs had been minimal to begin with, the budget worked out better than expected as shown in *Figure 6.* The original budget estimated a low of $1,726.75+, a likely $2,215.84+, and a high of $3,066.00+. With the cancellation of the focus group and the survey using existing subscriptions, much of the budget became obsolete. Regarding the subscription budget, a total of $746.30 was spent of a budgeted $764.36, for a total project spending of $18.06 below budget. What worked really well with the budget was that projected spending was divided by type and therefore the total projected could be sub-divided into categories as opposed to simply stating "*The project spent a total of $746.30 of a likely $2,215.84"* which would have been a misrepresentation of the actual projected spending.

Monthly Subscriptions	Bill Date	Month 1 June	Month 2 July, 2022	Month 3 August, 2022	Month 4 Sept. 2022	Month 5 Oct. 2022	Month 6 Nov. 2022	Month 7 Dec. 2022	Month 8 Jan. 2023	Month 9 Feb. 2023	Month 10 March, 2023	Month 11 April, 2023	Month 12 May, 2023	Total	Budgeted	Over/Under
Adobe Acrobat	5th of Month	$ -	$ 20.99	$ 20.99	$ 20.99	$ 20.99	$ 20.99	$ 20.99	$ 20.99	$ 20.99	$ 20.99	$ 20.99	$ 41.98	$ 251.88	$ 279.96	$ 28.08
Adobe Creative Cloud	5th of Month	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Monday.com	Free Subscription	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Calendly	29th of Month	$ -	$ -	$ -	$ 21.26	$ 20.96	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 42.22	$ 76.40	$ 34.18
SurveyMonkey	Sept 22,2022	$ -	$ -	$ -	$ 441.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 441.00	$ 408.00	$ (33.00)
Zoom	3rd of Month	$ -	$ -	$ -	$ -	$ 11.20	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 11.20	$ -	$ (11.20)
UM Forms	Free Subscription	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total:		$ -	$ 20.99	$ 20.99	$ 483.25	$ 53.15	$ 20.99	$ 20.99	$ 20.99	$ 20.99	$ 20.99	$ 20.99	$ 41.98	$ 746.30	$ 764.36	$ 18.06

Figure 6.6. Project spending per month compared with budgeted values.

Objectives and Deliverables

The deliverables produced for this project meet the project objectives within scope apart from objective 7, described in detail in the project objectives section of the framework recommendation report on page 151. Overall, the project is a large portion of the preliminary research needed for food product development from an environmental point of view, thus a realistic and feasible framework suggests that product development could continue to the next stage with the appropriate funding.

The data collection methods chosen to conduct the research were effective for producing increasingly specific data relating to the case study. The literature review offered a foundation of data to build upon and verify, the website review provided a general idea of Canadian initiatives, the survey offered Canadian specific data and a comparative model, and finally, the interviews provided specific data and a Winnipeg model. The development of the final framework recommendation with the combined data met objectives 1-6, and 7 partially. Exact values for the CO_2 emissions of various portions of the value chain could not be obtained, leaving objective 7 calculations limited to the estimated transportation routes of current waste management strategies with that of the framework. This was also difficult to calculate without transportation data from each Winnipeg craft brewery. However, the estimated data suggests that collaboration among Winnipeg craft breweries emits less than handling transportation individually.

With the project objectives being met with the research conducted, the focus group/feedback survey would have provided additional details to add specific details to portions of the framework. The intention was that feedback would verify and reinforce choices made in the framework and perfect the overall functions to be the absolute most convenient and realistic functions possible.

Overall Project Plan

Having the experience of writing and executing a complete project, I now understand the purpose of each project plan section in relation to planning and execution. My plan worked out well for me overall and resulted in data analysis and deliverables that the project partner was appreciative of, but portions of the planning focused on details of a missing bigger picture. For example, while worrying about how to analyze interview data, I overlooked that a lack of participants would also compromise data quality. While focusing on large-scale single demand (industrial food production), I overlooked that multiple smaller demands (such as restaurants and at-home use) could create an equal demand and therefore failed to recruit entire interview groups. As someone who is detail oriented, focusing on the details ended up not working out the best as some 'bigger picture' items were missed that could have added valuable depth to the overall project research.

Premises of the Research

The overall idea to "Think Global, Act Local" was intended to use global sustainability initiatives as goals and models to locally increase the sustainability of one industry without having to wait for government action. I believe this sort of initiative is important as government intervention and/or recommendations could potentially come too late when trying to mitigate something as unpredictable as climate change. The brewing industry is already an excellent example of how an industry can recycle its own packaging materials and now has potential for upcycling used ingredients.

Upcycling is not a new concept overall, but the use of the term is. For example, fries are a food product meant to be relatively long, so the middle of a potato is the most appropriate for a fry whereas the outer portions are short and rounded, making for small pieces. Instead of discarding 30%+ of each potato, the 'shorts' are upcycled to hashbrowns. While this is a simple example, finding use for secondary/waste products in the food industry is common as it is financially appealing to the

company. While some companies have the ability to upcycle products internally, it's obvious that spent grain's upcycling potential is outside the brewery and requires a separate process. Having substantially more knowledge regarding upcycling spent grain in Winnipeg than at the beginning of this project, the challenges to climate action are more apparent. Considering industries that are working on increased sustainability, lack of technology could be a real barrier they face. Considering only this project, the technology and processes needed to upcycle spent grain to human food products are available in small to large scale, yet multiple barriers exist to bringing the theory in to reality; namely financial. At small scale, a brewery or food company could easily and affordably upcycle small volumes of spent grain in human food products, but not at scales that would yield industry-wide impacts to sustainable operations. At large scale, industry-wide effects are possible but likely require other actors. As independent and local sustainability initiatives are valuable, the impact levels needed probably require government support such as regulatory or financial to overcome the monetary hurdle to starting a food processing company and the marketing hurdles of making "used food products" look and seem appealing to potential consumers.

Having admitted the barriers to the framework implementation, I still believe the premises and global models used are appropriate. At the time of writing this, the ideal government regulatory and financial supports are not in place, but I believe the overall "Act Local" has immense value. Spent grain upcycling is happening throughout Canada, so by acting locally in Winnipeg, the brewing industry can yet-again be an example of sustainable operations and encourage the government to support local action with regulatory and financial support. With beer being such a popular beverage globally, and craft beer admiration growing, I also believe that local craft breweries have ample opportunity to promote upcycling within their establishments without being pushy. I genuinely believe that the majority of people are concerned with the fate of the world and would be interested to know what can be done locally to support sustainability and that they can support that.

If I could do this all over again…

When starting the M.N.R.E.M. program, I didn't realize how much effort and planning goes into a project. The structure of the practicum stream (both developing and executing a project) was an invaluable experience. Although I'd thought that my meticulous planning was bullet proof, I would do some things differently next time.

1. Working within Covid restrictions resulted in a completely virtual project which made it difficult to recruit participants as my introduction was through email. While email has many benefits, I was painfully aware that the recruitment email was likely lost in a busy email box. I believe it was also difficult for participants to trust me as digital requests and scams are common. If I could start over, I would plan the introduction to be in-person as restaurants and brewpubs were allowed to host customers at times throughout the pandemic with appropriate social distancing. I believe I would have recruited more participants if they'd met me in person and were expecting the email as opposed to receiving a participation request from someone they'd never met or heard of.

2. I would have changed some of the information provided in the Informational PDF included with the recruitment email to outline all research stages and request their participation in all of them. I believe that if I'd outlined all the stages and asked for a participation confirmation through the consent form, participants would have been expecting the following participation requests and would have yielded a larger data set.

3. Regarding the interview recruitment, while I was primarily concentrating on large-scale impact, I wish I'd considered 'strength in numbers' and expanded my Food Company recruitment group to include chefs and anyone who bakes/cooks at home. Not only would this have expanded the scope of potential demand of upcycled spent grain, but I could have drawn on my own

network from having worked in restaurants and bars for over a decade. Considering that other upcycling companies sell consumer products, it would have been beneficial to actually include that group in the research.

4. If I could re-execute this project, I would have prepared a rough upcycling framework to show participants prior to the interviews so they had a more in-depth understanding of the data I needed to produce a quality framework. While the interviews provided vital quantitative data, I believe this change would have yielded high-value qualitative data to support the numbers. I also think this would have been beneficial as a visual could have eliminated some confusion or misunderstanding that a verbal explanation may have presented and would have therefore allowed the participant to better critically assess what was being presented.

5. In the overall scheduling of the project execution, I mostly considered a student/professor schedule as opposed to considering how businesses might plan and prepare for seasons and holidays throughout the year. If I were to do this project again, I would have prioritized participant schedules over my own to make it easier for them to participate.

6. When considering the research methods, I must admit that I considered digital skills at my parents (Boomers) level to be safe and planned more traditional methodology. If I could do this project again, I would still concentrate on participant's convenience but use more up-to-date and timely digital tools to communicate and recruit. For example, for businesses/companies that were not open to the public ever or during Covid, I should have used my digital skills to record an introductory video (Posted on YouTube) so participants could 'put a face to the name'. While I provided my email address and LinkedIn profile link, I believe that a video would have allowed potential participants to 'meet me' and increased the likelihood of participation.

7. If I were do this project again, I wouldn't try to plan a focus group with a group of participants that have a very high likelihood of being extremely busy and who work long hours. Considering the questions that I wanted to address, I don't believe a focus group was the best method to begin with, proved to be very difficult to plan, and resulted in scheduling setbacks. Instead, I would have planned the feedback survey to have been ready ahead of time and sent to participants after they'd confirmed their transcript. I believe this would have yielded a higher feedback response as the research and information would still be 'fresh in their minds'.

While the above would have likely improved the project, there are some things I wouldn't change for the world. To start, the more I learned about the potential of food waste through upcycling, the more I fell in love with my research topic. I thoroughly enjoyed speaking with participants about the potential of upcycling and how it could affect their production/operations. I felt extremely empowered and optimistic by participant's excitement and willingness to share information for a beneficial sustainability initiative. Having completed the project, I feel as though the 'floodgates' of my mind have been opened to this topic and I intend to explore it further throughout my career. The second aspect of my project that I thoroughly enjoyed was my committee. Iain, Brian and Filiz were all extremely supportive, knowledgeable, and just outright pleasant to work with. I felt comfortable seeking advice from my committee, and I couldn't have completed this project with the same level of quality without them. I would love to have the opportunity to work with any or all of them again.

My Contribution to Research

What I'd initially thought that I could achieve in a 12-month period was the development of a project from start to finish. Ignoring the fact that companies have entire departments for product development, I soon realized that the scope of such an endeavor was much longer and more complicated than what was expected at a master's level. Leaning back on my own skills and educational background, the project addressed the preliminary stage of product development:

research. I planned a project that defined a case study specific to Winnipeg to address the potential of upcycling brewers spent grain to human food products. A case study is "an intensive analysis of an individual unit (such as a person or community) stressing developmental factors in relation to the environment" (7). A case study is an "appropriate research design when you want to gain concrete, contextual, in-depth knowledge about a specific real-world subject" and "while case studies focus more on concrete details than general theories, they should have some connection with theory in the field" (8). There are many benefits to conducting a case study.

In writing the background information report, I developed an essential graph in defining the need for upcycling at large scales. Having referenced multiple sources, the numbers indicate that the amount of food wasted globally is actually enough to feed people who are currently malnourished as well as the projected 2050 global population. While there is global concern of feeding 9.7 billion people, re-imagining products conventionally seen as waste could be a key to halting environmental degradation and increasing the sustainability of current food and beverage production operations. I also learned that beer is one of the most commonly consumed beverages and produces large amounts of perfectly edible (and nutritious) food 'wastes'. While others have done research on the uses and consumer acceptance scores of upcycled spent grain products, I learned that the majority of these foods are produced in Manitoba and could support a local framework if a demand was generated. An important aspect of the data I learned is that the majority of spent grain is shipped to local farmers for use as ruminant feed at the expense of either the brewery or farmer, and can be hard to arrange and/or maintain. Overall, I learned that brewers spent grain is abundant, a 'burden to get rid of', is nutritious, has potential in many or all bakery products, upcycling can address a large portion of food waste for this particular industry, and that doing so would be a beneficial local effort to operate sustainability to 'do our part' towards global sustainability initiatives.

While drawing on the scientific research of others, I brought theoretical and global data together with locally specific data and developed an upcycling framework to address large portions of brewery wastes locally. I contributed to the field in the following ways:

1. I determined that although there is a relatively small brewery population in Winnipeg, there is in fact enough spent grain supply to meet a range of demands from individual to industrial if all breweries within the city of Winnipeg supplied their spent grain to the framework.
2. I was able to determine that based on the data, local breweries are in fact shipping their spent grain to local farmers as ruminant feed.
3. I documented and confirmed that the barriers to upcycling spent grain found in the literature review coincide with what local brewers are experiencing and was able to develop a framework to minimize or remove said barriers.
4. I located the necessary upcycling equipment through NETZRO (Minneapolis, MN) to dry spent grain at a sufficient rate to meet demand.
5. I also determined that while there may be demand for upcycled barley flour in the plant-based industry, the most likely, realistic, and profitable demand is as a mixture/replacement for flour in baking and cooking.
6. Through a variety of google searches, I was able to determine that Winnipeg is host to small-industrial scale bakeries, hundreds of restaurants, a multitude of grocery stores/retail outlets, and almost 1 million people who likely cook/bake at home multiple times per week. There is more than enough potential to market and sell upcycled spent grain locally if a sufficient demand can be created.
7. I also determined that, if all breweries were contributing their spent grain to the upcycling framework/company for processing, the average environmental footprint of moving spent grain per brewery would be 6x lower with a single pickup route, and 3x lower with two routes, ultimately saving the brewery time, money, resources (business and environmental).
8. To top it all off on a positive note, I was able to determine that there is in fact local interest in upcycling brewers spent grain from both brewers and those with potential demand.

The above listed contributions I made to the field ultimately have determined that upcycling brewers spent grain is possible, people are interested, and there's a lot of potential for the upcycling company itself with scaling options. If myself or someone else were to continue this research, here are some suggestions I can provide to advance the research:

1. Food Science Research – Conduct the nutritional testing necessary to define the nutritional profiles of (1) Winnipeg brewers spent grain samples, and (2) nutritional profiles of various beer styles, in comparison with literature values.
2. M.N.R.E.M. Practicum – Complete a business professional business plan for a project partner (investor) interested in starting an upcycling company in Winnipeg, MB.
3. M.N.R.E.M. Practicum – Complete the next stage of product development: Product development and testing. Dry and mill local spent grain samples to a flour and test recipes for an interested project partner. (Consider the most sustainable product options).
4. M.N.R.E.M. Thesis – Further develop, research and quantify the environmental impacts of moving spent grain from harvest to disposal to determine precise environmental impacts of grains used in the Canadian or Winnipeg brewing industry.
5. M.N.R.E.M. Practicum – Work with Minneapolis-based NETZRO to research and identify other potential uses for their patented upcycling equipment to use as scaling opportunities.

Practical Applications of the Data

The deliverables presented contain detailed data from multiple research stages detailing the case study done on *Exploring the Potential of Upcycling Brewers Spent Grain in Winnipeg, MB*, but what are the practical outcomes and conclusions of the associated 18 months of work?

To start, the qualitative data states there is sufficient supply to upcycle. There are enough breweries in Winnipeg, MB producing large enough volumes of spent grain to upcycle spent grain locally at some capacity. The reported volumes could satisfy individual and some retail demand, while the reported industrial demand would likely require spent grain from all Winnipeg breweries which may or may not be possible and/or realistic.

Second, there is local interest from real businesses, meaning actual potential exists. But while there is interest in the idea of upcycling brewers spent grain from potential suppliers and users/consumers, the actual commitment and interest of all parties will most likely be influenced by the financial implications and/or benefits of being a supplier or a user/consumer. It is unlikely that businesses would be interested in a product that does not create value for them and therefore a full financial analysis of the business model would be desirable.

Third, on the topic of financials, industrial sized processing equipment varies greatly in price but is more likely to be very costly. Even with large volumes of data and research, starting a food company at the scale outlined in the framework would require large sums of money from (but not limited to) investors and potentially government. While the suggested framework is theoretically feasible in terms of supply and demand, it does not guarantee financial feasibility. The practical option would be to start the company in a small space with minimal equipment to produce product samples for food companies while building a client and investor base and moving to a more sophisticated process with a secure consumer base.

Fourth, having reached out to many people and businesses, we've started the conversation on how to render brewing more sustainable locally and will hopefully spark collaboration as the knowledge of increased sustainability is now public.

Fifth, throughout the course of this 18-month project, two North American spent grain upcycling companies went out of business. While there are many possible explanations, upcycling is

a relatively new concept in modern food production and will likely require significant effort/time to gain momentum and popularity. With that said, craft breweries have become increasingly popular and offer great opportunities to advertise and promote upcycled spent grain products, certification for upcycled products exists, and consumers are increasingly aware of climate issues and ways to 'do their part' towards sustainability.

Sixth, while the original thought was to assess large scale demand/use for upcycled spent grain (primarily in the plant-based industry), the data revealed that there were many more opportunities at the retail and small business levels that had not originally been considered. Winnipeg is host to many locally owned bakeries, restaurants, and retail spaces with potential use for upcycled spent grain products. Individuals with the freedom to be creative (local bakers, chefs, food scientists, etc.) may play a key role in building an upcycling company and promoting efforts to reduce food waste while larger companies/corporations might not have the same flexibility.

Lastly, new product development consists of 7 overall stages: (1) Idea generation and concept development, (2) Market research, (3) Business plan, (4) Prototype, (5) Crowdfunding, (6) Design and production, and (7) Marketing and distribution strategy. Considering these stages, this research accounts for stage 1 and 2. The next step would be to do a comprehensive financial analysis and create a business plan.

To summarize, the project was overall intended to *explore* the possibility of upcycling spent grain locally and acts as the preliminary research stage of product development, essentially evaluating the question "*Should we continue to look into this?"*. The resulting framework outlines the general steps required in BSG upcycling food process with sophisticated space and equipment, but the significant level of resources should not be ignored. It's suggested that serious interest in upcycling BSG should be followed by a comprehensive business analysis to further assess if the endeavor is financially feasible.

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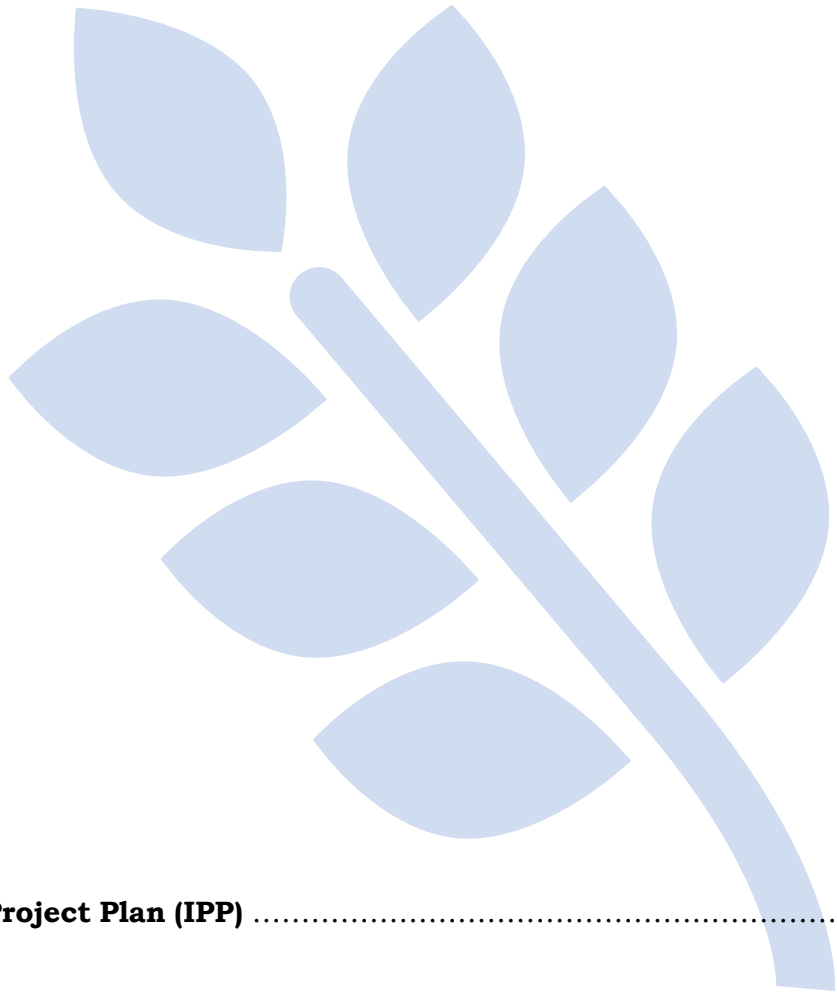
Appendices



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Appendix A: Integrated Project Plan (IPP)

Exploring the Potential of Upcycling Craft BSG in Winnipeg, MB

Marika Boryen

An Integrated Project Plan submitted to Iain Davidson-Hunt the Faculty of Graduate Studies of The University of Manitoba in partial fulfilment of the requirements of the degree of

MASTER OF NATURAL RESOURCES MANAGEMENT

Clayton H. Riddell Faculty of Environment, Earth, and Resources
Natural Resources Institute
University of Manitoba
Winnipeg

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Executive Summary

While sustainability is a topic at the top of every business's agenda, it is important to concentrate not only on initiatives at a global scale, but also those we can directly control in our own neighbourhoods. In considering sustainability, it's important to make the most of the energy and resources that have already been put into growing a human food product. It's with this in mind that we have focused on the Winnipeg Craft Brewing industry to capture the true value of spent grain. Information regarding the importance and need for this project is provided in Appendix A, the Background Information Report. Through our partnership with Barn Hammer Brewing, it is our goal to fully understand whether craft brewers spent grain can be upcycled for human food products instead of being disposed of in conventional ways such as ruminant feed, compost, or landfill. With a feasible upcycling framework tailored specifically to Winnipeg, spent grain would no longer be a 'burden' to dispose of from craft breweries, food processors gain a nutritionally rich ingredient, and local businesses take another step towards a circular economy. This project is carrying out the research necessary to explore and evaluate the potential of upcycling craft brewers spent grain in Winnipeg, MB. The project has two overall objectives and 3 primary deliverables as follows:

- *Objective 1* - Identify the possibilities for upcycling BSG into Plant Protein by *September 23, 2022*.
- *Objective 2* - To understand and quantify the greenhouse gas (GHG) emission differences between conventional waste management strategies and upcycling BSG in Winnipeg by *December 18, 2022*.
- *Deliverable 1* - A final report detailing research findings throughout the entire project will be completed by *October 21, 2022*.
- *Deliverable 2* - A focus group will be held to obtain critical feedback on the recommended upcycling framework for Winnipeg, MB on *November 27, 2022*.
- *Deliverable 3* - A final recommendation for BSG upcycling, including an updated framework and short report, specific to Winnipeg, MB will be finalized by *December 18, 2022*.

Information needed to meet the objectives will be acquired in various formats to ensure data accuracy and a realistic BSG upcycling framework. Preliminary research relating to brewing beer, circular economy, food upcycling, spent grain nutritional and textural qualities, and Manitoba food processing will be conducted to thoroughly understand the value of brewers spent grain which will allow for the identification of food processors with potential use of this ingredient. All Winnipeg craft brewers and identified food processors will be made aware of the project and its objectives, as well as be invited to participate in research. Research will begin with a Canada-wide Craft Brewery Website review to understand what is being done in other cities and the quantities required for implementation. A survey requesting preliminary data will then be sent to each of Winnipeg's Craft Brewery's owner or CEO, along with an information document with project details. Along with acquiring preliminary quantity estimates, the surveys will identify individuals who are interested in further participating in our research and will then be scheduled for individual interviews. Participants will be informed of the numerical data required in the interviews ahead of time to allow for accurate reporting of annual volumes. A key data resulting from the interviews is the identification of barriers faced by brewers in storing and moving spent grain after the brewing process, and barriers food processors face in using spent grain as an ingredient in their production. With the conclusion of all interviews, a framework will be created connecting Winnipeg craft brewers spent grain with Manitoba food processors that removes all possible barriers of both brewers and food processors. To ensure that the framework is realistic and desirable, it will be presented to participating individuals in a focus group that doubles as a networking event. Focus group feedback will be used to revise the upcycling framework, which will allow for the GHG emission calculation differences between conventional waste management practices and the upcycling initiatives.

The Integrated Project Plan (IPP) covers specifics of the project including the Project Charter, Project Scope, Project Schedule, Resource Needs and Acquisition Plans, Relationship Management throughout the Project, a detailed Risk Assessment, an in-depth Quality Management Plan, overall Budget Summary, and how changes to the project will be managed. Background information utilized to develop the IPP is provided in the appendices.

This project will provide food and beverage processors in Winnipeg with an example of food upcycling and a circular economy framework through our consideration of BSG within the craft brewing sector. The quality of research and data analysis is crucial to achieving our objectives, which aims to provide an effective framework that is both realistic and affordable to all parties. It would be detrimental to the project if identified individuals were not interested in participating, and therefore interviews will be done over Zoom to increase convenience of scheduling and meeting location. It's important that we make the processes convenient and appealing to ensure their participation.

A comprehensive risk analysis identified the most significant risk to completing this project as "*Personnel* – Focus group participants cannot provide valuable feedback related to framework due to: lack of understanding of any/multiple components, lack of interest, no ideas for improvement, etc.". To mitigate this risk, a copy of the proposed framework will be sent out to focus group participants prior to meeting date to ensure they have time to review and assess the process as it pertains to their business. Another mitigation strategy will be carried out by the project manager who will research BSG upcycling frameworks from other cities and countries that will serve as examples for the initial framework, as well as provide alternative options to address and formally decide on whether to include or not for this case at the focus group. The risk is ultimately managed by researching successful frameworks and the inclusion of first-hand industry knowledge vital to implementation.

I, Marika Boryen, am carrying out this project as the project manager with the support of my academic advisor, my project partner Brian of Barn Hammer, as well as my master's committee. My educational background is in Food and Environmental Science, and therefore I am qualified and able to complete the necessary research as outlined with the objective of making Winnipeg food and beverage production more sustainable. Global change towards a circular economy starts with a change in individual thinking, and we are setting out to change all Winnipeggers thinking around the way our city produces food and beverages!

As my expertise is in food and environmental science and Brian has real world expertise in brewing coupled with industry contacts, the successful completion of the project is undoubtedly anticipated to result in a framework that has considered all essential aspects for implementation. An upcycling framework resulting from rigorous research, successful real-world examples, along with industry feedback will provide participating parties with a comprehensive analysis of the local situation with improved management strategies benefitting all parties, local and large-scale food systems, as well as reduce the environmental impacts of feeding Winnipeg customers while contributing to global climate change initiatives. This research is supported in part by funding from the University of Manitoba Graduate Fellowship (UMGF).

Project Charter

The Project Charter is a document resulting from a series of meetings aimed at defining the overall project. It was developed from the original Project Concept, which is included as Appendix B. It is an agreement between myself (the project manager), Iain Davidson-Hunt (my advisor) and Brian (the project partner), confirming what has been agreed upon in terms of objectives and deliverables. It provides an overview of the entire project, justifies its need and serves as a rough expectation for completion dates. Subsequent project documents are based on this agreement including scope, schedule, budget, and quality management. During execution of this project the charter will serve as a living document where all changes to project plans are documented and approved by myself and the partner brewery.

Project Overview:

The project is centered around exploring the potential of upcycling craft BSG in Winnipeg, MB, by determining: (1) if there is sufficient quantity of BSG in Winnipeg to render upcycling plausible, (2) what local breweries currently do with their spent grain, (3) the barriers brewers face in using/moving/storing spent grain, (4) if/which breweries are interested in upcycling potential, (5) who the potential users are of BSG as an input, (6) the intermediate steps required to link BSG with potential users, and (7) the energy/CO_2 emission differences of current management strategies compared with that proposed.

As there are considerably more breweries in Winnipeg than a decade ago, the project is intended to conduct the research necessary to determine if there is sufficient quantity of BSG to generate a local demand of a particular upcycled product(s). We will use frameworks from other cities who have BSG upcycling initiatives in place as reference for what might be doable in Winnipeg based on research findings. As this project is not intended to carry out upcycling activities, it will provide a comprehensive analysis of upcycling BSG to consider the potential for Winnipeg.

Justification/Need:

Food and beverage production yields high waste as producers try to meet quality standards for consumers, and/or when ingredient inputs become large volumes of waste products such as barley (and other) grains used in brewing beer. It is our goal with the overall project, partnered with Brian of Barnhammer, to explore the potential of diverting craft brewers spent grain (BSG) in Winnipeg from conventional waste streams (landfill, compost, ruminant animal feed) by employing concepts from circular economy and food upcycling. We will ultimately identify the barriers brewers face in dealing with spent grain and consider possibilities of upcycling the food to other human food production cycles. To the benefit of local breweries, potential uses aim to overcome barriers and render spent grains a potentially valuable product input as opposed to a burden as waste. While there are large efforts globally to move towards a more plant-based diet, it is essential that we consider the value of spent grain remaining in the human food production cycle as they are highly nutritious. If we do not proceed with this project, brewers spent grain in Winnipeg will continue to be conceived as a waste product and a burden to remove from the brewery property, thus not realizing the true nutritional value and potential of the product.

Objectives and Deliverables:

Objective 1

- Identify the possibilities for upcycling BSG into Plant Protein by *September 23, 2022*.

Objective 2

- To understand and quantify the greenhouse gas (GHG) emissions differences between conventional waste management strategies and upcycling BSG locally in Winnipeg, MB by *December 18, 2022*.

Deliverable 1

- A final report detailing research findings throughout the entire project will be completed by *October 21, 2022*.

Deliverable 2

- A focus group will be held to obtain critical feedback on the recommended upcycling framework for Winnipeg, MB on *November 27, 2022*.

Deliverable 3

- A final recommendation for BSG upcycling, including an updated framework and short report, specific to Winnipeg, MB will be finalized by *December 18, 2022*.

Requirements:

BSG into Plant Protein

- Resulting from a combination of literature review, existing global upcycling frameworks, and firsthand industry knowledge

Final Report

- A comprehensive analysis and final report of all project research (Website review, surveys, and interviews)
- Research will produce quantitative data that will be subject to numerical analysis (eg. How many Canadian craft breweries are currently upcycling BSG), and qualitative data subject to analysis (eg. What are the current upcycled BSG products in Canada? What is the interest level of Winnipeg craft brewers to upcycle BSG?) for a thorough report on findings
- Upcycling framework must be inclusive only of Winnipeg craft brewers and Manitoba food processors to ensure local supply chains

Greenhouse Gas Emission Differences

- Emission differences will be based on an estimate of waste routes post-BSG collection from brewery compared with estimates of BSG upcycling framework activities/operations
- Available standardized values for GHG emissions will be used for consistency and accuracy

Focus Group

- Focus group participants will include WPG craft brewers and MB food processors
- Focus Group feedback will be used to improve framework
- Meeting must encourage networking between participants

Final Framework and Short Report

- Must be encompassing and accurate summary focus group
- Short report must outline the details of framework operations and justify why they are the best option for this case study
- Report must detail benefits to brewers and food processors, as well as the global benefits of upcycling

Resource and Cost Estimates:

The current cost estimate for this project is $2,415.84 which has two associated unknown costs. The first unknown cost is the event space rental for the focus group which is TBD but will take place at Barn Hammer (partner brewery). The second unknown cost is associated with beverages, which will also be clarified with the event booking at Barn Hammer.

Roles and Responsibilities:

Iain

- Review/Edit Background Information Report (BIR)
- Secure Committee Member (Food Science)
- Review/Edit Integrated Project Plan (IPP)
- Review Ethics Application

Marika

- Edit Background Information Report (BIR)
- Complete Integrated Project Plan (IPP)
- Edit Integrated Project Plan (IPP)
- Acquire list of all Canadian Craft Breweries in preparation for website review
- Arrange Committee Meeting for April 29, 2022 (Or date same week)
- Identify Initial list of potential users of upcycled BSG
- Prepare Survey Questions
- Prepare Interview Questions
- Submit Ethics Application
- Register for required project accounts/memberships

Brian

- Review/Edit Integrated Project Plan (IPP)
- Communicate and promote the research project to other local craft breweries
- (TBD) Host the Focus Group and Networking event
- Provide local industry knowledge (when available) to facilitate research activities

Charter Approvals:

Charter (Version 1) – Approved by Project Manager, Advisor and Partner on *March 9, 2022*

Project Scope

The Project Scope document outlines what can be expected from the project and potential expectations that cannot and will not be met, which is agreed upon by the project manager, advisor and partner brewery. Following are the identified exclusions to the current scope, thus further detailing the exact expectations of the project deliverables within the proposed budget. There are a number of assumptions that have been made in the planning stages which are subject to affect project timing if not met, therefore scope management decisions are defined at the end of the document should vital changes be needed. The acceptance criteria defined within this document may not be compromised in order to complete a task/stage successfully throughout the project and must be signed off as "satisfactory" in order to progress to further stages.

Exclusions from Scope:

The overall goal of this project is to conduct the research needed to evaluate and explore the potential of upcycling BSG in Winnipeg, MB. As this is valuable knowledge for select industries, there are a number of potential expectations that cannot be met and are therefore excluded from the scope of this particular project:

1. Research will be promoted to potential interview candidates (Manitoba craft breweries and food processors with potential use for upcycled BSG) and findings will be presented in a focus group, but the final research findings will not advertised publicly as budget does not allow for marketing.
2. Exact quantities of spend grain will not be possible but educated estimates will be required in order to define the potential supply and demand of BSG.
3. Food manufacturers operating in other provinces will be considered outside of the project scope as this will lengthen supply chains.
4. Any cost analysis associated with the BSG upcycling framework will be quoted as accurately as possible, but exact costs may not be possible from quotes.
5. As this research will make a final recommendation in the form of an upcycling framework for improve 'waste' management of BSG, the implementation of the framework is outside the scope of this project.
6. The implementation of this framework cannot be guaranteed as it is outside the scope of this project and will be up to research participants to carry out.
7. The focus group is aimed to generate feedback on the upcycling framework. While all suggestions for improvement will be considered, it may not be possible to incorporate them all due to various reasons.
8. The exact GHG emission differences between conventional waste management of BSG and upcycling will not be possible within this project but educated estimates of a range or value will be conducted and provided in the final report.
9. As there are many known uses for BSG (including energy production, animal food/treats, compost, etc.) this project will concentrate on upcycling BSG to human food products.

Assumptions:

A number of assumptions are being made in the planning of this project which are believed to be true at this time as follows:

1. The government listings of all active breweries at the time of research are updated a true as this will serve as the sample for website review and survey distribution.
2. It is assumed that a significant portion (90%+) or all of the Winnipeg craft breweries and Manitoba food processors with potential use for upcycled BSG have sufficient incentive and interest in the project outcomes to participate in interviews, and to respond openly and honestly to all questions.
3. During the website review, it's assumed that if a brewery is participating in some sort of upcycling initiatives it will be advertised or mentioned on their website publicly.
4. As there are many known uses for BSG (including energy production, animal feed/treats, compost, etc.) this project will concentrate on upcycling BSG to human food products.
5. It is assumed that of all possible human food products that can incorporate BSG, more than one of these products will be manufactured in Manitoba.
6. It is assumed that a realistic (feasible and affordable) framework for upcycling BSG will be possible in Winnipeg, MB with the defined quantity of spent grain.
7. It's assumed that sufficient examples of successful BSG upcycling frameworks from other cities are available to analyze the potential success/feasibility of our proposed framework.
8. It is assumed that focus group participants will have sufficient interest in the research outcomes to provide valuable feedback to enhance the final upcycling framework to a level where participants are motivated and capable of implementing recommendations.
9. It's assumed that the majority of craft brewery representatives/owners will attend the focus group as well as the majority of food processor interview participants to obtain valuable feedback before finalizing recommendations.

Constraints:

The planning of this project has identified some constraints that could impact the success of this project at various levels, defined as follows:

1. This project is limited to the annual supply of BSG generated in Winnipeg, MB to ensure a local supply chain and therefore recommendations for upcycling will be limited to the quantifiable volume obtained through research.
2. This project has a constraint of defining potential demand of BSG through the current operating food processing facilities in Manitoba.
3. The lack of systematic weighing of BSG leaving breweries means that a standard conversion ratio will be used from beer production numbers.

Acceptance Criteria:

Following are the indisputable criteria measuring the success and completion of deliverables and milestones associated with Exploring the Potential of Upcycling Craft BSG in Winnipeg, MB:

1. Framework developed based on data collected through research.
2. Framework presentation meeting must allow for honest communication and identification of brewer/producer barriers in framework in order to properly re-analyze framework.
3. Final Framework meeting must allow for social networking of brewers and food processors in order to make the connection between supply and demand and must motivate affected parties of the importance of upcycling spent grain.
4. The final report must be inclusive of all data analysis from all research activities to fully outline the BSG situation in Winnipeg, MB and to justify final recommendations.

Scope Management:

The overall objective of this project is to determine Winnipeg supply of brewers spent grain and explore the potential demand in human food processing in Manitoba. The project will end after a final framework and recommendations for upcycling have incorporated focus group feedback to address final concerns associated with the framework. We anticipate some excitement among the brewers at the potential of a secondary income on spent grain, but due to high financial risk of implementing upcycling initiatives without first conducting the necessary research, resources at this time are reserved for accurately defining supply and demand.

Any proposed changes to the scope of the project must be thoroughly reviewed and accepted by myself, Iain and Brian. If the change is deemed vital to the success of the project and increases the quality of the final product, changes will be considered, and a decision will be made within 24 hours. Changes cannot change timing and meeting dates within the project, unless vital to the completion of the project.

Upon a proposed change:

1. Timing of the project progression may not be changed as interviews will be booked ahead of time to ensure project stays on track.
2. Proposed changes must be presented as early as possible in the project to myself and the partner brewery and are subject to review. All parties must agree on the proposed change and will be measured against the overall objectives and deliverables.
3. Changes will be analyzed both in terms of feasibility and financially.
4. Upon acceptance, changes will be reflected in the change management plan and the change log (Active Document).
5. Accepted changes that alter project objectives and/or deliverables will be reflected in the Project Charter and an updated copy will be redistributed to the project team.
6. Accepted changes that require a change in ethics will be subject to the wait-time of a new Ethics application and Project Schedule will be updated reflecting new timelines.

Project Schedule

The Project Schedule has been created as a result of developing Project Activities, a Work Breakdown Structure, the Sequence Diagram, defining Milestones, and calculating the Critical Path. Schedule details are provided as Appendix C. The Project Schedule exists as a time tracking mechanism with task progress updated each day of the project and will be used by the project manager for daily planning. The schedule is a living document, and although the project has been scheduled as outlined below, it is subject to change as the project progresses. Timing of float tasks may be completed at different dates so long as the critical path of the project is not altered. Tasks may be added to the project schedule as needed, upon the approval of myself, Iain and Brian. Significant changes will be recorded in the Change Management Plan and Change Log, and will be dealt with accordingly.

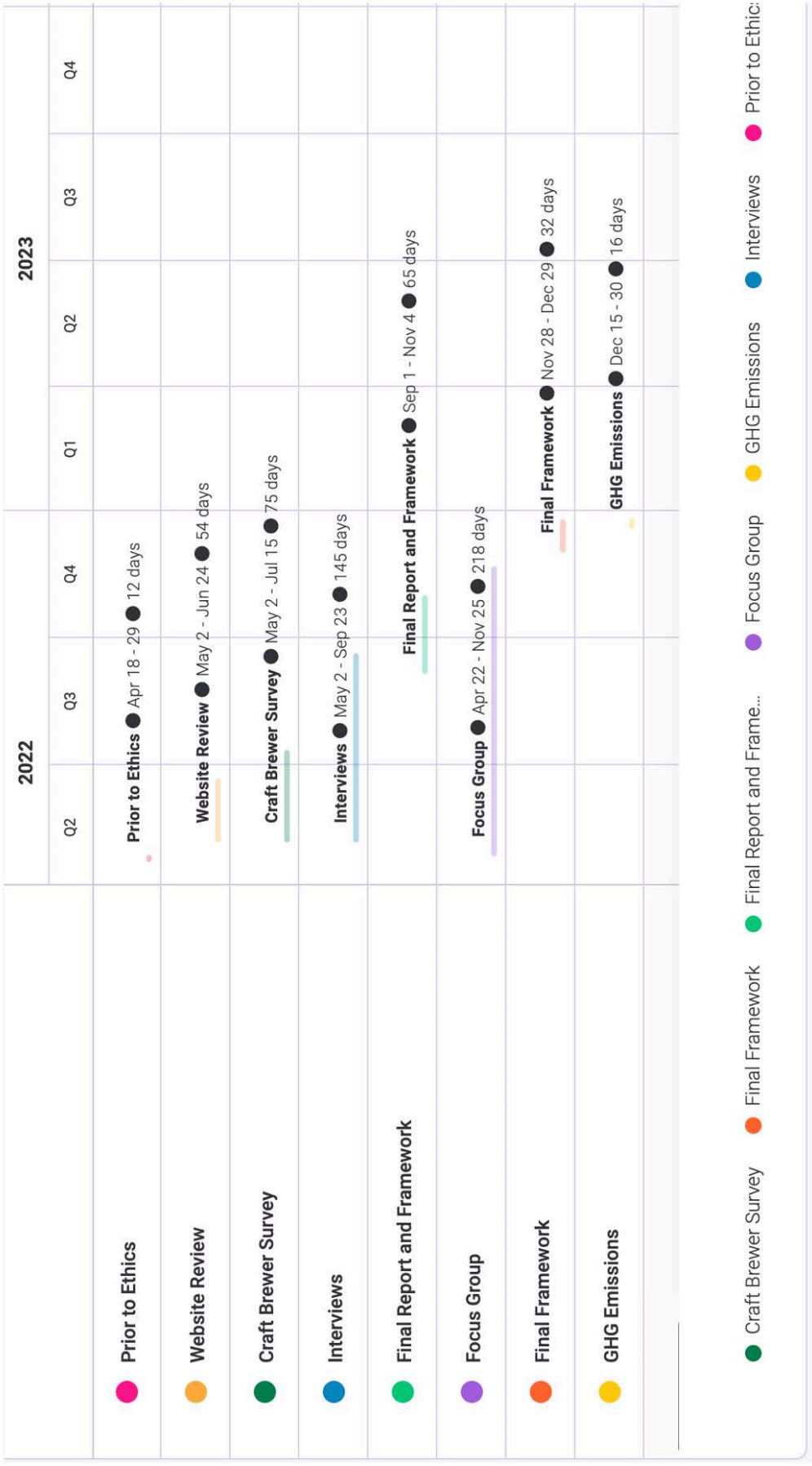
The schedule has been created as a Gantt chart to easily visualize the progression of tasks which are organized by deliverables categorized with varying colours, coordinating with the Critical Path calculations, as outlined by schedule colour below:

1. Work to be Completed Prior to Ethics Application
2. Website Review
3. Canada-Wide Craft Brewery Survey
4. Interviews (Winnipeg Brewers and MB Food Processors)
5. Final Report and Framework Development
6. Focus Group
7. Finalizing BSG Upcycling Framework
8. GHG Emission Assessments

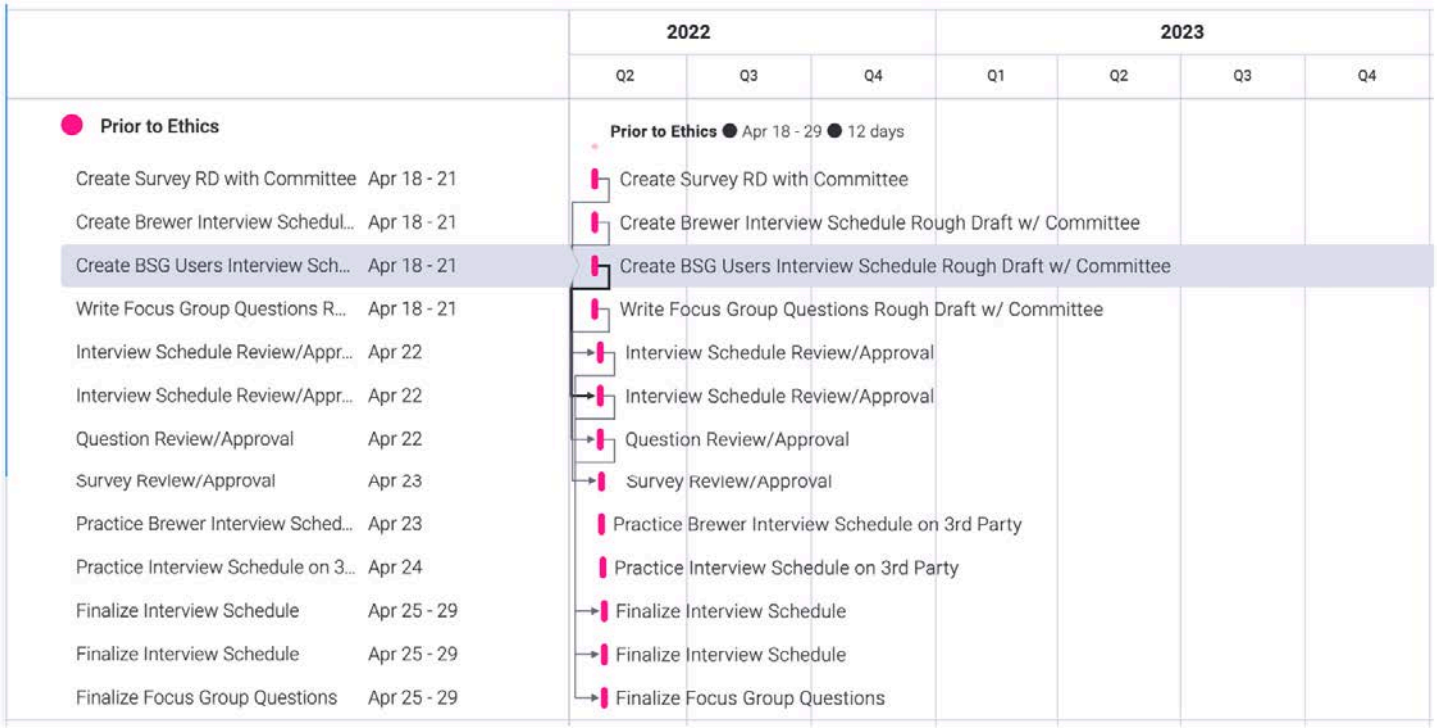
The schedule outlines task durations, start and end dates based on a single day and time, and is considering the majority of work is done in a 40 hour work week. At times, the project manager has been scheduled over a weekend to perform time sensitive data analysis or research, but weekend work is not expected outside of these exceptions. Unless otherwise noted, tasks are automatically assigned to the project manager, who holds the full responsibility for completing tasks, adhering to project schedule, as well as holding all others accountable for their assigned tasks.

The completed Project Schedule is provided on the following four pages and is current at the time of writing this document. (April 23, 2022) As calculated in the Critical Path Calculations table (Appendix C), the early start/early finish and late start/late finish dates are the same due to the nature of project activities. The project start is set as May 2, 2022 and will end by December 30,2022 as completion is essential to affected parties schedules including graduation requirement deadlines, meaning there is no available float time outside of the allotted calendar. The schedule is a living document on Monday.com, and is made available to the project partner, advisor and partner so updates or changes can be viewed immediately, by anyone, from anywhere.

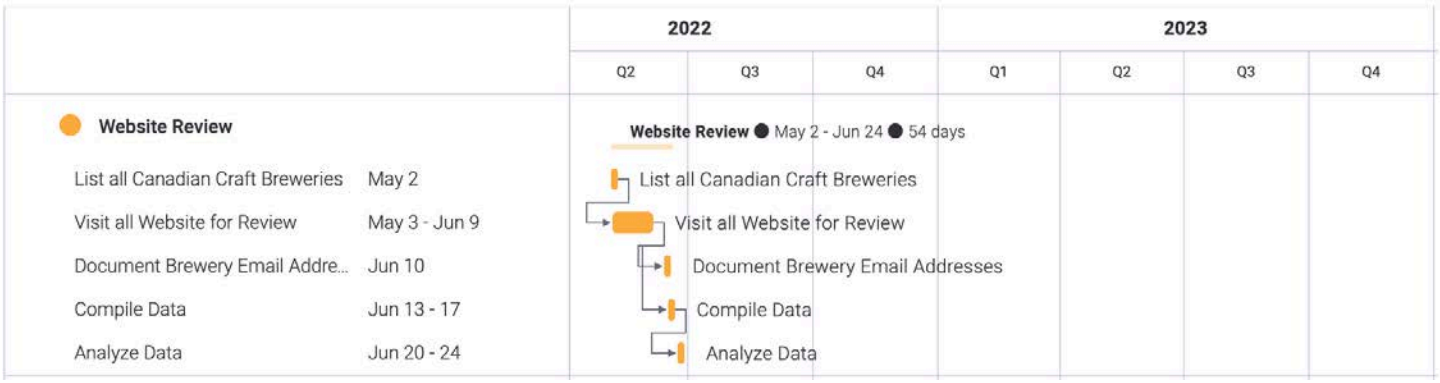
Project Overview by Designated Sections



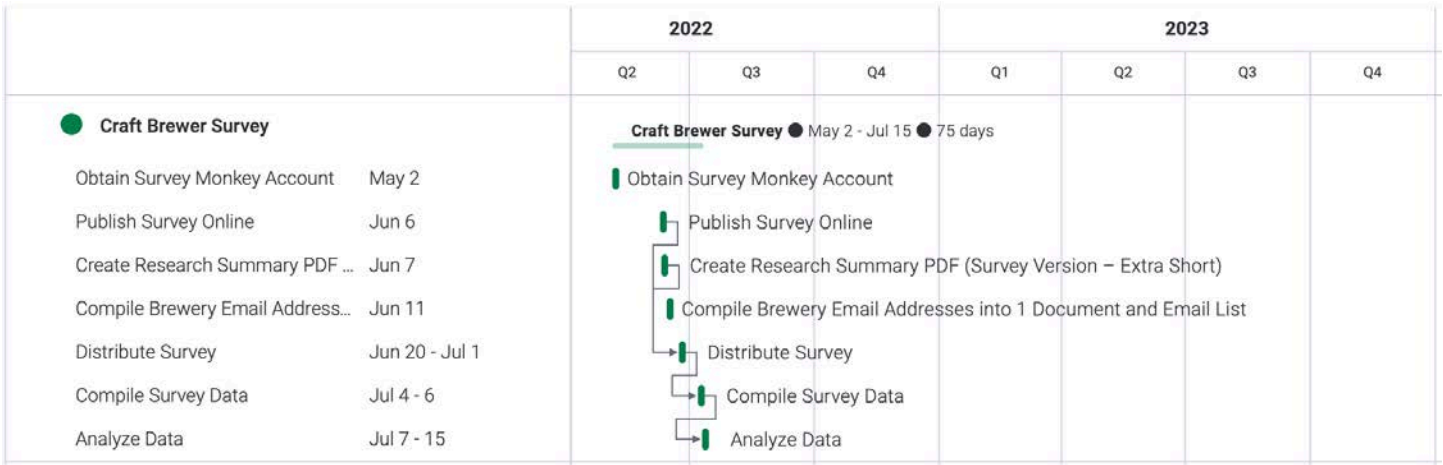
Work to be Completed Prior to Ethics Application



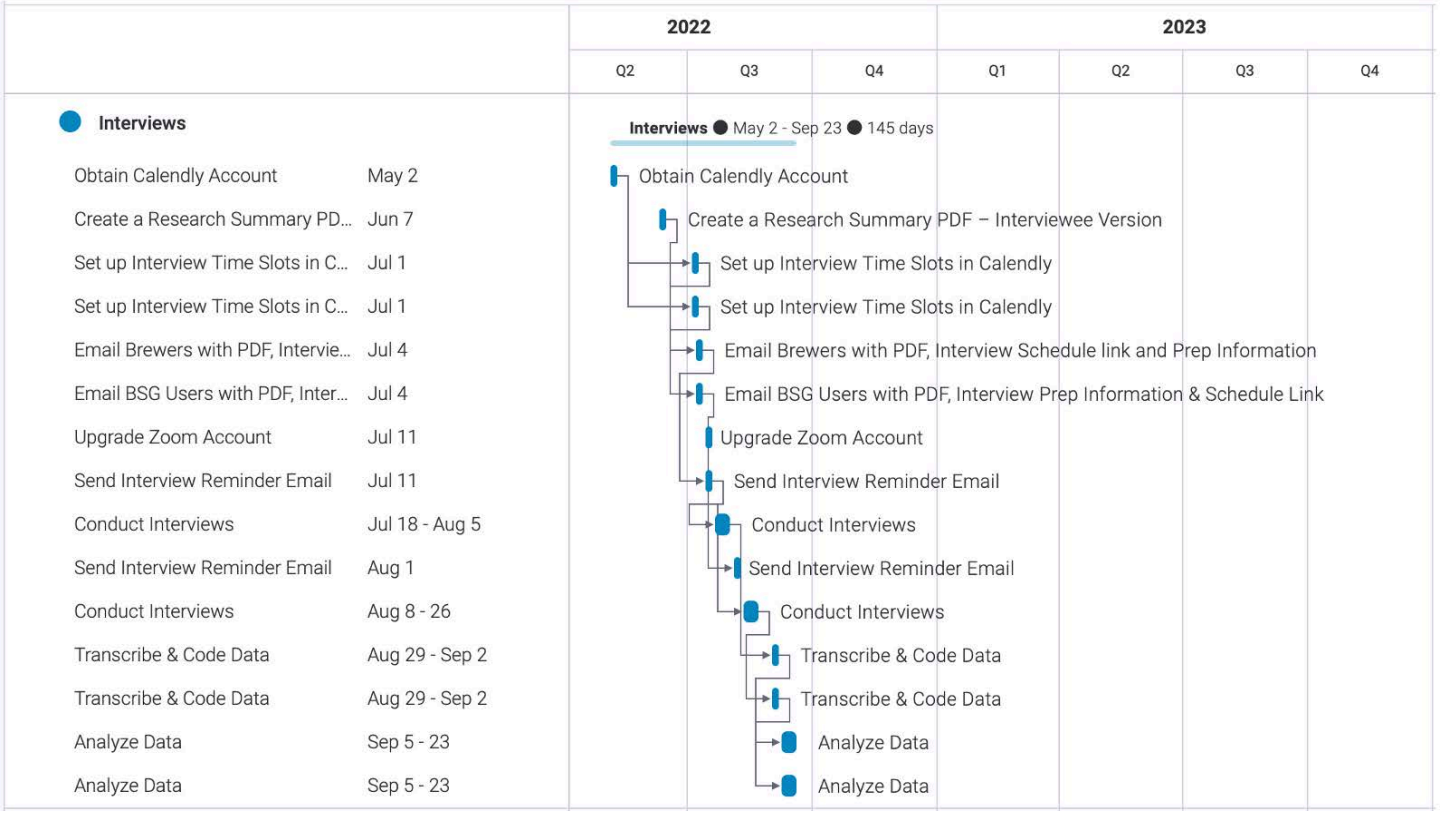
Website Review



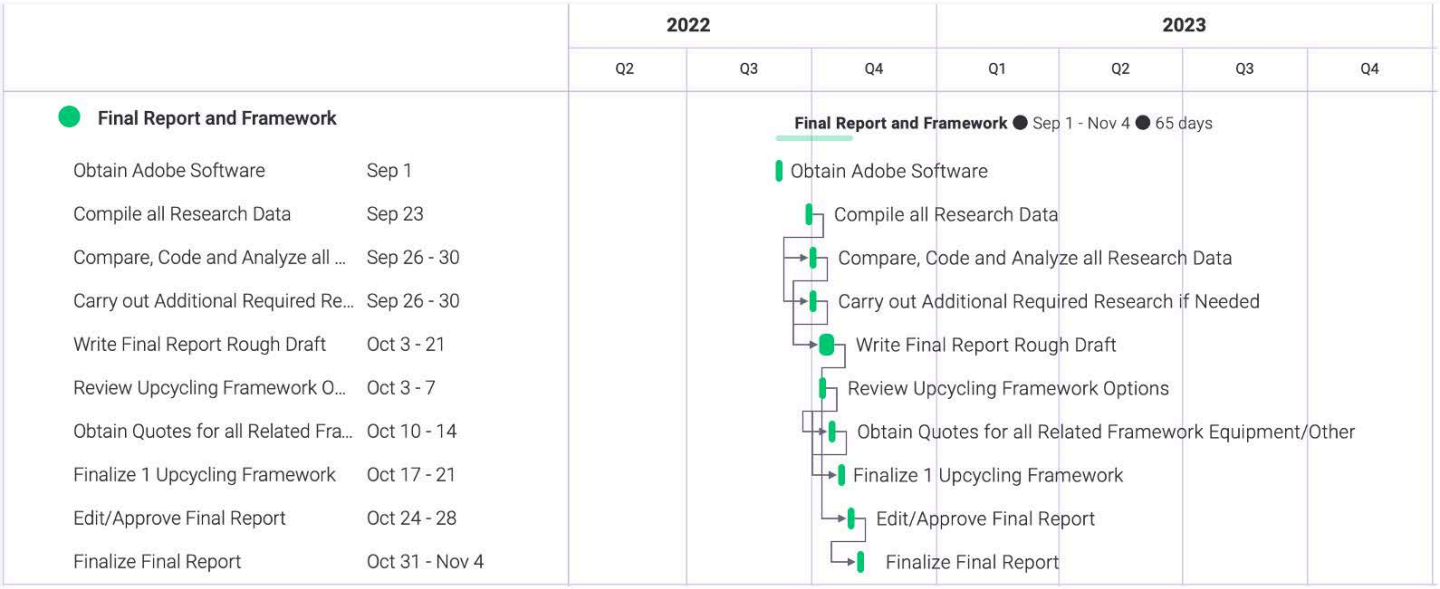
Canada-Wide Craft Brewery Survey



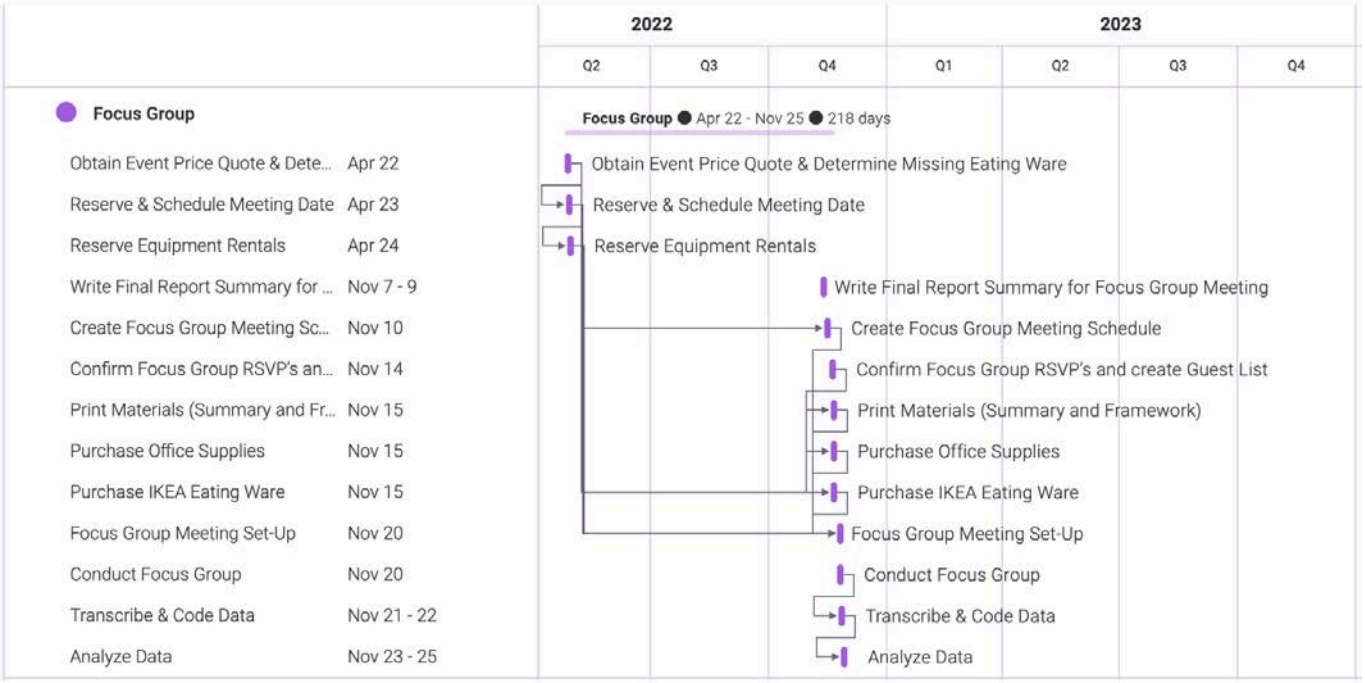
Interviews (Winnipeg Brewers and MB Food Processors)



Final Report and Framework Development



Focus Group



Finalizing BSG Upcycling Framework

GHG Emission Assessments

Resource Plans

The following section outlines the resources needed to complete the project that require acquisition outside of the resources available/held by project members. The 'Skills and Knowledge' describes what is needed outside of the expertise held by the three team members and how we plan to acquire those, and the 'Materials, Supplies, Equipment' is a summary of the tools needed that need to be obtained for specific portions of the project. A comprehensive list of the resource needs is provided as Appendix D.

Skills and Knowledge

The project "Exploring the Potential of Upcycling Craft BSG in Winnipeg, MB" requires a variety of skills and knowledge in order for all objectives and deliverables to be completed with the highest quality standards. As outlined in the *Resource (Skills and Knowledge) Needs Assessment*, all skills and knowledge required are held by the project team (Marika, Iain, Brian) therefore no additional individuals/companies are required.

Materials, Supplies, Equipment

Viewable in the *Resource Needs (Materials, Supplies and Equipment) Assessment*, a large portion of the project can be executed with personal equipment held by the project manager, mainly; an internet connection and student access to UofM libraries for research, a personal laptop with all basic programs (word, excel, PowerPoint), and a cell phone. Additional materials, supplies and equipment that is not already owned will be procured in a variety of ways. Prior to project start, all online accounts will be acquired through their respective websites and set up so project activities are seamless and convenient. The focus group requires the most significant portion of outside resources and will be immediately addressed upon booking confirmation with Barn Hammer. All the materials required for the focus group meeting will be acquired 1-2 weeks prior to meeting date by project manager and stored at the brewery to ensure it is available.

Managing Relationships

Managing Relationships – Planning Elements

Communication within the project is crucial to its success and therefore the following section outlines the parties that need to remain informed at various times throughout the project. A detailed outline of the Relationship Management Plan can be found in Appendix E. This plan outlines who needs to be communicated with and the timing of communication so that individuals are aware of progression/changes to their roles within the project. Communications are separated by internal parties who are involved in decision making, and external parties who play a different but important role in the completion of this project. The critical components of the communications plan are understanding what individuals need from us, what we need from them, the method of communication, as well as timing to satisfy the parties needs while meeting our needs as well.

Interested Parties Register

The following individuals are internal to the project and therefore have a role in the success. Communication with them involves planning, decision making, financials, to provide data, meeting attendance, and require updates on activities including (but not limited to) progress and completion of tasks and milestones.

1. Iain Davidson-Hunt (Advisor)
2. Brian Westcott (Project Partner)
3. Food Science Committee Member

The following individuals are external to the project but hold key roles in the success of the projects research goals. Whether parties are providing research data, feedback, or are positively/negatively affected by the outcome of the project, they have been identified and any/all communication must remain open and honest.

4. Winnipeg Craft Brewers
5. Potential Users (Food Processors) of Upcycled BSG
6. Livestock Farmers Currently Receiving BSG
7. Transporters of BSG from Brewery to _____ (Farm, Compost, etc.)
8. Individuals using BSG for Compost
9. Ingredient Suppliers of MB Food Processors
10. Processing Equipment Supplier
11. Government of Manitoba
12. General Public

Communication Methods and Timing

Following is a list of the suggested communication methods and timing within the project with various parties to ensure schedule adherence and to ensure tasks are being completed with the upmost quality. Suggested communication methods are those that have been identified as the most efficient within the project plan, but other methods that are determined to be more convenient for affected parties may be used as well.

1. Email – The most convenient communication method for a professional setting, ensuring there is a record of communications throughout the project. Email will be used for frequent/when necessary conversation is needed, as well as to contact interviewees with research materials and necessary links. The project managers email will be made available to all interviewees to use when needed for reasons related to the research. In developing the framework, the project managers email will be used for communication with potential suppliers in order to have record of quotes and other details. *(Interested Parties: 1, 2, 3, 4, 5,10)*
2. Phone – This method will be used when communication requirement is more urgent or requires an immediate answer, in which case an email will be sent following conversation/decision to record the necessary information. Project team members will be provided each other's numbers and are invited to contact each other with this method. All project interviewees will be provided with the project managers number but will be encouraged to use email. *(Interested Parties: 1, 2, 3, 4, 5,10)*
3. Zoom – This method will be used among project team for conversations that are pertinent to the project and/or when decisions/changes need to be discussed and decided on. Zoom will also be used to conduct interviews as it is convenient for both the interviewer/interviewee and requires no additional equipment to record. *(Interested Parties: 1, 2, 3, 4, 5)*
4. In-Person – As this project was planned during Covid and uncertainty regarding regulations is still relevant, in-person meetings are not an expectation of this project unless a situation arises that requires this type of communication. In that circumstance, all current Covid regulations will be adhered to.

Product Service Promotion Plan

This project, 'Exploring the Potential of Upcycling Craft BSG in Winnipeg, MB', is ultimately intended to conduct the necessary research to evaluate the feasibility of a particular framework for upcycling BSG in Winnipeg. The feasibility of a framework is dependent on a variety of factors but is centered around rendering the local brewing and food industries more sustainable. As such, a 'Product Service Promotion Plan' is intended to promote sustainability initiatives of the involved local businesses to generate (1) a demand for the upcycled food products, and (2) support (financial and brand loyalty) for implementation of upcycling framework. Success of this project will be obtained with the highest quality of research and a feasible framework for all involved parties. Following is an outline of the promotion plan to obtain the required support and demand needed to drive research outcomes forward.

Overall Goal of the Project

The overall goal of this project is to 'Explore the Potential of Upcycling Craft BSG in Winnipeg, MB' in an effort to make local food system changes to support global climate change initiatives.

Intended Audience(s)

- Local Craft Breweries
- Local Food Processors
- Other Local Businesses looking to reduce their Environmental Impacts
- MB Government
- Funding Organizations/Opportunities/Investors
- General Public

Key Messages of the Promotion Plan

1. The process of making a highly sought-after beverage yields _____lbs of high-value "waste" products every year, while huge amounts of energy/resources are being used to produce new products that are largely negatively impacting our planet because we haven't taken time/thought of how to implement circular economy concepts in production cycles.
2. The production of new products uses an increasing number of resources that contribute to the escalating levels of "garbage" polluting the environment, when "waste" products have plenty of life and potential left.
3. Brewers spent grain has plenty of life and too high value to simply become cattle feed after brewing.
4. Give new meaning to "Spent Grain Waste" by using it as an environmentally friendly input into other food products for human consumption that ensure a sustainable future.
5. Local Businesses care about the future our City and Citizens.

Suggested Communication Vehicles

Following are the suggested communication vehicles required for a successful promotion plan. Descriptions and reasons for choice can be found in the full document in Appendix E.

1. Social Media
2. Radio Segment
3. Manitoba Brewers Association
4. Upcycled Food Association
5. Canadian Association for Food Studies

Risk Management

As no project comes without risks, an in-depth risk analysis has been created for this project with the full document provided as Appendix F. The Risk Management Plan starts with an extensive list of possible risks associated with this project resulting from multiple comprehensive discussions with the advisor and partner brewery concerning deliverables, schedules, contracted/hired work, affected parties and the data required. The identified risks are listed in a 'Probability and Impact Matrix' where risk probability and impact are carefully scored on the included scale to identify the most significant risks to the project. Those with the highest probability of occurrence are ordered by significance in a Risk Register, which is used to monitor risks throughout the project by the project manager. All risks with higher probability in this project have an associated response plan as described below and provided in the respective appendix.

Risk Response Plan

The following table is the Risk Response Plan which addresses the top scoring risks from the Probability and Impact Matrix and the Risk Register. The Risk Response Plan addresses the response strategy (Escalate, Accept, Avoid, Transfer, Mitigate) and the details of associated strategy.

Table A.1. Risk response plan.

Risk	Response Strategy	Response Details
Schedule – Focus Group participants forget about meeting and have RSVP's yes but don't show up.	Avoid	To avoid this risk, a question during the interview will address their willingness and interest to participate in the focus group with the incentive of a networking event, food, drinks, and their say in the final framework. Following the interview, a confirmation email with a calendar invite will be sent out with meeting details.
	Avoid	To avoid this risk closer to the meeting date, a reminder email will be sent out a month before the event with an RSVP request. RSVP's will be due a minimum of 7 days prior to the event for accurate planning.
	Mitigate	To mitigate the effects of this risk upon occurrence, research on other frameworks will be completed ahead of time to address the pro's and con's of their models to provide personal feedback. In this case the framework would be presented to members of the NRI and Food Science departments for academic review. In this case, all interviewees will be emailed as a group (with permission) to make people interested in upcycling known to each other.
Personnel – Focus group participants cannot provide valuable feedback related to framework due to: lack of understanding of any/multiple components, lack of interest, no ideas for improvement, etc.	Mitigate	To mitigate this problem, a copy of the framework with a brief description of components/workings can be sent out to confirmed Focus Group participants a week prior to the meeting to ensure they have had a chance to review it and understand/think about the process. This will allow time for idea generation prior to the meeting so they can confidently share well thought-out ideas.

	Mitigate	Ideas and examples from BSG upcycling frameworks from other cities/countries will be researched before the meeting. The project manager will come prepared with a list of secondary or tertiary ideas for the framework to present as a conversation starter or to generate visions of improvements.
Personnel – Less than 50% of Canadian breweries complete online survey due to missed email or lack of interest, leading data to not be representative of Canada.	Avoid	To avoid this risk, a reminder email will be sent to breweries that have not completed the survey within the first week. A secondary reminder will be sent after 10 days, and a third survey reminder will be sent on the 13th day to decrease the possibility that the email was just missed.
	Accept	As the survey is meant to understand the general effort to upcycle BSG in Canada and is not vital to the framework formation for Winnipeg, if there is still low response after the email reminders we will have to accept that outcome and write data findings on the population we were able to generate responses from.
Schedule – The products with BSG incorporated in literature are not manufactured in Manitoba leading to a small group of potential users.	Avoid	As the full range of products that can successfully incorporate BSG are not known at this time, if local companies are not producing those products, we will focus on international companies that operate in MB to ensure the supply chain is kept local.
	Avoid	Potential users of BSG will be made known through literature review, as well as through snowball sampling where people already identified for interviews can recommend someone else they think might be interested in the research. This method intends to avoid the risk by ensuring that interviewees are not only identified by the project team but by industry experts as well.
	Mitigate	If the risk cannot be avoided, the mitigation strategy will be to concentrate on one industry we identify who can successfully incorporate BSG into their products. As BSG can be used as a flour, this could mean concentrating on the local bakeries.
Personnel – The potential food processors that can use BSG as an ingredient are not obviously listed on online directories and might therefore be missed for research activities.	Avoid	Potential users of BSG will be made known through literature review, as well as through snowball sampling where people already identified for interviews can recommend someone else they think might be interested in the research. This method intends to avoid the risk by ensuring that interviewees are not only identified by the project team but by industry experts as well.
	Mitigate	As a secondary effort to reduce the impacts of this risk, several search platforms (Ex. Google, LinkedIn, Literature review, NGO's, etc.) will be used to identify food processors in Manitoba

Quality Management

The following Quality Management Plan is the result of thorough discussions in multiple meetings with the advisor and partner brewery in relation to how quality will be defined and measured throughout the project. All tasks and deliverables have been through a comprehensive analysis to determine which ones introduce risks. Although there are no outside standards or regulations pertaining specifically to the research, there are many regulations that need to be adhered to in the event of implementation that need to be kept in mind to ensure feasibility and quality standards are met throughout the entire project. This section lists the most significant risks to the projects quality and lists the measures we have put in place to guarantee that project standards are met.

Quality Standards, Regulations and Commitments:

Following are the 'Quality Standards, Regulations and Commitments' associated with the project of *Exploring the Potential of Upcycling Craft BSG in Winnipeg, MB* as it pertains to the research and deliverables:

1. Consent – All individuals participating in interviews must complete a consent form before any data is collected to ensure they have agreed to participate and are not being included against their will.
   https://umanitoba.ca/research/orec/ethics/guidelines.html
2. Confidentiality – All participants confidentiality must be adhered to at all points throughout the project to ensure their personal information is used only in the ways they have agreed to, as well as to protect their identities/personal information from people whom they do not wish to share this with.
   https://umanitoba.ca/research/orec/ethics/guidelines.html
3. Food Safety and Handling – Adherence with food safety and food handling standards from the Canadian Food Inspection Agency, Health Canada, and the Public Health Agency of Canada must be considered in designing the proposed framework to ensure seamless execution with future implementation. This is also important to consider in avoiding any potential legal implications pertaining to the quality of the proposed product (brewers spent grain) as an ingredient.
   https://inspection.canada.ca/eng/1297964599443/1297965645317
   https://www.canada.ca/en/health-canada.html
   https://www.canada.ca/en/public-health.html
4. Food Processing and Packaging Standards – Packaging materials are regulated under the Food and Drugs Act (Division 23), which states that packaging materials cannot contain materials that are harmful to humans and must be considered in any processing and packaging of materials if outlined in the proposed framework.
   https://laws-lois.justice.gc.ca/eng/regulations/c.r.c.,_c._870/index.html
5. Food Additives – If a new product results from this research, food additives must meet regulations under the Food and Drug Regulations and associated Marketing Authorizations (MA's). "Food additives, including most food colours, must meet the specifications of either the Food Chemicals Codex (FCC) or of the Joint FAO/WHO Expert Committee on Food Additives (JECFA)".
   https://www.canada.ca/en/health-canada/services/food-nutrition/food-safety/food-additives.html

Most Significant Risks to Quality:

The following list outlines various project requirements that pose the most significant risks to the quality and success of the project:

1. Canadian Craft Brewery survey data must be representative and therefore requires a response rate of at least 50% of all survey recipients.
2. Initial contact with brewery and food processing individuals must be professional and provide enough information to peak interest/confirmation of participating in research efforts.
3. Data acquired from surveys must be specific and general enough to allow for quantitative and qualitative analysis and should provide enough information that interviews enhance data but are not vital if participants decide not to participate after survey.
4. Interview questions should be more concise than survey questions to allow for a more in-depth understanding of the specific case of BSG in Winnipeg that will allow for framework creation.
5. The proposed framework must be specific to Winnipeg, MB including (but not limited to) transportation options, pricing, equipment, schedules, personnel, etc. to ensure future implementation can proceed as outlined and will not require significant changes apart from factors out of our control.
6. As an incentive for upcycling is to contribute to a reduction of global GHG emissions, the proposed framework should have reduced environmental impacts (GHG emissions, land use, food waste, plant-based diets, etc.) compared with conventional waste streams.
7. Focus group must provide valuable feedback to ensure final framework is realistic for them.

Quality Management Procedures:

1. Canadian Craft Brewery survey data must be representative and therefore requires a response rate of at least 50% of all survey recipients.
    a. Survey's will be sent to all registered and operating Canadian craft breweries as of send date
    b. Survey will outline research efforts and benefits of participation
    c. Introduction will include my contact information in case of questions or wanting extra details
    d. Survey will be less than 30 minutes to complete to ensure it's not a big commitment
    e. Survey will allow 2 weeks for completion, if it's not completed within 5 days a reminder will be sent, as well as a reminder after 8 days and a final 1 day reminder
2. Initial contact with brewery and food processing individuals must be professional and provide enough information to peak interest/confirmation of participating in research efforts.
    a. Winnipeg craft brewers will be informed of the exact research objectives as a professional 'elevator pitch' will be prepared and presented to them
    b. Literature review of potential human food products made with BSG will be done prior to selecting potential food processing interviewees
    c. Food processors with potential use for BSG will be requested from other food processors and brewers to allow for a snowball style participant recruitment, as well as to ensure all potential users in MB have the opportunity to participate
    d. They will be contacted personally to ensure they recognize myself and the project
    e. Benefits of the research and participation will be explained thoroughly
    f. All breweries that participate in interviews will receive mention (with their permission) in the final report and analysis as a *Thank You* for participating
    g. Interviews will be a limit of 1 hour and will be done over zoom for their convenience
    h. Appreciation for their time and effort will be expressed
    i. An informational PDF document will be created to address potential questions and highlights of research for them to review at their convenience
    j. My direct contact information will be provided to them for convenient communication

3. Data acquired from surveys must be specific and general enough to allow for quantitative and qualitative analysis and should provide enough information that interviews enhance data but are not vital if participants decide not to participate after survey.
    a. Surveys will contain closed- and open-ended questions to address all research needs
    b. Survey questions will be prepared by the project manager, project partner, and project advisor to ensure required data is obtained and questions are appropriate for research purpose
    c. All research objectives will be addressed in the survey to ensure a broad understanding of the Canadian situation of BSG upcycling is understood
4. Interview questions should be more concise than survey questions to allow for a more in-depth understanding of the specific case of BSG in Winnipeg that will allow for framework creation.
    a. All survey data will be analyzed before starting interviews to ensure that any important/relevant information brought up in the surveys can be addressed during the interviews
    b. Interviews will contain closed- and open-ended questions to address all research needs
    c. Interview questions will be prepared by the project manager, project partner, and project advisor to ensure required data is obtained and questions are appropriate for research purpose
    d. All research objectives will be addressed in the interview in more depth to ensure a detailed understanding of the Winnipeg BSG situation is understood
    e. Interview questions will be practiced on an individual (not involved in the project) to ensure that I'm confident at the execution and can clarify responses for accurate data
    f. All interview participants will receive confidentiality forms to sign prior to interviews to ensure their information and answers are protected and remain private
5. The proposed framework must be specific to Winnipeg, MB including (but not limited to) transportation options, pricing, equipment, schedules, personnel, etc. to ensure future implementation can proceed as outlined and will not require significant changes apart from factors out of our control.
    a. Barriers identified by both brewers and food processors will be thoroughly analyzed and understood prior to concluding interviews to ensure they are thoroughly addressed in the proposed upcycling framework
    b. BSG upcycling frameworks from other cities/countries will be assessed to address the potential for success of components in Winnipeg, MB
    c. All data used in the framework will be thoroughly researched and/or have precise price quotes to ensure that it is as specific and 'ready-to-go' as possible
    d. The framework will be made in such a way that it is beneficial to both the brewers and food processors to encourage future implementation and participation
    e. All quotes and equipment will be obtained from MB companies to ensure that supply chains are local and that we remain true to our objectives of reducing environmental impacts
6. As an incentive for upcycling is to contribute to a reduction of global GHG emissions, the proposed framework should have reduced environmental impacts (GHG emissions, land use, food waste, plant-based diets, etc.) compared with conventional waste streams.
    a. The waste routes of BSG will be addressed in surveys and interviews to ensure that an accurate estimate of total GHG emissions of 'disposal' can be made
    b. All emissions of upcycling framework will be analyzed as specific as possible to ensure that an accurate estimate can be made
    c. All GHG emission values and conversion values will be researched in peer-reviewed journals or with recognized global organizations to ensure precision in values
7. Focus group must provide valuable feedback to ensure final framework is realistic for them.
    a. The focus group date will be planned early in the project execution to ensure that all interview participants are notified of the meeting date at the end of their interview
    b. An initial confirmation email of meeting date will be sent along with a *Thank You* to all interview participants as a written confirmation

c. Reminder of the meeting date will be emailed 4 weeks prior to meeting date
d. Confirmation of meeting attendance will be requested from all interviewees, and will be accepted up to 1 week prior to meeting date
e. Food and beverages will be provided at the meeting to incentivize participants and to create a social atmosphere to facilitate discussion
f. Focus group questions will be prepared by the project manager, project partner, and project advisor to ensure required data is obtained and questions are appropriate for research purpose
g. Focus group will begin with a presentation of research findings to provide justification for the proposed framework, as well as outline what is available and possible with BSG and specifically in Winnipeg, MB
h. Focus group feedback period will be limited to not exhaust participants or allow for a loss of momentum in meeting energy
i. Focus group will allow for participant networking as this is important to making industry connections and recognizing who has elevated interest in the research outcomes

Roles and Responsibilities:

The overall quality standards are the role of the project manager in ensuring complete success of the project. Quality must be executed carefully and monitored throughout the progression of the project. Following is a list of responsibilities held by the project manager to ensure quality of all project activities:

1. All research data will be thoroughly analyzed and presented to the project partner and project advisor for approval before the final report is written to ensure accuracy and relevance
2. All research questions, including survey and interview, will be piloted with an individual outside of the project prior to any data collection to ensure quality data is obtained.
3. Constant and open communication will be held with the project partner and advisor to ensure all activities are completed as outlined before continuing.
4. If there are 'breaks' between activities, required research for next steps will be conducted in order to get ahead of schedule and allow ample time for data analysis and report writing.
5. Project schedule will be followed closely and reviewed daily to ensure all activities are being completed on time (or early) so that future activities are not rushed.
6. All online accounts will be acquired and ready to use in advance of needing them to allow time if there are issues so that execution is seamless when it's needed.

Attendance and Meeting Date:

Below is a list of meetings involving comprehensive discussions pertaining to project quality, quality risks, and risk management. Meeting dates and attendees are documented upon approval of the Quality Management Plan from all parties.

Meeting 1 - Project Manager, Advisor and Partner on *March 9, 2022*

Budget Summary

The table below lists the most accurate estimates of associated project costs, grouped by the type of activity/expense. The table shows three cost estimates for each group resulting in a low (yellow highlight), likely (green highlight), and high (red highlight) cost estimates. The likely costs are those calculated from the most likely progression of the project, low costs are those associated with below-average costs (Ex. Rental Equipment changes, Gas price changes, etc.), and high costs are estimated if interview and focus group budgets are higher than expected but are deemed vital to project quality. Likely interview costs are calculated in the case that owners are all reached by email and interviews are conducted over Zoom. Low costs will be very similar to the likely costs, but high costs are calculated in the event that some owners (breweries and food processors) are needing to be contacted in person and prefer an in-person interview. Although the in-person calculations have a minimal potential of occurrence, they will honoured but not offered. Unforeseen expenses have been worked into the high cost estimates and may result from additional resource needs, conducting interviews, or price changes in equipment between now and purchase. Project costs are supported in part by funding from the University of Manitoba Graduate Fellowship (UMGF). A detailed budget allocation in the "likely" situation is provided as Appendix G.

Resource and Cost Estimates

Table A.2. Resource and cost estimates.

Activity	Associated Costs	Total (Low)	Total (Likely)	Total (High)
Literature Review	Online Research – UofM Libraries (Background Information Report)	$0.00	$0.00	$0.00
Website Review	Online Research – Public Websites	$0.00	$0.00	$0.00
Online Surveys	Internet Access – Public Websites	$0.00	$0.00	$0.00
	Survey Monkey Account	$408.00	$408.00	$408.00
	Data Analysis	$0.00	$0.00	$0.00
Interviews	Internet & Phone	$0.00	$0.00	$0.00
	Calendly Account	$57.30	$76.40	$114.60
	Zoom Account	$108.00	$108.00	$108.00
	Data Analysis (NVivo)	$0.00	$0.00	$121.98
	Gas	$0.00	$0.00	$300.00
Final Report - Written	Internet & Phone	$0.00	$0.00	$0.00
Networking Meeting	Infographic – Adobe Programs	$209.97	$279.96	$419.94
	Printed Materials (Staples)			
	Brochures ((25 = $22.49) x 2)	$44.98	$44.98	$44.98
	Report (3 pages x $1.47 x 50)	$73.50	$73.50	$73.50
	Presentation (Laptop, Power Point, Word)	$0.00	$0.00	$0.00
	Projector Rental (RealTime)	$225.00	$225.00	$275.00
	Meeting Space/Location	*Unknown*	*Unknown*	*Unknown*
	Beer (2/person x $5.00 x 50 ppl)	$300.00	$500.00	$600.00
	Snacks	$300.00	$500.00	$600.00
	Total Preliminary Cost Estimate:	$1,726.75 *+ 2 Unknown*	$2,215.84 *+ 2 Unknown*	$3,066.00 *+ 2 Unknown*

Cost Estimate Descriptions

Literature Review - $0.00

The materials required (laptop and internet connection) are the personal resources of the project manager who has access to the UofM Libraries for research purposes. There is no associated project costs to carrying out the background research.

Website Review - $0.00

The website review is an analysis of publicly available data posted by breweries on their own websites, which are available to view at no cost. Business names and emails can also be accessed online at no cost, thus the review requires no project funding to conduct.

Online Surveys - $408.00

As Craft Brewery contact information is acquired during the Website Review, the only associated cost with the online surveys is the SurveyMonkey account that will be used to create an accessible and convenient survey to craft breweries across Canada.

Interviews - $184.40

Interviews will be conducted over zoom thus requiring an upgrade from the student account currently held by the project manager. To increase scheduling convenience, a Calendly account will be obtained and set up with available interview slots to decrease/avoid excessive email communication for scheduling. If an individual insists on an in-person interview, additional costs will be associated. Data analysis will be partially done with the university NVivo account, but this may require being purchased in the rare event it is not available when needed.

Final Report Writing - $0.00

The final report requires resources (Computer, Word, Excel, UMLibraries, Internet) held by the project manager and therefore does not require project funds to execute.

Networking Meeting - $1,623.44 + Unknown Cost

The final focus group will double as a networking event which makes it essential to be done in person to facilitate participant interaction and conversation. This meeting is essential to the success of the project and is valued as such. An event rental with the partner brewery is TBD, at which time an updated budget may be provided and food/beverage costs adjusted as such. Participants will engage in a focus group session during which they'll be provided food and drinks to encourage discussion and ease tension of the 'research environment'.

Change Management

The following section is the Change Management Plan for 'Exploring the Potential of Upcycling Craft Brewer BSG in Winnipeg, MB', which provides a predictable response should any project changes arise. It is essential that the project progresses in a timely manner despite changes, therefore the project has been thoroughly evaluated to identify the most likely tasks/activities that present opportunities to change. Changes may arise from uncontrollable circumstances, external parties, or internal parties including the Project Manager or partner brewery.

Change Management Plan

The highest project components that risk significant change in the project are as follows:

1. The most significant risks identified in the Risk Management Plan.
2. Risks to the quality of the project as described in the Quality Management Plan.
3. Initial surveys are not completed within the suggested time frame. (2 weeks)
4. Individuals scheduled for interviews cancel close to the interview date.
5. Craft Brewery spent grain supply is not sufficient for Manitoba food processors.
6. Food processors are not interested in research and do not participate.
7. Participating parties cannot attend the framework meeting to provide feedback.

How the changes will be managed if they arise:

1. The most significant risks identified in the Risk Management Plan.
    a. If the identified risks arise, the risk response plan will be consulted. No acceptance discussion will be held as these changes will happen regardless.
    b. Identified responses will be evaluated in terms of the current situation.
    c. Progression with the project will be determined by the Project Manager and the partner brewery, and future timelines will be evaluated to determine if any future changed will result from the current change.
2. Risks to the quality of the project as described in the Quality Management Plan.
    a. Quality is essential to the completion of this project and risks to quality have been identified in the Quality Management plan. They have been thoroughly analyzed and addressed so quality is not compromised.
    b. No discussion will be held in regard to accepting the change as any changes needing to ensure quality will be made.
    c. Upon suggestions of quality risk occurrence, the Quality Management plan will be consulted, and suggested progression will be analyzed and decided upon by the Project Manager and partner brewery according to the situation.
3. Project activities resulting in changes to project objectives and deliverables.
    a. Project objectives and deliverables are the primary basis of project approval and changes to what is produced may alter the project team's the desire for project.
    b. Changes will be thoroughly assessed and presented to team members (Marika, Iain, Brian) in a meeting to discuss/approve updated satisfactory objectives and deliverables.
    c. Approved changes will be made in the Project Charter and a new copy will be distributed to Project Team.
    d. Changes significantly affecting project schedule: see bullet 4.
    e. Changes requiring additional approval from the ethics committee: see bullet 5.
4. Project changes resulting in project end date moving 1+ month from original end date.
    a. Changes that affect the project end date will push into 2023, thus requiring additional time from all project members which was not originally agreed upon as well as pushes back student graduation date.

    b. Significant schedule changes will be thoroughly analyzed for possible alternatives to end on time. If original project end is no longer possible, schedule changes will be presented to project team with an updated completion plan.
    c. Approved schedule changes will be reflected in the active schedule document, as well as in the Project Charter which will be redistributed to project team.
5. Project activities resulting in a need for additional ethics approvals.
    a. Changes that require additional ethics approval may result in a significant change in project schedule due to application review time. Schedule changes: see bullet 4.
    b. Activities requiring additional approval will be meticulously assessed and presented to project team in a review/approval meeting.
    c. Accepted changes will be submitted with supporting documents for ethics approval.
    d. Upon approval, project schedule will be reviewed according to bullet 4.

If the change is accepted and proceeds:

1. All proposed/unexpected changes to the project must be reviewed by the Project Manager, advisor and the partner brewery before any decision is made towards denying, accepting, or adapting to the change.
2. The accepted change will be documented in the appropriate place, including the project charter with the associated meeting documented and approved as signed.
3. The project schedule will be reviewed in order to analyze any other changes that may occur from the current accepted change.
4. The affected individuals will be made aware of the change by phone if they are part of the task execution, and an email to all project parties will be contacted by email to inform the change and reasons.

Change Documentation and Meetings:

1. All significant changes to the project (those affecting schedule, budget, or personnel) will be documented in the Project Charter with the meeting date and approval signatures from both the Project Manager and Partner Brewery.
2. Any other documents included in this project plan that are affected by the change will be updated to reflect approved changes.
3. All minor changes (those not affecting schedule, budget, or personnel) will be communicated by phone or email to affected individuals if it's determined necessary.
4. A project Change Log (Active Document) will be created specifically for the purpose of this project to document all changes (significant and minor) and will be accessible by the Project Manager, advisor and the partner brewery.

Appendices

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Appendix A: Background Information Report

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2021 Global Population = 7.87 Billion (1)

Global Environmental Issues Defining the Issue of Food Waste

Despite being in the 21st century with all the latest technology and all the knowledge we have, "more than 820 million people have insufficient food and many more consume low-quality diets that cause micronutrient deficiencies and contribute to a substantial rise in the incidence of diet-related obesity and diet-related non-communicable diseases, including coronary heart disease, stroke and diabetes" (2 p. 447). With projections of a growing global population, an estimated 9.7 billion by 2050 (3), questions of resource and food availability come to mind. Where will all these people live? Will there be enough resources to support healthy lifestyles and high standards of living? Can we even feed all these people?

The overall global situation, represented in *Figure 1*, starts with 40% (2 p. 468) of land mass producing 100% of humans' food. Of the total food production, approximately 30% is wasted (4 p. 4), leaving 100% of the worlds 7.87 billion people living off 70% of the food harvested and manufactured. Approximately 10.42% of the earth's population (820 million people) (2 p. 447) are malnourished, leaving 89.58% of people full on 70% of the food produced. Simply put, each 10% of global food production currently feeds 1.007 billion people adequately. Therefore, the 30% of food that currently goes to waste has the potential of nourishing 3.02 billion people. That 30% of "waste" could not only feed those who are currently alive and malnourished but could also nourish the 2050 projected population if we can find ways to rethink "waste" and improve our food systems at all stages. While it might be unrealistic to expect that every single ounce of food produced will make it to someone's stomach, the potential of this colossal waste is certainly worth some effort.

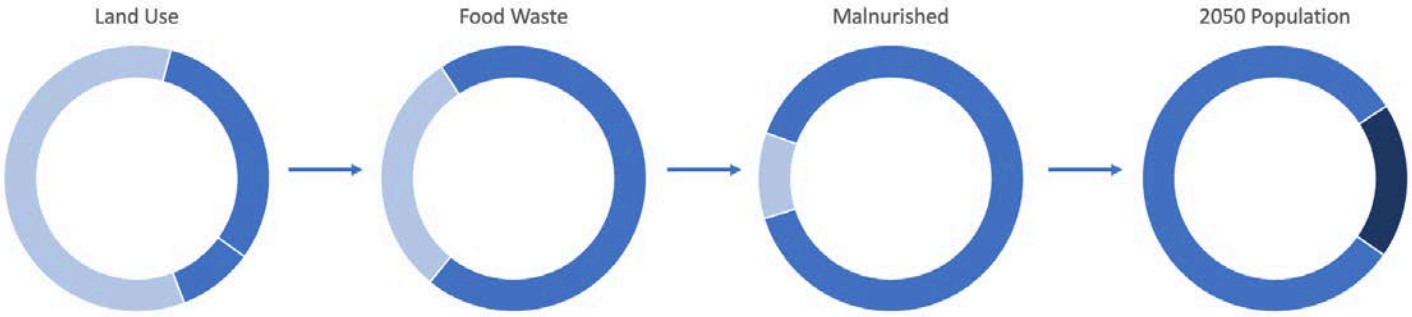

Figure A.A.1. Depiction of the projected global population of 2050, highlighting the current number of citizens who are malnourished off modern agricultural production and food waste percentage. Land use is shown as 40% agricultural (23% grazing (lightest blue) and 77% croplands (light blue), while 60% is non-agricultural (dark blue) (2 p. 468). Food waste is shown as approximately 30% of global production wasted (light blue) with 70% consumed (dark blue) (4 p. 4). Malnourishment is shown as 820 million people malnourished globally (light blue), while 7.05 billion are not (dark blue) (2 p. 447). The 2050 global population is shown as a current 7.87 billion (dark blue), with a projected 9.7 billion in 2050 (darkest blue) (3).

A growing human population has increased resource demands globally. Human enterprises such as agricultural and food production, industry, energy production, urbanization, recreation, and international commerce are forms of consumption that have large effects on Earth Systems. "These enterprises and other are transforming Earth's land surface, altering its biogeochemical and hydrologic cycles, and adding and deleting species, destroying and modifying ecosystems, and ultimately changing climate and biological diversity" (5 p. 83). Various proximate and underlying causes lead to agricultural expansion, which then leads to increased tropical deforestation, including demographic, economic, technological, political and institutional, and cultural and sociopolitical factors (6). Converting forests and other ecosystems to croplands has been a global driver of ecosystem

function and services loss over the past 40-50 years as it happened at a rate of 0.8% yr^{-1} (7). While food is essential to our survival, it should not simultaneously threaten it.

Planetary boundaries are the best-known estimates for humanity to operate within safe limits in respect to the functioning of Earth Systems (8 p. 33). In terms of food production, the planetary boundary is proposed as "no more than 15% of the global ice-free land surface should be converted to cropland" (8 p. 48). Planetary boundaries are measures in the Anthropocene against the Holocene which started approximately 10,000 years ago. The Holocene was a stable period that allowed human agricultural activities and other environmental investments to occur, which we're now reliant on. Until recently, no clear global scale Earth System changes have been caused by human activities. "Since the industrial revolution (the advent of the Anthropocene), humans are effectively pushing the planet outside the Holocene range of variability for many key Earth System processes" (8 p. 33) (5 p. 81).

"For Humanity to stay within this boundary, cropland should be allocated to the most productive areas, and processes that lead to the loss of productive land, such as land degradation, loss of irrigation water, and competition with land uses such as urban development or biofuel production, should be controlled. Demand-side processes may also need to be managed; these include diet, per capita food consumption, population size, and wastage in the food distribution chain. Agricultural systems that better mimic natural processes (e.g., complex agroecosystems) could also allow an extension of this boundary" (8 p. 48).

Currently, of the earth's land surface, 51% is considered as intact ecosystems, while 40% of ice-free landmass is used as cropland and grazing lands; 23% of which is for grazing. The amount of land used for food production has remained stable since the mid-20th century but was accomplished with a reduction of production in temperate regions and increase in "biodiversity-rich tropics", thus contributing to biodiversity loss (2 p. 468). It's essential in achieving the Paris Agreement target of limiting global warming to 1.5°C (9) that global decarbonization involves food systems that "provide negative emissions" and makes "protecting carbon sinks in natural ecosystems" a priority (2 p. 451). Global sustainability is now highly considered in business operations. In terms of food production and considering ways of operating more sustainably, grazing lands offer opportunity for reforestation to sequester carbon (2 p. 469) to aid in reducing the environmental effects of producing food. This consideration is supported by dietary research on plant-based diets, as well as the increasing sophistication of meat alternatives.

The United Nations' Paris Agreement is "a landmark" to global efforts in combating climate change as "for the first time, a binding agreement brings all nations into a common cause". This agreement uses the most up-to-date science to determine 5-year cycles of increasingly ambitious actions to limit global warming to 2°C, but preferably below 1.5°C. The Paris Agreement was signed by 196 parties in December 2015, went into effect in 2016, and country's plans for nationally determined contributions (NDC's) were due in 2020 (10). The agreement requires economic and social transformations in order to successfully meet targets, and therefore changes are required at every level of society including individual, community, city, provincial, national, global, and every layer in between. As this agreement is legally binding, it forces all industries to reconsider their operations, including all inputs, outputs and supply chains, and will hopefully lead each sector to a point where globally they are operating within planetary boundaries in time to meet the Paris Agreement target.

To further support sustainability initiatives, The United Nations also has a set of 17 Sustainable Development goals that are part of the 2030 Agenda for Sustainable Development that "provides a shared blueprint for peace and prosperity for people and the planet, now and into the future" (11). Sustainable Development Goal 12.3, of particular interest to this project, aims to "halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest" by 2030 (12). With an approximate rate of 30% food waste and loss (accounting for a global total of 28% cultivated land and 21% of freshwater use), many actions along the food supply chain are needed.

Food systems have the potential to be sustainable while simultaneously providing healthy diets to the worlds population. The healthy reference diet, proposed by the EAT-Lancet Commission on healthy diets from sustainable food systems, suggests all global populations eat a diet that "largely consists of vegetables, fruits, whole grains, legumes, nuts, and unsaturated oils, includes low to moderate amount of seafood and poultry, and includes no or a low quantity of red meat, processed meat, added sugar, refined grains, and starchy vegetables" (2 p. 447). Unfortunately, current systems are contributing to climate change while many people face food insecurities globally leading to diet-related diseases. Food production is a major contributor to "climate change, biodiversity loss, freshwater use, interference with the global nitrogen and phosphorous cycles, and land-system change" (2 p. 447). Food Systems as a whole "account for 29% of global anthropogenic greenhouse gas (GHG) emissions", with agricultural production contributing up to 86% of the total food systems contribution (13). Global comparisons of dietary patterns compared with the healthy reference diet are provided in *Figure 2*.

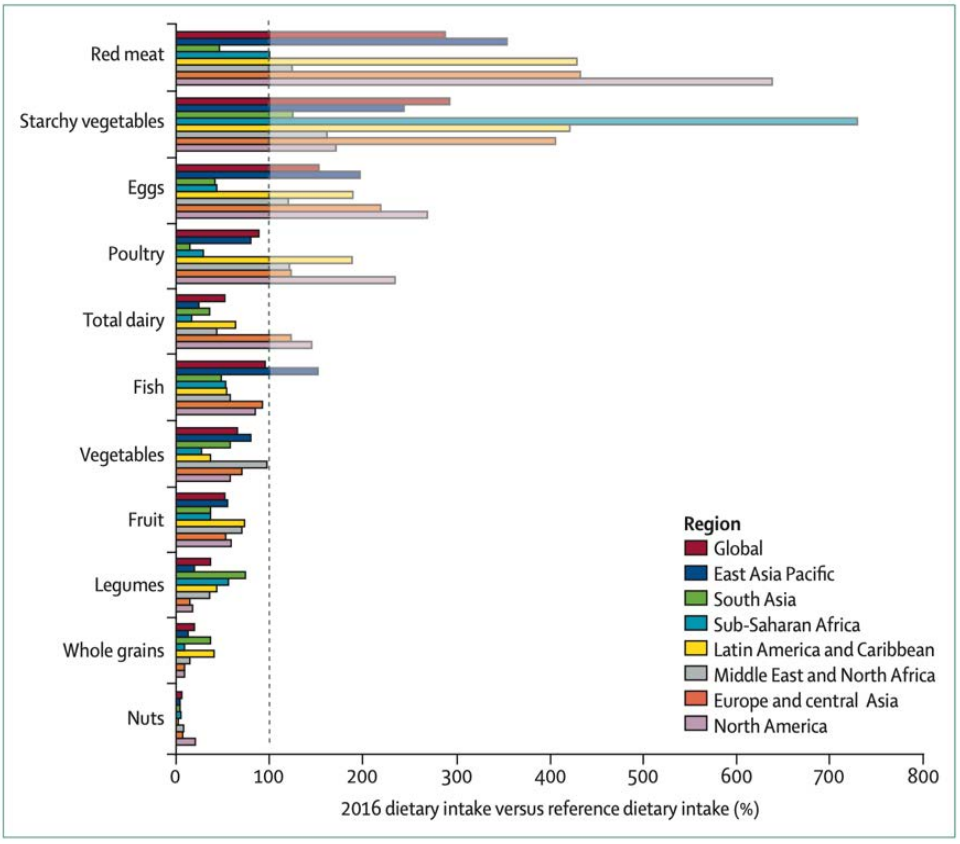

Figure A.A.2. Diet gap between dietary patterns in 2016 and reference diet intakes of food. Intakes are from 2016 and dotted line represents intakes in reference diet. Figure from: (2 p. 460)

While we are now aware that there's a diet that is both nutritious and sustainable, it's essential that we make systematic changes in the way's we operate as a society which can start with reducing "waste". The first step is to not consider "waste" as actual waste, and instead to see value in products that are used and/or finished what they were first intended to do.

"A circular economy is one that is restorative by design, and which aims to keep products, components and materials at their highest utility and value, at all times." (14)

This "starts from the assumption that the earth's 'natural capital', the resources which we depend on, are 'stocks' that need to be conserved, kept in use for as long as possible and reused, rather than being used up as needed and then discarded. This is necessary because the global market at present does not properly account for or price the environmental costs of the extraction of resources, their manufacture into goods, or for the environmental impact these goods have in use or after their eventual disposal" (15 p. 1). Circular economy involves planetary boundaries, servitization, cradle-to-cradle, sharing economy, closed loop and upcycling concepts (16). Circular economy has also been expanded from the traditional 3 R's of recycling to 10 R's of CE; refuse, reduce, re-sell/re-use, repair, re-furbish, re-manufacture, re-purpose/re-think, re-cycle, recover, and re-mine (17).

"When something is recycled (or 'downcycled'), it's broken down into something of lesser quality – a process that consumes energy. Upcycling adds value by transforming or reinventing an otherwise disposable item into something of higher quality" (18).

Upcycling, in terms of circular economy concepts, relates to rethinking what is generally referred to as waste and repurposing the material. As we're focusing on food systems, food upcycling refers specifically to repurposing food wastes based on the concept of using what you have. "Upcycled foods use ingredients that otherwise would not have gone to human consumption, are procured and produced using verifiable food chains, and have a positive impact on the environment." Food upcycling is based on capturing the value of "waste", increasing the value of upcycled products, reducing food waste, promoting sustainability by maximizing current land use without expansion, and decreases anthropogenic GHG emissions (19). Not only does this address Sustainable Development Goal 12.3, but re-imagining food "waste" could reduce need for agricultural expansion, thus operating within the recommended Planetary Boundary. Sustainability is a global responsibility that needs to start local to reach the level of change needed to achieve the Paris Agreement.

It's estimated that "20% (or 11 million tonnes) of all the food produced in Canada annually becomes avoidable food loss or waste – food that could have been eaten, but was instead landfilled, incinerated or managed as organic waste" (20 p. 1) (21). Although this is significantly lower than the global average of 30% (22), there is still much room for improvement. The Canadian food supply chain starts with production. Food is then transported, processed, packaged, and distributed to retail, restaurants and other food services, and finally to consumers at home. Each stage introduces opportunities for food loss and waste as shown in *Figure 3*, resulting in an increasing percentage of uneaten food along the supply chain. Every resource that went into growing and producing wasted food has also gone to waste, thus unnecessarily contributing to climate change.

Food losses are all the crop and livestock human-edible commodity quantities that, directly or indirectly, completely exit the post-harvest/ slaughter production/supply chain by being discarded, incinerated or otherwise, and do not re-enter in any other utilization (such as animal feed, industrial use, etc.), up to, and excluding, the retail level. Losses that occur during storage, transport and processing, also of imported quantities, are therefore all included. Losses include the commodity as a whole with its non-edible parts.

Food waste is defined as food and associated inedible parts removed from the human food supply chain in the following sectors: manufacturing of food products (under certain circumstances); food/grocery retail; food service; and households. "Removed from the human food supply chain" means one of the following end destinations: landfill, controlled combustion, sewer, litter/discards/ refuse, co/anaerobic digestion, compost / aerobic digestion, or land application. (22 p. 19)

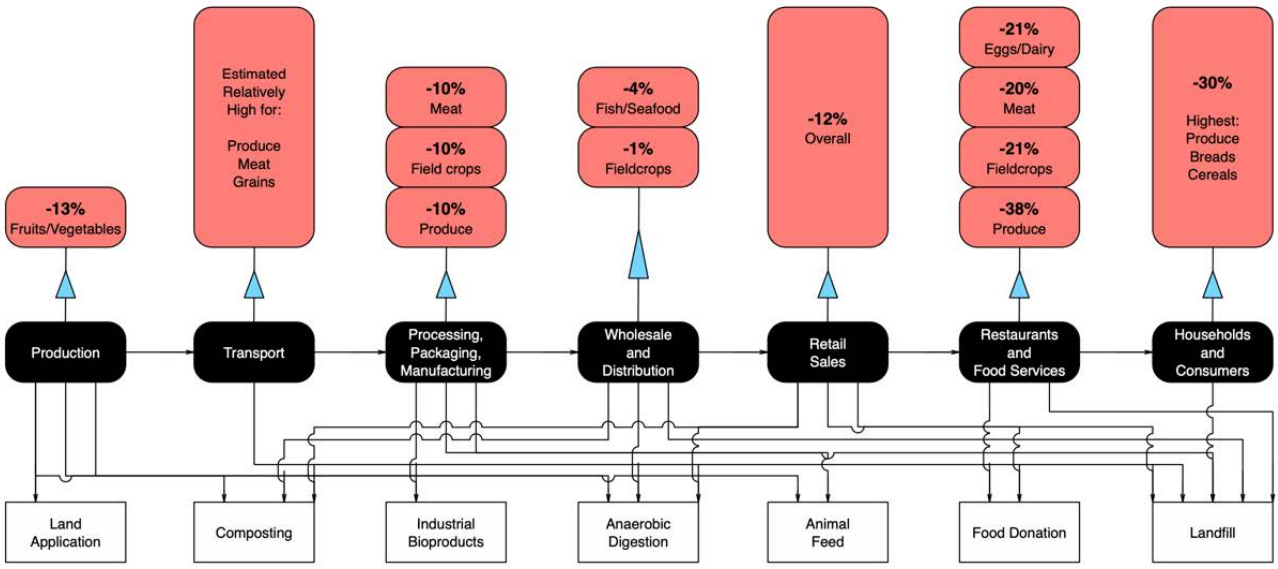

Figure A.A.3. Food loss and waste percentages (shown in red) along the Canadian food supply chain (shown in black) including final destinations of said food (shown in white). Summarized from: (20).

Brewing Beer – Inputs and Outputs

The beloved beverage of many, beer, is popular around the world. The brewing process can vary slightly between styles, but generally involves similar steps to ferment sugars from barley (and/or other grains), producing a carbonated alcoholic beverage. Beer production requires 4 main ingredients: water, malted barley, hops and yeast (23 p. 49). As depicted in *Figure 4*, other grains may be added in the mashing stage to derive distinctive flavours in the finished product. In the US, approximately half of the barley grown is used as livestock feed, while a quarter is typically used for brewing (24 p. 104). In 2020, 10.254 million tonnes of Barley were produced in Canada, with 53.7% used for Malting and 38.5% as general purpose (25). The barley used in brewing can be of three main varieties, 2-row (lower in protein), 4-row (higher protein, not common) or 6-row (higher protein, very common) (24 p. 104). In Canada, 2-rowed barley accounts for 96.68% of the total barley production with those most common for brewing are CDC Copeland, AAC Synergy, AC Metcalfe, and AAC Connect, all of which are 2-rowed (25).

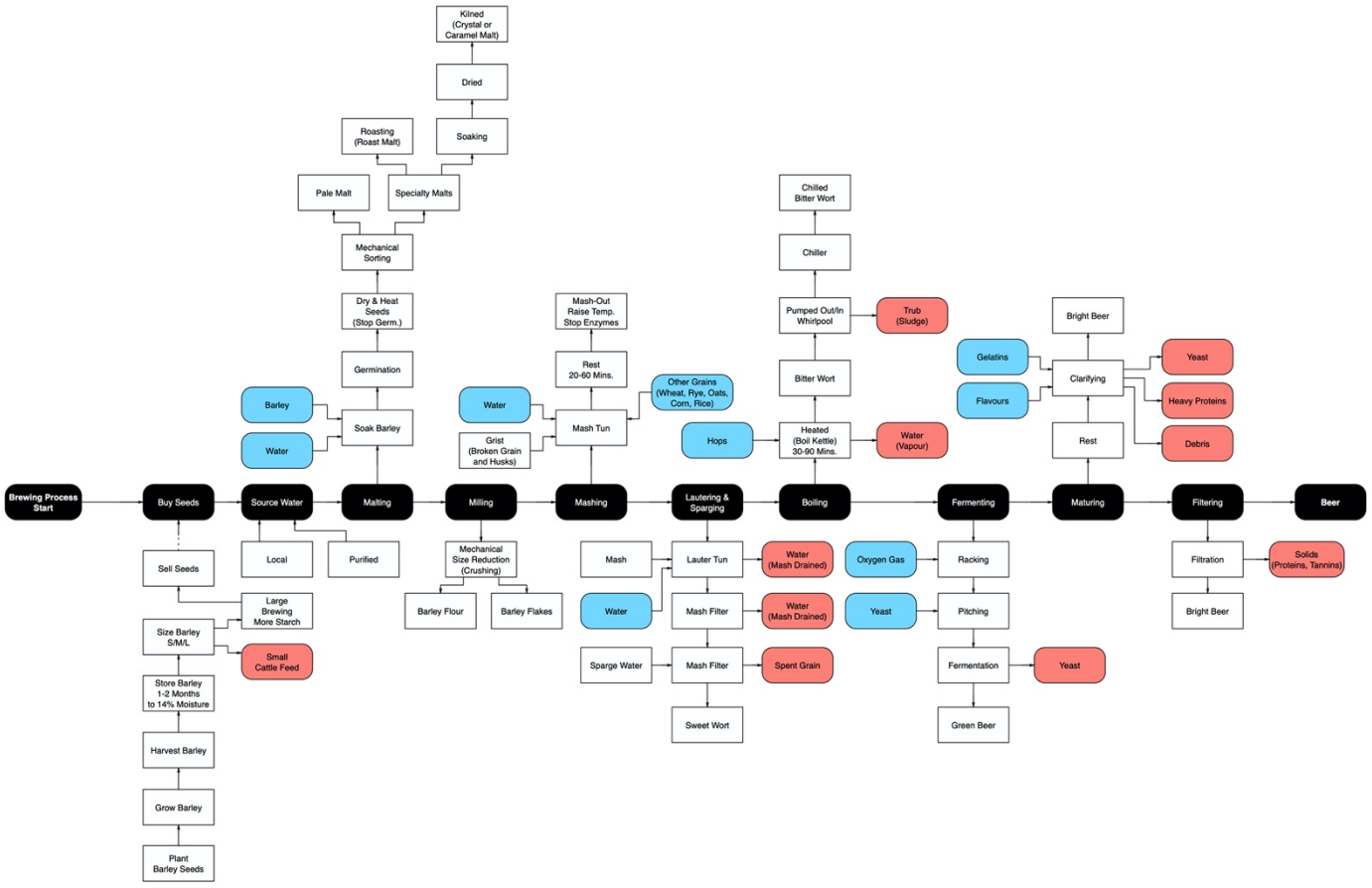

Figure A.A.4. Overview of barley beer brewing process, depicted by written processes (24 pp. 103-117). General steps in the brewing process are shown with black rounded rectangles, raw inputs are shown in blue rounded rectangles, and outputs/wastes are shown with red rounded rectangles for a complete overview.

Beer production yields several outputs including water from vapour and mash drainage, spent grain, yeast, trub (sludge) and other solids as shown in *Figure 4*. Brewers Spent Grain (BSG) accounts for approximately 85% of total by-products. Considering that approximately 20kg of wet BSG is produced for every 100L of beer (26.42 gallons), the brewing industry produces large quantities of "waste" products that have substantial upcycle potential. In 2020, the United States had 6,406 breweries producing a total of 179,960,476 barrels (31 gallons/barrel) (26). In the same year Canada had 1,210 Breweries, producing a total of 22,674,000 hL, equivalent to 598,983,711 gallons or 19,322,055 barrels (27). Manitoba is now home to 27 breweries, 20 of which are in Winnipeg, MB, which will serve as the project's demographic (28). Generally, on a dry weight basis brewers spent grain is approximately 50% dietary fiber, and up to 30% protein but is usually closer to 20% (29).

Water is an essential ingredient in beer and performs other functions in the brewing process including cleaning. The entire process requires 0.35-0.60m^3 of fresh water per hectoliter of sellable beer. 1 m^3 = 264.172 US gallons and 1 hl = 26.4172 US gallons, meaning that tested values indicate 3.70-4.40 gallons of fresh water are required for every 1 gallon of beer produced. In 2020, Molson Coors achieved a ratio of 3.23:1 of water to beer (30 p. 17), while literature values show quantities of 4.07-11.49 gallons of fresh water per gallon of beer (31 p. 622). Tested values as well as literature values and ranges are provided in Appendix A.1. As this suggests that approximately 3 gallons of wastewater are produced for every gallon of beer, water accounts for a large non-solid waste in all breweries, and because brewing is not a continuous process and is instead done in batches, wastewater from various operations fluctuate in soilage concentrations, pH values, and temperatures (31 p. 622). The makeup of brewery wastewater can include organic materials that act as depletion materials, nutrients, polluting materials, and interfering substances; as such, can have high biological and chemical oxygen demands (BOD, COD) (31 p. 623). Brewery waste water has a COD:BOD_5 of 1.5, while domestic waste water has a ratio of 2. This ratio indicates good degradability under aerobic conditions if the value is lower than 2 (31 p. 624).

Breweries have options on how to deal with wastewater, depending on the waste types and concentrations. Wastewater disposal can be done directly, meaning discharged directly into a natural water body after appropriate treatments, or indirectly, meaning discharge to a treatment facility (32 p. 667). A preliminary consideration is to combine or split wastewater sources. Multiple in-house measures can be taken to reduce water waste depending on the source. These include reducing water loss by preventative measures/equipment and by varying flow, a reduction of pollutant load by recovery processes (wastes and resources), in-house water treatment, and reductions due to improved processes (31 p. 631). In-house wastewater treatments can include pH neutralization before discharge, aerobic wastewater treatment with activated sludge, high-performance reactors, or aerated wastewater ponds, or anaerobically in 4 steps including: hydrolysis, acidogenesis, acetogenesis, and methanogenesis (31 pp. 632-638).

The beer industry is well known to implement large scale recycling initiatives with their packaging materials: cans and bottles. A small deposit on alcoholic beverage containers results in huge positive environmental impacts and increased recycling rates of beverage materials within the brewing industry. A 2019 Canadian report concluded that 97% of refillable beer bottles were recycled, while aluminum cans were lower at 73% (33 pp. 15, 27). Recycling materials reduces the amount of Greenhouse Gas (GHG) emissions from the production of new beverage containers and keeps materials out of landfills. The 2019 recycling rates "saved over 17 million GJ of energy and eliminated over a million metric tonnes of CO_2 equivalent emissions, equal to taking roughly 240,000 cars off the road" (33 p. 16). Manitoba boasts a return rate of 98.8% for refillable bottles and 79.5% for cans (33 p. 63). The beer industry has continuously shown high success rates of packaging materials recycling, but simultaneously produce large volumes of edible "waste". Concepts from circular economy (CE) can be expanded from material in this industry to food waste applications (called food upcycling) to increase the sustainability of the overall industry. Since water and packaging materials already have CE concepts in place, the importance in concentrating on BSG is that output volumes are large, therefore if upcycling demand can be generated, the significance of this output would have a larger positive impact than focusing on other process outputs.

Brewers Spent Grain Nutritional Profile

Brewers spent grain is "constituted by the husks that covered the original barley malt grain in mixture with part of the pericarp and seed coat layers that are obtained as residual solid material after the wort elaboration step" (34 p. 1264). Depending on the type of beer brewed and the desired flavours, other cereal grains may be added therefore changing the nutritional profile of spent grain but this analysis will consist of barley spent grain as it is the base ingredient and major component of brewers spent grain.

Although BSG is largely composed of fibre, proteins and minerals, spent grain can vary in chemical composition due to a number of factors including barley variety, harvesting time and conditions, malting and mashing techniques used by the craft brewery, and other cereals added to the brewing process. However, overall, brewers spent grain is rich in proteins, sugars, and minerals, and samples remain fairly consistent across breweries (34 p. 1264). Appendix A.2 of the background information report shows the variations among BSG in different countries that may arise from one, some or all the factors affecting composition.

Dietary fibre, a significant portion of BSG nutritional profile; is a carbohydrate. Carbohydrates are organic compounds with a ratio of one carbon, one oxygen and two hydrogen in a repeating chain, and consist of simple and complex carbohydrates, depending on chain length. Complex carbohydrates are long chains of monosaccharides, called polysaccharides and can be classified as starches or fibres (35 p. 265). Cellulose is a "complex carbohydrate, or polysaccharide, consisting of 3,000 or more glucose units." It is not digestible by humans (36) and is therefore a significant source of fibre in spent grain. Dietary fibre passes through the human digestive track until they are broken down by bacteria in the large intestine. Fibre provides health benefits including protection against cardiovascular disease, obesity, type 2 diabetes, and is generally important for digestive health (37 p. 291).

Hemicellulose is also a dietary fibre, thus a polysaccharide (37 p. 269). Hemicelluloses are classified into four different cell-wall classes; xylans, mannans, β-glucans, and xyloglucans. Xylans are diverse polysaccharides, part of the plant cell wall, and comprise of 20-50% of the Hemicellulose biomass depending on the type of plant (38 p. 5). Arabinoxylans (AX) are a major hemicellulose component of cell walls of the starchy endosperm and outer layers of cereals grains, and account for approximately 40% of BSG on a dry weight basis (29). Barley grains are high in β-glucans (5-11%), which have shown to have effects on the glycaemic, insulin and cholesterol responses to foods (39).

Lignin comprises a large portion of BSG but lacks an exact definition due to the diverse structural complexity and molecular complexity of this plant-derived biopolymer (40 p. 11). Lignins are found in plant cell walls, specifically in the middle lamella and the secondary wall (40 p. 13). As shown in Figure 5, cellulose, hemicellulose and lignin form microfibrils which mediate the structural stability of plant cell walls. Lignans are classified as natural products with many studied and reported biological activities including antiviral, anticancer, cancer prevention, anti-inflammatory, antimicrobial, antioxidant, immunosuppressive, hepatoprotective, and prevention against osteoporosis (40 p. 370). Properties such as antimicrobial, antifungal, antiviral, antioxidant, insecticidal, and antifeeding likely aid in plant defense, but exact functions are not clear (40 p. 383).

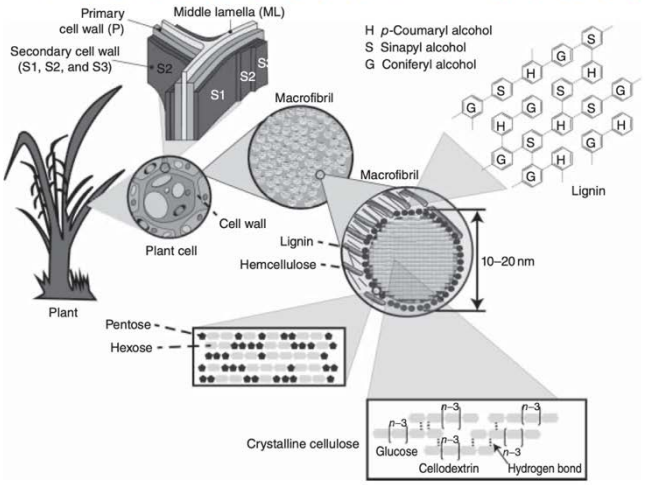

Figure A.A.5. Scheme of the microfibril and structure of the plant cell wall. (135)

Acetyl groups form a small portion of the major components of BSG and is "a small molecule made of two carbon, three hydrogen, and one oxygen atoms. Acetyl groups are added to or removed from other molecules and may affect how the molecules act in the body" (41). "N-acetyl amino acids are being considered as ingredients in chemically-restricted diets and for fortifying plant proteins to increase their biological value" (42 p. 17).

Brewers spent grain usually has a 20% protein content but may be as high as 30% (29), and consists of mainly hordeins, glutelins, globulins, and albumins (43). Proteins supply the building blocks for protein biosynthesis, a process where cells build proteins, and "directly contribute to the

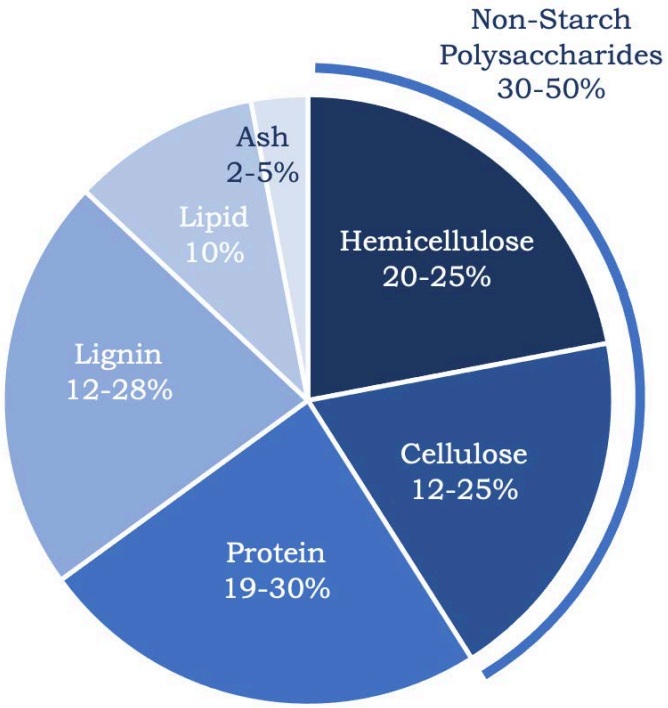

Figure A.A.6. Typical barley BSG composition. Graph replicated from (29 p. 555), adapted from (137) and (136).

flavour of food and are precursors for aroma compounds and colors formed during thermal or enzymatic reactions in production, processing and storage of food" (42 p. 8). Of the total spent grain protein content, approximately 30% is essential amino acids. Lysine represents 14.3%, leucine at 6.12%, phenylalanine at 4.64%, isoleucine at 3.31%, threonine at 0.71% and tryptophan at 0.14% of total protein. The remaining 70% protein content is non-essential amino acids comprising of histidine at 26.27%, glutamic acid at 16.59%, aspartic acid at 4.81%, valine at 4.61%, arginine at 4.51%, alanine at 4.12%, serine at 3.77%, tyrosine at 2.57%, glycine at 1.74%, asparagine at 1.47%, γ-aminobutyric acid at 0.26%, and glutamine at 0.07%. Lysine is generally a limiting amino acid in other cereals, which makes BSG valuable (44).

A final consideration of the nutritional value of BSG is the 1.13% mineral content, of which calcium, magnesium and phosphorous are relatively high. Fortification of food products with calcium may contribute to reduced risk of osteoporosis and colon cancer (45), while magnesium offers protective effects against Type-2 Diabetes. Phosphorous contains an anti-nutrient called Phytate, which is reduced through lactic acid bacteria fermentation, resulting in the increased magnesium and phosphorous minerals. The poly-phenol concentration in BSG is higher than in barley grain, offering "DNA-protective effects by acting as powerful antioxidants" (44 p. 772). Overall, BSG is rich in nutrients and have potential to add quality nutrition in human diets.

Brewers Spent Grain Sensory Qualities

Brewers spent grain has mostly been studied in bakery products with some studies summarized in Appendix A.3. As a flour product, BSG is usually dried and then milled. Sieving has also been studied as various fractions of the milled product can be separated (29 p. 561). Upcycling BSG to bakery products has been tried with breads, biscuits, cookies, muffins, cakes, waffles, pancakes, tortillas, snacks, doughnuts and brownies. BSG can increase the protein, fibre and amino acid contents while decreasing the overall calories in a food product. BSG incorporation increases water absorption and decreases fat absorption but is best incorporated in coloured products to not alter the final products appearance. It's been found that up to 100 g kg^{-1} in food formulations, or 10% has the best results (34 p. 1267) to minimize any unwanted textures in final products.

Barley is a rich source of β-glucans (39 p. 1) at 5-11% (46). As mentioned, Canada primarily grows 2-rowed barley which has been found to be higher in β-glucans than 6-rowed barley varieties (47). "Inclusion of barley β-glucans into breads showed that increased mixing and fermentation times resulted in a decrease in their molecular weight (MW), although the cellotriosyl/cellotetraosyl ratio was unaffected by these processes" (39 p. 8) (48). MW did not differ between dough and baked bread, indicating β-glucans were not affected (39 p. 8) and that health benefits are not compromised.

A 2021 study incorporating spray-dried brewers spent grain and fermented brewers spent grain at two concentrations (source of fibre (SF), and high in fibre (HF)). The higher concentration showed "rapid protein network formulation followed by a fast breakdown" as well as "two peaks,

indicating the aggregation of two protein groups" (49 p. 1646) while both concentrations showed a faster and stronger gluten development with increased dough resistance/stiffness. "Fermentation improved bread characteristics resulting in increased specific volume, reduced crumb hardness and restricted microbial growth rate over time" (49 p. 1639). This study shows that fermented BSG can improve bread characteristics as opposed to dried BSG at moderate quantities. Another study done on the incorporation of fermented BSG in Sourdough bread found that the loaf colour darkened as the concentration of BSG increased, and a reduction of bread cross-section likely due to the gluten matrix being interrupted by the increased fibre (50 p. 100).

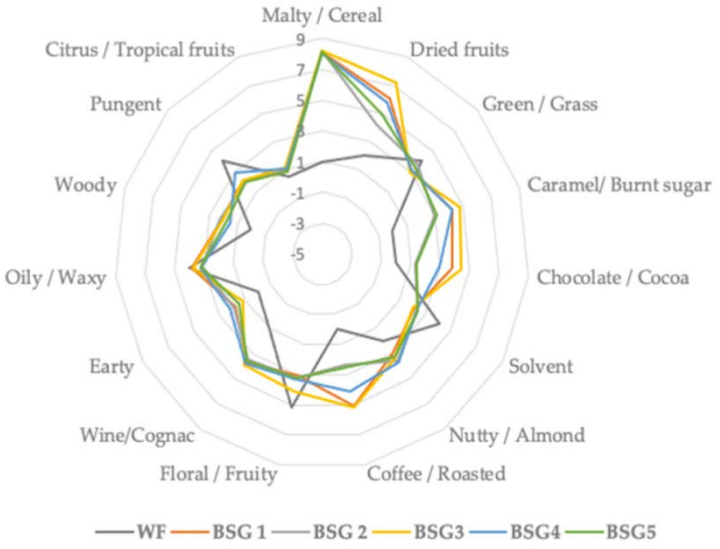

Figure A.A.7. Aroma profile of wheat flour (WF) and different BSG types of main compounds classes identified during GC-MS analysis. (53 p. 2511)

A study on the addition of BSG in bread found that the xylan interaction of BSG with starch affects bread-making quality and "studies on the effect of ws-AXs on gelatinization and retrogradation of starch revealed that addition of the xylan had no effect on gelation kinetics, but enhanced the storage modul G', and influenced starch retrogradation" (38 p. 17). Retrogradation is when "disordered amylose and amylopectin molecules of gelatinized starch hydrophobically interact with one another to form an ordered structure." "The retrogradation properties of starch are related to a range of quality attributes of starch-based food products, such as bread staling and digestibility" (51 p. 93).

Also with bread, arabinoxylans (AX) are a major hemicellulose component of cell walls of the starchy endosperm and outer layers of cereals grains, and account for approximately 40% of BSG on a dry weight basis (29). Part of AX is water-extractable while the majority is released in alkali solutions. "The alkali-extractable AX samples are of particular interest as they have similar but stronger bread-improving properties than the water-extractable AX, which were usually supposed to be the most responsible for the baking performance of cereal flours" (38 pp. 10-11).

In making breadsticks, scanning electron microscopy shows that while wheat flour has lentil-shaped starch granules, BSG flour is virtually void of starch and appears rough. BSG was added at 15%, 25% and 35% with a baked colour darker in accordance with higher concentrations of BSG. As with the bread, higher BSG content also resulted in a flatter breadstick which is associated with the increased fibre content, which also jeopardized the cellular structure resulting in a loss of crispness. The breadsticks were observed to have a more stable shelf life due to slow moisture and a_w changes over time as water was bound and not free (52).

BSG was studied as an ingredient in cookies to increase nutritional value, functional properties, and sensory characteristics. Another 2021 study (53) found that various BSG samples used at a 20% ratio with wheat flour showed large variations in final colour of the cookies. As shown in *Figure 7*, the variety among different malts and ingredients can result in a variety of different flavours in a final product that's used BSG. This same study also found a higher moisture content in the BSG samples due to the increased fibre content which could lead to a shorter shelf life, while the increased protein content "influences the spread ratio value in a positive way" (53 p. 2518).

BSG has also been studied in extruded products such as chickpea-based snacks, where it was found to "significantly increase protein content, phytic acid and bulk density, decreased sectional

expansion index, individual area and total area of the cells". Higher contents of incorporated BSG resulted in a rougher surface and thicker cell walls. (54 p. 469)

An interesting study incorporated dried and ground BSG of various sizes to beef Frankfurters at 1%, 3% and 5%. Results showed that BSG increased the fibre content of the frankfurters with the course ground having the highest increase. The final colour was not significantly different, but acceptance testing has lower results (lowest was 5.47) when compared with the control Frankfurter (7.57) which is likely due to the decreased fat percentage. While acceptance scores decreased with the increase in BSG concentration, scores were still relatively positive, which led to the conclusion that BSG can be added in small amounts without compromising sensory parameters (55).

In relation to plant proteins, acetyl groups are added to or removed from other molecules and may affect how the molecules act in the body" (41). "Acetylated starches with low DS (degree of substitution) are used in food industry as agents of texture, consistency and stability in food and current being studied in the development of biodegradable packaging and pharmaceutical applications" (56 p. 249). "N-acetyl amino acids are being considered as ingredients in chemically-restricted diets and for fortifying plant proteins to increase their biological value" (42 p. 17).

Current Waste Management Strategies of Brewers Spent Grain

Approximately 20 kg of wet spent grain is produced per 100 L of beer with a moisture content of close to 80% (29 p. 556). As the specific gravity of a 3.75% alcoholic beer at 4°C is 1.008, while water is 1.000, meaning that 100 L of beer is equal to 100.8 kg (57). The Boomerang CoOp in Montreal has identified the 4 most prevalent issues that brewers face with managing their spent grain as space, smell, flexibility and cost. A lot of craft breweries are situated in urban areas with limited space, especially to store "waste" products. Brewing schedules vary, making it difficult to plan consistent management of spent grain with it's rapid degradation (58). The high moisture content in BSG makes it very heavy and expensive to move resulting in low-cost animal feed as a popular disposal route. Moisture, along with protein and polysaccharide contents of spent grain make it an optimal bacterial and fungal growth medium, thus degrading quickly and adding unfavourable odors to storage of BSG. To properly store BSG, it has been recommended to store at approximately 10% moisture (29). Freezing is not suitable as volumes are too large but drying BSG both increases storage stability and reduces product weight. However, it was found that a temperature of less than 60°C must be used to avoid unpleasant flavours (59). Safe storage of brewers spent grain requires proper equipment to dry grain, and thus introduces additional financial burden on craft brewers if they were to store on site.

The three current and most common waste management strategies described in literature for brewers spent grain globally are animal feed, composting, and landfill disposal. Each method contributes to global methane emissions, thus highlighting the need for new "waste streams". An outline of waste stream methane emissions are provided in Appendix A.4. As barley and other cereals have already been grown and harvested, it is beneficial to extend the use and lifespan of the products already harvested to extend the outputs of the initial energy input.

Methane is an important consideration in waste management of BSG as it is a contributor to climate change. The Climate and Clean Air Coalition (CCAC) was established in 2012 in which Canada sits as a co-chair. Canada is helping raise awareness of short-lived climate pollutants (SLCP's) and reduce levels at the national, regional and global levels. SLCP's include "black carbon, which is a component of fine particulate matter ($PM_{2.5}$), methane and hydrofluorocarbons (HFCs), and ground-level ozone". They are potent GHG's and air pollutants and are released from activities such as heavy duty diesel vehicle emissions, the waste management sector, agriculture, and oil and gas production (60). Methane is a potent GHG as well as a precursor in the production of tropospheric ozone, an air pollutant leading in reduced crop yields (61 p. 3). Reductions in both CO_2 and SLCP's are required to achieve the Paris Agreement as CO_2 is slowly removed from the atmosphere, while SLCP's are removed quickly with reductions having potential to reduce global warming by 0.5°C by 2050 (61 p. 183).

Canada's 2019 Food Guide & National Health Issues

The current version of the Canada Food Guide suggests making "half your plate vegetables and fruits", and to "choose protein foods that come from plants more often" (62). Since the release of the new food guide, several new "plant-based" products have become available, shown in *Figure 8* (63 p. 17). "Plant-based protein foods can provide more fibre and less saturated fat than other types of protein foods. This can be beneficial for your heart health" (64). Brewers spent grain is high in protein (20-30%) and fibre (up to 50%) (29). According to the Canada Food Guide, a ≤5% daily value (DV) is referred to as "a little" and ≥15% is "a lot". The higher fibre content in whole grain foods can help lower risk of stroke, colon cancer, heart disease and type 2 diabetes in humans (65). The DV of nutrients is provided in Appendix A.5 along with other allowed nutrient claims (66).

In the United States, the 2020-2025 Dietary Guidelines for Americans (DGA) has comparable recommendations with making half your plate fruits and vegetables, making half your grains whole grains, varying your protein routine, and limiting sugars, saturated fats, and sodium (67 p. 13). The United States recommended intake of macronutrients is provided as Appendix A.6. The US dietary guidelines for protein are 46 g for women aged 19-51+, and 56 g for men the same age (67 p. 133), while the Canadian guidelines do not provide a daily value (66). As BSG is also high fibre, the US guidelines for fibre indicate 22-28 g for women between 19-51, and between 28-34 for men the same age (67 p. 133). In Canada the recommendations are lower at 25 g (66).

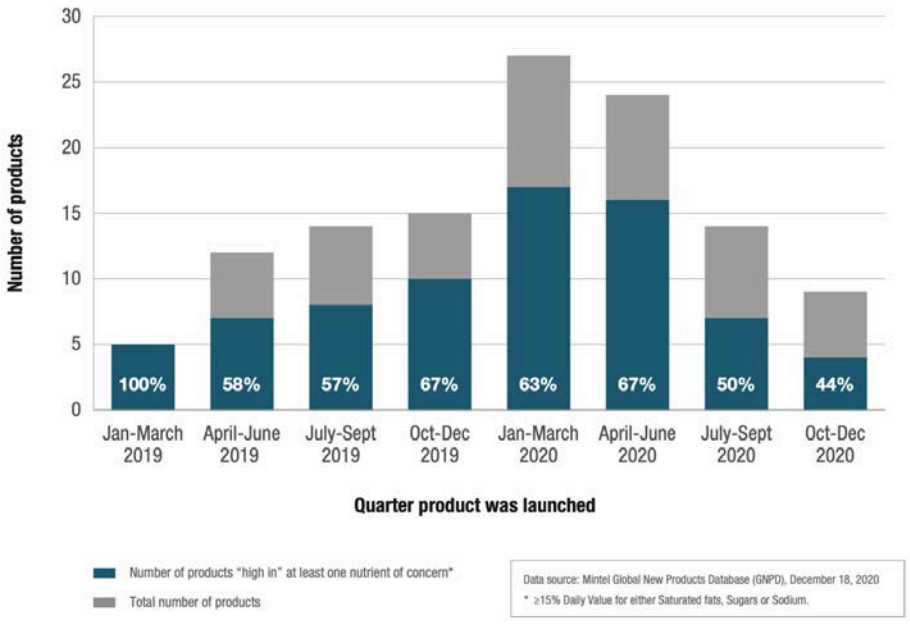

Figure A.A.8. Number of new plant-based products in Canada since Canada's food guide launch in January 2019. (63 p. 17)

Similarly, based on planetary boundaries, "a novel concept… for estimating a safe operating space for humanity with respect to the functioning of the Earth System" (8), it is recommended that 100-300g of fruits, 200-600g of vegetables, 232g of whole grains, and 0-100g of starchy vegetables are consumed daily as a part of a healthy diet, while only 0-14g of beef and lamb, 0-14g of pork, and 0-58g of poultry should be included in a regular diet. (2) A 2021 study on the contributions of animal and plant based dietary patterns on nutrient quality of adult Canadians found that 63.3% of protein comes from animal sources while 36.7% is plant-based on average. They found that diets with less than 25% protein coming from plant-based sources had higher intakes of total and saturated fats and protein, with lower intakes of carbohydrates and dietary fibre. Diets with more than 50% plant-based protein consumption had higher intakes of carbohydrates and dietary fibre, with lower intakes of total and saturated fats and protein. A diet balancing plant-based and animal protein results in a more balanced diet including vitamin and mineral intakes (68).

Concentrating on eating a healthy diet is beneficial to all humans to lower risks of nutrition-related diseases. In Canada, 26.8% of people over the age of 18 reported being obese with an additional 36.3% being overweight. A total of 63.1% of the population having increased health risks

due to weight, specifically increasing risk of diabetes, high blood pressure, and heart disease. (69) The Unites States also has a number of nutrition-related health conditions affecting its citizens. 74% of adults are overweight or obese, with heart disease being the leading cause of death. Type 1 and 2 Diabetes affects nearly 11% of Americans, and 17% of women and 5% of men have osteoporosis (67 p. 5). Compared with recommended intakes, adults between the ages of 31-59 don't eat enough vegetables, fruits, or dairy, meet the low requirements for total grains, and either meet or exceed protein intake. More than half this age group eats too many added sugars, about 70% consume too many saturated fats, and over 82% overconsume sodium. (67 p. 99)

How we will Think Global and Act Local

Winnipeg has a growing brewing industry as seen with the recent increase of craft breweries as shown in Appendix A.7, meaning there is also an increase in the supply of BSG being produced locally thus increasing the need for efficient waste strategies. *Figure 9* shows the worst-case scenario in not realizing the potential of any industry outputs by sending all outputs as waste to the landfill.

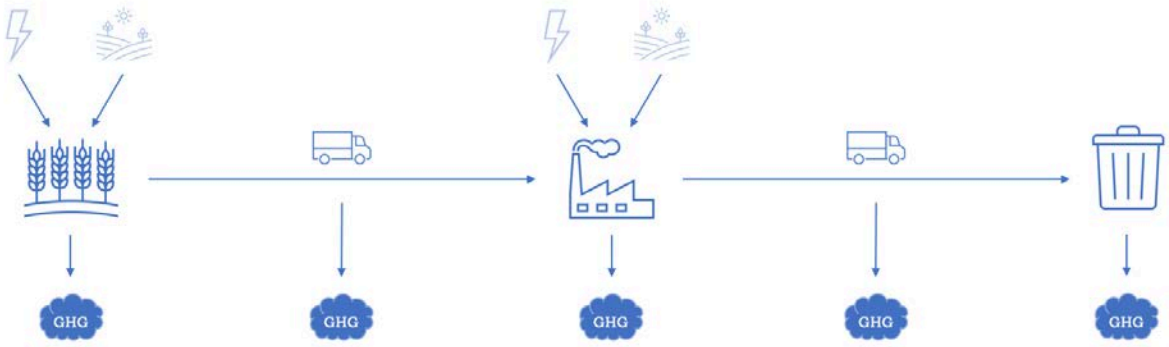

Figure A.A.9. Depiction of the worst-case scenario of waste management within the brewing industry, showing all brewing waste/output being immediately sent to landfill.

While *Figure 9* is an example of a typical linear economy, it's not an accurate representation of actual documented waste management strategies of BSG. The craft brewing industry has made efforts to become more circular in their operations by using BSG as compost at local farms or other composting initiatives, or by partnering with local farmers to provide/sell BSG as ruminant feed. While packaging materials such as bottles and cans were discussed but are not shown in *Figure 9*, they are also used in a circular fashion with recycling initiatives to reduce the environmental impacts such as material use, energy requirements, and GHG emissions.

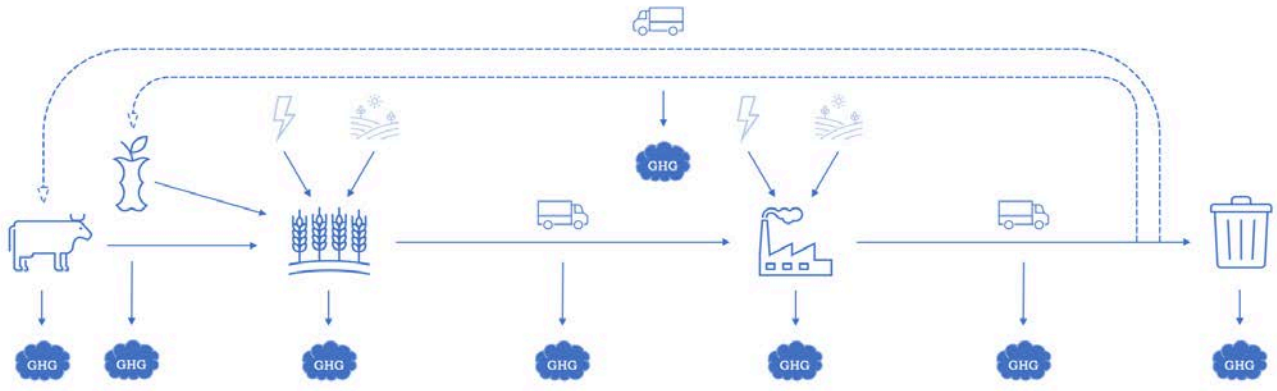

Figure A.A.10. Depiction of the current documented waste management strategies within the brewing industry: landfill, cattle feed, and compost.

Below, shown in *Figure 11*, is a representation of the project objectives. The overall purpose of this project is to explore the potential of upcycling brewers spent grain in Winnipeg, MB, to add value to the solid BSG "waste" produced from brewing our favourite beverage: beer. By identifying potential upcycling options based on peer-reviewed literature and examples of implementation in other cities, BSG can become a value-added product that is not a burden to 'get rid of'.

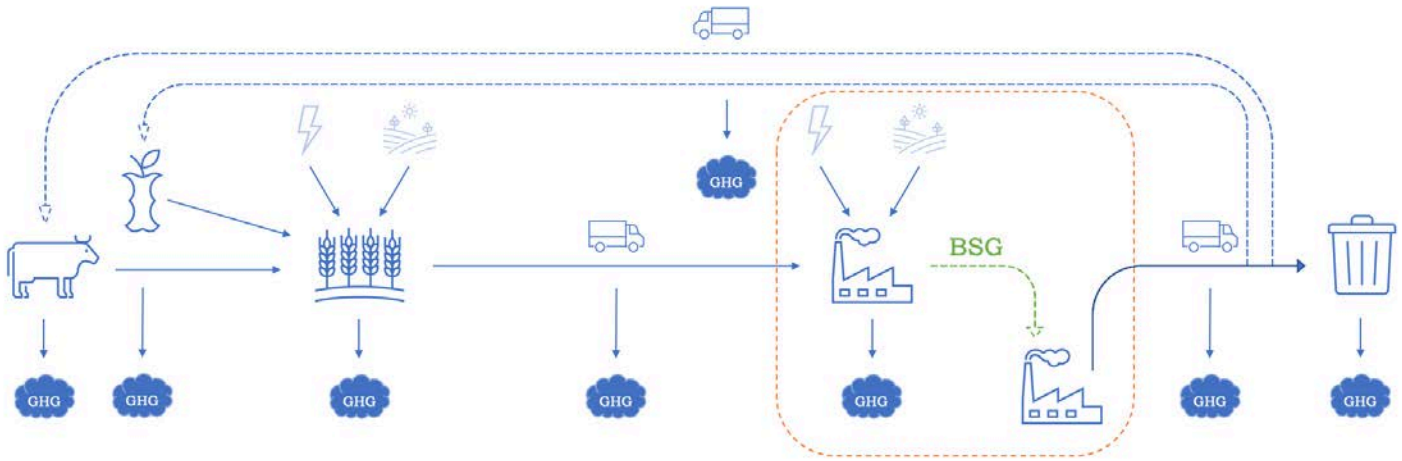

Figure A.A.11. Overview of the targeted benefits of the project research of "Exploring the Potential of Upcycling Craft BSG in Winnipeg, MB". The above graphic shows the various contributors of GHG emissions along the supply chain of moving barley/BSG, along with the agricultural land and energy demands of sourcing ingredients. The upcycling potential of BSG is shown within the orange dashed square, with the green dashed arrow showing the re-routing of brewers spent grain with upcycling, thus reducing industry waste, shortening supply chains, and reducing agricultural output pressures.

While the climate crisis is of global concern, it affects every living thing on this planet and threatens future life as we know it. Global initiatives such as the Paris Agreement (goals due 2050) (10) and the Sustainable Development Goals (goals due 2030) (11) have large communal goals where success requires change at every level of society, including the individual. The responsibility of every person is to move towards sustainable operations in every way possible.

In this case, individual responsibility comes in the form of rethinking what has traditionally been seen as "waste" to upcycle BSG to a food product of value to humans. Not only will this contribute to global climate change efforts but will also set an example to other local industries of how a community can come together to reduce demands on agricultural systems, contribute to a decrease in global food waste, as well as shorten supply chains thus avoiding unnecessary GHG emissions wherever possible. With predictions of a growing global population, food systems need to be as efficient as possible based on every piece of knowledge and technology available to us. It would be a shame to know that we could have done something, but didn't.

Project Methodology

The overall goal of this project's research is to 'Explore the Potential of Upcycling Craft Brewers Spent Grain (BSG) in Winnipeg, MB'. The objectives include to first define and quantify current waste management strategies for BSG, second is to understand the opportunities and barriers to upcycling BSG, and finally to recommend potential upcycling options. The overall objectives have been broken down in to seven specific objectives as follows:

1. Quantitatively determine if there is enough BSG in Winnipeg to render upcycling plausible
2. Quantify and map what local breweries currently do with their spent grain
3. Document the barriers brewers face in using/moving/storing spent grain
4. Determine if/which breweries are interested in upcycling potential for their BSG
5. Research and identify who the potential users are of BSG as an input in Winnipeg
6. Identify and evaluate the intermediate steps required to link BSG with potential users
7. Quantify the energy/CO_2 emission differences of current management strategies compared with the final proposed upcycling framework

As there are considerably more breweries in Winnipeg than a decade ago, the project is intended to conduct the research necessary to determine if there is sufficient quantity of BSG to generate a local demand of a particular upcycled product(s) which will be presented directly to brewery owners and food processing companies to implement.

My research focuses on a very specific issue that a limited/defined group of people have control over, therefore it is best studied from a qualitative research approach as this is "an approach for exploring and understanding the meaning individuals or groups ascribe to a social of human problem" (70 p. 4). The objectives are more centered around 'How?' and 'Why?', therefore cannot be fully addressed with quantitative methods that focus on *Cause-and-Effect* relationships (71). Much consideration has been attributed towards the research question to avoid a 'risky path', described by *Kammerlander & De Massis* as falling into common traps and mistakes of qualitative research (72 p. 4). Specifically, a suggested guideline in choosing a research question is "be open to further improvement ideas and never forget about the 'theoretical contribution' of your work', which has been addressed through the contribution of this research to think global and act local to contribute to large-scale climate change initiatives by finding ways to reduce waste and greenhouse gas (GHG) emissions.

I will take a pragmatic approach to this research as I want to find a valuable solution to the problem of managing BSG, meaning it should not be seen as waste or a 'burden' to dispose of. "Instead of focusing on methods, researchers emphasize the research problem and use all approaches available to understand the problem" (70 p. 10), thus my pragmatic worldview allows me the freedom to choose a custom research design that allows me to meet my objectives (70 p. 11). As I come from a science background, quantifying the amount of BSG currently produced in Manitoba is essential to understanding the effectiveness of various possible solutions, but questions such as "Why isn't this currently being upcycled?" also need in-depth analysis to fully understand the facts around this case study, thus requiring the qualitative pragmatic approach.

The research design most appropriate for this project is a case study which is "a design … in which the researcher develops an in-depth analysis of a case, often a program, event, activity, process, or one or more individuals. Cases are bounded by time and activity, and researchers collect detailed information using a variety of data collection procedures over a sustained period of time" (70 p. 14). The research question satisfies the three required characteristics: (1) "A significant business issue or issues", (2) "Sufficient information on which to base conclusions", and (3) "No stated conclusions" (73 p. 13). Case studies have also been suitable for novice researchers as they are manageable and valuable (74 p. 8). A case study allows a researcher to thoroughly evaluate a specific problem to find an appropriate solution that will work for a specific case but may not be appropriate/possible in other

cities/situations, also known as a holistic account. Holistic account describes that I will identify many data sources to define the larger picture of the problem (70 p. 186). To further define the design, an exploratory case study was chosen to answer 'How?' and 'What?' and this is typically the type of case study used when "there is no single set of outcomes", whereas an explanatory case study answers 'How?' and 'Why?' and is typically used to explain presumed casual links that are too complex for surveys or experimentation (75).

Obtaining data to meet the objectives in this case study will be done with multiple information sources, as is typical in qualitative research. Complimentary forms of data will include surveys, interviews, and document review to meet my research objectives rather than basing final recommendations on one data source (70 p. 185).

The research will begin with a Canada-wide craft brewer online survey. An online survey was chosen because questions are asked in the same way in the same order to all recipients, therefore data can result in totals, percent's, comparisons, and correlations (76 p. 99). This allows analysis to address some quantitative aspects of the research objectives in a convenient manner for both the researcher and craft breweries since surveys are easily distributed through company emails listed on brewery websites. The quantitative value that is especially important to this research is the volume of BSG produced in Winnipeg in comparison with other cities currently upcycling BSG. Quantitative values will be drawn from all Canadian craft brewery survey respondents to understand how many currently upcycle their spent grain (or other 'wastes') compared with conventional waste streams such as cattle feed, compost and landfill and the associated costs with each. Quantitative data will be generated through analysis of questions regarding annual beer production from 2017-2021, estimated weekly/monthly/annually volumes of BSG produced, current volumes of BSG going to each/all waste streams (including upcycling activities), and costs/profits of waste/upcycling activities. Although BSG upcycling frameworks from global examples will be drawn upon when developing the Winnipeg framework, the survey sample group has been chosen exclusively as Canadian craft breweries to understand the potential of upcycling where primary data comparisons/examples are analyzed from populations under similar laws and regulations, thus an appropriate case comparison. Winnipeg craft breweries are the central focus in this case study and are included in the survey, while existing Canadian BSG upcycling frameworks will provide valuable qualitative and quantitative data to contribute in meeting objectives 1, 4, 5 and 6.

The second form of data will be generated from in-depth, semi-structured interviews, allowing research to expand on data of interest obtained from the initial surveys, as well as gain a deeper understanding of the personal barriers that brewers face in managing spent grain. Quantitative data will be generated from similar questions asked in the survey regarding production values, waste management and costs/profits, while qualitative data will address the level of interest local breweries have in upcycling, the barriers they face in managing spent grain, decisions leading to current waste management, thoughts on improved management, suggestions/referrals to potential local users of spent grain, and their feelings towards the environmental benefits of local upcycling. Individual interviews also provide a unique opportunity to expand/ask follow up questions pertaining to relevant and interesting data specific to the case study (76 p. 95). Individual interview participants have been chosen exclusively as the whole Winnipeg craft brewer population as they meet the specific criterion of this case study (77 p. 71) and a complete understanding of the Winnipeg BSG case is essential to developing a realistic upcycling framework. The sample selection of Winnipeg craft brewers' population and not all of Canada is also due to a lack of infinite time to complete research. Interviews will provide data to meet or contribute to meeting objectives 1, 2, 3, 4, 5, 6 and 7.

The third data source will be through document review, both physical and online. Documents vary widely in nature and hold more information than one might see at first glance and can therefore be particularly valuable (74 p. 55). Any documents of interest will be requested from breweries if they're willing to provide them as evidence, but the primary document review will be in form of a Canadian craft brewery website review specifically looking for the number of breweries that mention

upcycling or any other spent grain management strategies that will result in a percentage and/or relevant information in which to base the Winnipeg recommendations on. This source will contribute to both the quantitative (percentage of breweries upcycling) and qualitative (various waste management strategies/frameworks for BSG) objectives, specifically objectives 1, 5 and 6.

The fourth round of data collection will be semi-structured interviews with local businesses and manufacturers that may have use and/or interest in the upcycled BSG product. Participant selection will be based on a snowball effect (77), starting with Winnipeg businesses that are identified as processors of food products comparable to those found in literature. Potential users will further be identified through Winnipeg brewer and food processor referrals. In-depth semi-structured interviews will be based on collecting both quantitative and qualitative data. Questions for obtaining quantitative data will be centered around determining annual production between 2017-2021 and required volumes of BSG to meet annual production volumes. Qualitative data surrounding interest will be generated through questions determining level of implementation interest, barriers they face in using spent grain, other potential user referrals, and suggestions for improved management to aid in recommending realistic upcycling options to both brewers and potential users. As with the brewer interviews, a semi-structured style will allow me to expand on interesting information that can enhance my research outcomes in meeting objectives 1, 5 and 6.

The final data collection method will be done with literature review which involves obtaining scientific data from peer reviewed journal articles. Scientific data is needed to research potential uses of BSG and the associated nutritional and sensory qualities of those products to ensure all potential users in MB are identified. Peer reviewed journals are also required to obtain standardized GHG emission data for various processes and transportation vehicles as these measurements are outside the scope of this project. Literature review will provide data for meeting objectives 5 and 7.

Data analysis will take unique quantitative and qualitative forms for each data collection method. Portions of quantitative data from the brewer surveys and interviews will be used to calculate the actual annual volumes of BSG in Canada, and specifically Winnipeg. Numerical data will also provide quantities, such as raw values and percentages, of BSG being diverted into various waste streams. Other numerical data obtained from surveys and interviews will be subject to statistical analysis in evaluating the feasibility of various option in developing an upcycling framework for Winnipeg. Food processor interviews will generate similar numerical data in relation to required quantities of BSG for annual production, therefore interview data will be subject to statistical analysis such as calculating averages and percentages. The data obtained from the website review will provide quantitative data in providing information on the portion of Canadian Craft Breweries that currently upcycle spent grain. The final GHG emission calculations will be based on literature and supplier information of emissions and therefore numerical data is essential to accurate reporting of differences.

Each data collection method will also provide a set of qualitative data. Brewer and food processor interviews will be individually transcribed through the Zoom feature and analyzed using NVivo. We have specifically chosen NVivo because of the program's general ease of use and its ability to code, organize, and group data to find themes among interviews for a full-scale analysis of the case study. All qualitative data will be coded with a combination of pre-defined codes (eg. Suggestions of food products to incorporate BSG, Level of interest in upcycling BSG) and emergent codes (allowing codes to emerge from data and grouping during analysis). The pre-defined codes will be related to data directly targeted through interview questions, while emergent codes are those that might arise through follow-up questions in semi-structured interviews. The Canada-wide Craft Brewery survey data will generate a different set of data that will also be subject to analysis through NVivo to find themes as well as common issues and successes of various waste management or upcycling activities. Finally, a small portion of qualitative data will be obtained from the document review that will be used to primarily document the types of upcycled products currently being made from BSG in Canada.

Methodology Summary

Table A.A.1. Project methodology by guiding objectives.

Overall Objectives	Guiding Objectives	Data Collection Method	Participants or Sources of Data
Define and quantify current waste management strategies for BSG	1. Quantitatively determine if there is enough BSG in Winnipeg to render upcycling plausible	Document Review	Canadian Craft Brewery Websites Brewery Documents
		Online Survey	Canadian Craft Breweries
		Interviews	WPG Craft Breweries MB Food Processors
	2. Quantify and map what local breweries currently do with their spent grain	Interviews	WPG Craft Breweries
Understand the opportunities and barriers to upcycling BSG	3. Document the barriers brewers face in using/ moving/storing spent grain	Interviews	WPG Craft Breweries
	4. Determine if/which breweries are interested in BSG upcycling potential	Online Survey	WPG Craft Breweries
		Interviews	WPG Craft Breweries
Recommend potential upcycling options	5. Research and identify who the potential users are of BSG as an input in Winnipeg	Document Review	Canadian Craft Brewery Websites
		Literature Review	Peer-Reviewed Journal Articles
		Online Surveys	Canadian Craft Breweries
		Interviews	WPG Craft Breweries MB Food Processors
	6. Identify and evaluate the intermediate steps required to link BSG with potential users	Document Review	Canadian Craft Brewery Websites
		Online Survey	Canadian Craft Breweries
		Interviews	WPG Craft Breweries MB Food Processors
	7. Quantify the energy/CO_2 emission differences of current management strategies compared with the final proposed upcycling framework	Interviews	WPG Craft Breweries
		Literature Review	Peer-Reviewed Journal Articles

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APPENDIX A.1: Water Use in Brewing

Table A.A.1.1. Fresh Water Requirements in a brewery. Adapted from: (31 p. 622).

Area	Tested brewery fresh water (m^3/hl)	Equivalent Gallons (US gal/hl)	Literature values fresh water (m^3/hl)	Equivalent Gallons (US gal/hl)
Water Treatment	0.0186	4.91	NA	NA
Brewhouse/Worst Cooling	0.177	46.76	0.130-0.236	34.34-62.34
Fermentation	0.029	7.66	0.032-0.080	8.45-21.13
Storage Cellar	0.015	3.96	0.024-0.067	6.34-17.70
Filtration Cellar/Pressure Tank Cellar	0.011	2.91	0.010-0.109	2.64-28.79
Steam Generation	0.0015	0.39	0.001-0.030	0.26-7.93
Air Compressor/Cooking Water	0.052	13.74	0.012-0.050	3.17-13.21
Miscellaneous	0.02	5.28	0.100-0.300	26.42-79.25
Total	**0.37-0.44**	**97.74-116.24**	**0.407-1.149**	**107.52-303.53**
Total (US gal/US gal)		**3.70-4.40**		**4.07-11.49**

1 m^3 = 264.172 US gallons
1 hl = 26.4172 US gallons

APPENDIX A.2: Literature Values for BSG Chemical Composition

Table A.A.2.1. Chemical Composition of Brewers Spent Grain*. Adapted from: (78).

Study	Mussatto and Roberto[1]	Kanauchi *et al.*[2]	Carvalheiro *et al.*[3]	Silva *et al.*[4]	Meneses *et al.*[5]	Waters *et al.*[6]
Country	Brazil	Japan	Portugal	Portugal	Portugal	Ireland
Spent Grain Type	100% Barley	100% Barley	Barley & Adjuncts		Barley & Adjuncts	100% Barley
Components	g kg^{-1} (dry weight basis)					
Cellulose (Glucan)	168	254	219	253	217	260
Hemicellulose	284	218	296	419	192	222
Xylan	199	NR	206	NR	136	NR
Arabinan	85	NR	90	NR	56	NR
Lignin	278	119	217	169	194	NR
Acetyl Groups	14	NR	11	NR	NR	NR
Proteins	153	240	246	NR	247	221
Ashes	46	24	12	46	42	11
Extractives	58	NR	NR	95	107	NR
Minerals	mg kg^{-1} (dry weight basis)					
Silicon	10740	NR	NR	NR	NR	1400
Phosphorus	5186	NR	NR	NR	6000	4600
Calcium	3515	NR	NR	NR	3600	2200
Magnesium	1958	NR	NR	NR	1900	2400
Sulfur	1980	NR	NR	NR	2900	NR
Potassium	258.1	NR	NR	NR	600	700
Sodium	309.3	NR	NR	NR	137.1	100
Iron	193.4	NR	NR	NR	154.9	100
Zinc	178.0	NR	NR	NR	82.1	100
Aluminum	36.0	NR	NR	NR	81.2	NR
Manganese	51.4	NR	NR	NR	40.9	NR
Cobalt	NR	NR	NR	NR	17.8	NR
Copper	18.0	NR	NR	NR	11.4	NR
Strontium	12.7	NR	NR	NR	10.4	NR
Iodine	NR	NR	NR	NR	11.0	NR
Barium	13.6	NR	NR	NR	8.6	NR
Chromium	5.9	NR	NR	NR	<0.5	NR
Molybdenum	NR	NR	NR	NR	1.4	NR
Boron	NR	NR	NR	NR	3.2	NR

NR, not reported

*Brewing processes were not provided in studies and therefore some variation may be attributed to the brewing process along with other factors.
Table References: [1] (79) [2] (80) [3] (81) [4] (82) [5] (83) [6] (44)

APPENDIX A.3: Food Products made with BSG

Table A.A.3.1. Studies done on incorporating BSG in various food products at different concentrations, along with main findings. Replicated from Lynch, Steffen, & Arendt (29 pp. 562-564).

Food Product	Processing/form of incorporated BSG (or component)	Proportion BSG incorporated (% w/w)	Main Findings	Reference
Cookies	Oven dried at various temperatures, milled and fractionated into specific flour components	10, 20, 30, 40	Cookies prepared with 20% sieved BSG (dried, 45 °C) had protein, lysine and fibre contents increased by 55, 90 and 220%, respectively, compared with control dough	(84)
Extruded Snack	Extruded	10, 20, 25, 30	Increased fibre and protein content. Phytic acid increased with BSG inclusion.	(85)
Bread (Wheat), baker's yeast, kefir, *Lactobacillus casei* immobilized on BSG	Untreated, (autoclaving followed by microorganism immobilisation)	6, 8 and 10 BSG-yeast/BSG-kefir, 25, 35, 50 BSG-kefir (sourdough), 50 BSG-Lb. casei (sourdough)	Lower specific volume than yeast leavened control bread Sourdough breads had 4-day increased shelf-life Higher number and concentration of volatile compounds in sourdough compared with yeast-dough breads Sourdough had higher moisture retention during baking, lower rates of staling, maintained freshness for longer	(86)
Ready-to-eat snacks of various bases (e.g. wheat flour, yogurt powder, tomato powder)	Flour	10, 20, 30	Increased protein and fibre content with increased BSG	(54)
Bread (wheat)	Four untreated – BSG flour only added to dough Treated – enzymes also added to each dough: Maxlife 85, Lipopan Extra, Pentopan, Pentopan + Celluclast	10, 20, 30	BSG addition significantly improved the fibre level of breads but increased crumb hardness and decreased loaf volume Enzyme addition (except Maxlife 85) improved the texture, loaf volume and shelf life BSG could be added up to 30% to a bread formulation with appropriate enzymes to improve the loaf volume, texture and shelf life	(87)
Ready-to-eat (extruded) snacks	Dried and Milled	10	Increased total dietary fibre No decrease in phytic acid during extrusion	(88)
Frankfurters	Milled and sieved to various fractions	1, 3, 5 (fat substituted)	Dietary fibre and water holding capacity increased with increasing additions of BSG The textural parameters except springiness reduced because of the amount of BSG and the low level of fat Sensory scores decreased as the content of BSG increased	(55)
Breadsticks	Flour	15, 25, 35	15% BSG doubled the content of dietary fibre Decreased volume with increased BSG content Lack of typical cellular structure and altered textural properties Longer shelf-life compared with control	(89)
Bread	Flour produced by: extrusion and milling – untreated (Celluclast BG and Pentopan Mono BG added to dough)	12	Enzymatic treated BSG in extruder – no effect on the characteristics of bread Untreated BSG with enzymes added to the dough – better texture and volume	(90)

	Extrusion and milling – treated with Celluclast BG and Pentopan Mono BG during extrusion		compared with control (e.g. reduced hardness)	
Bread (wheat)	Untreated flour (BSG) Flour fermented with *Lactobacillus plantarum* (BSG SD)	5, 10, 15, 20	Low levels of BSG-SD resulted in softer bread than the wheat bread control Reduced specific volume in breads with increasing BSG/BSG SD Lightening of crust colour on BSG SD incorporation Staling retarded in BSG SD-substituted breads Sensory acceptability, up 10% BSG/BSG SD Perceived sweetness of bread decreased upon addition of BSG and BSG-SD	(91)
Fruit Beverages	Hydroxycinnamic acid (phenolic extracts), liquid	2.5, 10 (%v/v)	Addition of BSG phenolic extracts to juices and smoothies (2.5 and 10%) did not significantly enhance their total phenolic content nor significantly alter the scavenging activity Only ferric reducing antioxidant power (FRAP) activity was significantly increased in cranberry juice with added phenolic extracts compared with the un-supplemented control	(92)
Dough (wheat)	Flour	15, 25, 35	Increased water absorption and dough development time with increasing levels of BSG Decreased final viscosity Storage and loss moduli were increased, indicating more solid-like behaviour Decreased dough height in rheofermenter. Poor extensibility of dough Breads of low volume and dense structure are to be expected	(93)
Baked snacks (crispy-slices)	Flour	10, 15, 25	BSG addition increased the fibre and the protein content of the samples Addition of >10% BSG affected the texture – high levels of BSG led to a closed, compact structure BSG altered the odour profile in the snacks, compounds present in high levels in the BSG flour were observed in high levels in the BSG-containing snacks Use of 10% BSG resulted in snacks with similar texture and structure as the control and was accepted by panellists	(94)
Bread (wheat)	Untreated flour (BSG)Flour fermented with sourdough starter (BSG SD) ± xylanase or dough conditioner	15	Highest firmness observed for BSG and BSG-SD breads Xylanase and dough conditioner reduced firmness of both bread types Antioxidant activity highest in BSG-SD samples Fermentation reduced the phytic acid content of BSG breads by 30% Dough conditioner alone and the combination of BSG-SD + dough conditioner improved the sensory properties of the BSG breads	(95)

Spent Grain as Animal Feed

Farmers can purchase brewers spent grain at low cost from breweries as it is available reliably throughout the year. The main benefit of this waste management strategy is that as ruminant feed, it can be used in its wet form of approximately 80% moisture without treatment, or a dried form. BSG is beneficial as animal feed due to the high protein and fibre content (34). BSG provides animals with all the essential amino acids when combined with a nitrogen source. The "inclusion of BSG in the cow's diet increases milk production and the content of total solids while decreasing the content of fat in the milk produced" (34) (96).

The major prebiotics found in barley are β-glucans, arabinoxylans (xylooligosaccharides and arabinoxylooligosaccharides), and isomaltooligosaccharides (97 p. 463). "The β-glucans, arabinoxylan, and its derivatives xylooligosaccharides and the arababinoxylooligosaccharides have been studied to have prebiotic potential as these compounds favourably improve the activity of beneficial microbial population which influence numerous physio-biological mechanisms to an animal" (97 p. 462). Specifically, the "most important reported physio-biological functions influenced by the inclusion of prebiotics in animal diet include modification of microbial population in the GIT (gastrointestinal tract), improving immunity, antioxidant potential, lipid metabolism, improved intestinal architecture, glucose homeostasis, suppression of pathogens, as well as improvement of nutrient absorption" (97 p. 466).

BSG is also used to supplement poultry diets as it was found to increase weight gain but the majority of cell wall polysaccharides of spent grain cannot be digested by this type of bird due to the missing enzymes required for hydrolysis (98). However, BSG is used as a low-cost poultry feed with the addition of xylanase and β-glucanase enzymes to allow these birds to digest arabinoxylan and β-glucan of the cell wall polysaccharides (34). Despite nutritional benefits as animal feed, BSG is recommended to be used within 7 days of removal from the brewing process as it can ferment quickly due to the high sugar and moisture contents. Decomposing organic materials can pose several health risks to both animals and humans as it attracts insects and rodents, and/or molds to produce mycotoxins which can affect the respiratory system (97 p. 469).

"The manufacture, sale and import of livestock feeds are regulated in Canada under the Feeds Act and Regulations and Health of Animals Act and Regulations administered by the Canadian Food Inspection Agency (CFIA). All feeds must be safe for livestock; for humans (by the potential transfer of residues into human food, that is, meat, milk and eggs, and via worker/bystander exposure); and for the environment. Feeds must also be fit for purpose and must be properly labelled to ensure safe and appropriate use" (99).

Under Canadian law, cattle, horses, sheep, goats, swine, poultry (chicken, turkeys, duck, geese), fish, foxes, mink and rabbits feed are regulated under the *Feeds Act* and Regulations (100). Animal production is a large global source of methane (CH_4), a potent greenhouse gas contributing to climate change. Domestic ruminants in particular produce methane through enteric fermentation; a digestive process where methane is produced as a by-product of food decomposition and fermentation within the animals digestive tract (101). "Ruminants excrete the largest quantity of methane annually (86 Tg of CO_2 equivalent), mainly beef cattle (55.9 Tg), followed by dairy cattle (18.9 Tg) and sheep and goats (9.5 Tg)" (102 p. 81). Ruminants alone account for approximately 30% of global methane emissions in which cattle account for 77% of that value, equal to 23.1% of total global methane emissions. Approximately one third of cattle are farmed globally for meat while the remaining two thirds for dairy. As methane emissions can currently be reduced by "optimizing feed digestibility and availability, balancing and fine tuning feed rations; promoting better animal health, and; improving performance through breeding" (101), the global shift towards a more plant based diet suggests that

global meat production should decrease and therefore food upcycling of spent grain has a higher value being kept in human food systems as opposed to use as animal feed.

Spent Grain as Landfill Waste

Biodegradable waste in landfills has significant impacts for GHG emissions contributing to climate change. A European study from the UK Environment Agency found that methane and carbon dioxide are the major components of mature landfill gas at typical values of 63.8% and 33.6% respectively (103 p. 51). Methane is a potent greenhouse gas having a relatively short lifespan of 10 years, but on a 100 year basis 1kg of methane has 25 times the global warming potential (GWP) of 1kg carbon dioxide, and 72 times in 20 years (104 p. 212). Global methane concentrations are "more than double pre-industrial (1750-1800) value" (105 p. 5). The production of methane from decomposition of biodegradable materials in landfills happens in five stages. First, aerobic microbial activity consumes oxygen, producing carbon dioxide (CO_2), water (H_20), and heat. Second, long-chain polymers, such as lipids, proteins and carbohydrates, undergo hydrolysis and acetogenic processes in anaerobic conditions producing short chain organic compounds, ammonia (NH_3), carbon dioxide (CO_2), hydrogen (H_2), water (H_2O), and heat. Third, in anaerobic conditions, methanogenic bacteria use products from the previous stage to produce carbon dioxide (CO_2) and methane (CH_4). Fourth, hydrolysis/acetogenesis and methanogenesis are producing methane (CH_4) and carbon dioxide (CO_2) at a 3:2 ratio respectively. Fifth, limited organic materials results in endogenous respiration where interstitial gasses consume atmospheric air (103 pp. 56-58).

Current estimates suggest that a total 570 million tonnes (Mt) of Methane are emitted annually, 40% from natural sources and 60% from anthropogenic activities. Waste represents 68 Mt while agriculture represents 145 Mt. (106). Agriculture alone accounts for 25.4% of total global methane production or 42.4% of anthropogenic sources, while waste contributes 11.9% of total global methane production and 19.9% of anthropogenic sources. Biodegradable waste gas emissions differ from non-biodegradable as the later emits hydrogen (H_2) from metal corrosion, hydrogen cyanide (HCN) from waste reacting with acidic materials, amines from waste reacting with alkali materials, and sulfur oxides (SO_2, SO_3, etc.) from redox reactions with within waste (103 p. 51).

Spent Grain as Compost

Another common waste management strategy for brewers spent grain is composting. Compost is "a mixture that consists largely of decayed organic matter and is used for fertilizing and conditioning land". To Compost means "to convert (a material, such as plant debris) to compost" (107). More scientifically, "composting is a thermophilic process of microbial degradation, stabilization, and sanitization or organic wastes under aerobic and/or anaerobic condition to produce compost" (108 p. 2). Composting is generally a method of organic material decomposition that reduces landfill volumes and produces renewable energy and soil amendments, although the process requires management to ensure aerobic landfill conditions are not replicated. Air and water are required for composting to allowed for desired microbial activity as anaerobic conditions result in large amounts of methane (and nitrous oxide (N_20)) production as discussed above (109). In proper conditions, composting produces methane at >1% of the initial carbon content, and nitrous oxide at 0.5-5% of initial nitrogen content (110). Proper management is more difficult at larger scales due to the increase of anaerobic sites within the material and therefore composting may still contribute significant amounts of GHG (carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_20)) depending on the carbon and nitrogen concentrations of the organic materials. Globally altered carbon and nitrogen cycles are of added concern, increasing the need to monitor GHG emissions from all sources including composting (108). A pre-treatment involving anaerobic digestion (AD) captures and utilizes methane for energy production, reduces the amount of water and energy requirements for composting as well as reduces the amount of GHG emitted during the decomposition process (109).

Table A.A.5.1. Canada's Food Guide nutrient daily values (DV). (66)

Nutrient	Daily Value (DV)
Fat	65 g
Saturated and Trans Fat	20 g
Cholesterol	300 mg
Sodium	2400 mg
Carbohydrate	300 g
Fibre	25 g
Sugars	No DV
Protein	No DV
Vitamin A	1000 RE
Vitamin C	60 mg
Calcium	1100 mg
Iron	14 mg
*Note: RE = Retinol Equivalents	

Table A.A.5.2. Allowed nutrient content claims in Canada. (111)

Keywords	What it Means	Nutrients Used With / Nutrient Criteria	
Free No 0 Zero Without	The food provides an amount of a nutrient that is so small it likely won't have any effect on your body.	Calories/Energy	Less than 5 Calories*
		Sodium/Salt	Less than 5 mg*
		Fat	Less than 0.5 g fat*
		Saturated Fat	Less than 0.2 g saturated fatty acids AND less than 0.2 g of *trans* fatty acids*
		Trans Fat	Less than 0.2 g of *trans* fatty acids AND 2 g or less of saturated fatty acids and *trans* fatty acids combined*
		Cholesterol	Less than 2 mg of cholesterol AND 2 g or less of saturated fatty acids and *trans* fatty acids combined*
		Sugars	Less than 0.5 g of sugars AND less than 5 Calories*
Low Little Few	The food provides a very small amount of the nutrient	Calories (Energy)	40 Calories or less*
		Fat	3 g or less of fat*
		Saturated Fat	2 g or less AND 15% or less energy from the sum of saturated fatty acids and *trans* fatty acids combined*
		Cholesterol	20 mg or less of cholesterol 2 g or less AND 15% or less energy from the sum of saturated fatty acids and *trans* fatty acids combined*
		Sodium/Salt	140 mg or less of sodium*
		Protein	No more than 1 g protein per 100 g of the food
Reduced Less Lower Lower in Fewer	The food is processed/modified so that it contains at least 25% less of the nutrient when compared with a similar product	Calories (Energy)	At least 25% less Calories than the food to which it is compared*
		Fat	At least 25% less fat than the food to which it is compared*
		Saturated Fat	At least 25% less saturated fat than the food to which it is compared*
		Trans Fatty Acids	At least 25% less *trans* fatty acids than the food to which it is compared*
		Cholesterol	At least 25% less cholesterol than the food to which it is compared*
		Sodium/Salt	At least 25% less sodium than the food to which it is compared*
		Sugars	At least 25% less sugars than the food to which it is compared*
Lightly	The food provides at least 50% less of the added nutrient	Sodium/Salt	At least 50% less added sodium than the food to which it is compared*
No added Without added	The food has none of the nutrient added to it	Fat	Contains no added fats or oils or added butter or ghee, or ingredients that contain added fats or oils, or butter or ghee

		Sugar	Contains no added sugars, no ingredients containing added sugars or ingredients that contain sugars that functionally substitute for added sugars
		Sodium/Salt	Contains no added salt, other sodium salts or ingredients that contain sodium that functionally substitute for added salt
Source Contains	The food provides a significant amount of the nutrient	Calories (Energy)	At least 100 Calories*
		Protein	Protein rating of 20 or more**
		Omerga-3 Polyunsaturated Fatty Acids	At least 0.3 g of omega-3 polyunsaturated fatty acids*
		Omega-6 Polyunsaturated	At least 2 g of omega-6 polyunsaturated fatty acids*
		Fibre	At least 2 g of fibre, if no fibre or fibre source is identified in the statement of the claim* OR 2 g or more of each identified fibre or fibre from an identified fibre source if a fibre or fibre source is identified in the statement or claim* or the food contains at least 1 ingredient that meets the conditions above, if the food is a pre-packaged meal
		Vitamins/Minerals	At least 5% of the recommended daily intake
More Higher Higher in	At least 25% more of a nutrient compared with a similar product	Calories (Energy)	At least 25% more Calories, totalling at least 100 more Calories than the food to which it is compared
		Fibre	At least 25% more fibre, totalling at least 1 g more, if no fibre or fibre source is identified in the statement or claim, or at least 25% more of an identified fibre source, totalling at least 1 g more, if a fibre or fibre source is identified in the statement or claim* OR At least 2g fibre if no fibre or fibre source is identified in the statement or claim, or at least 2 g of identified fibre or fibre from an identified fibre source* or the food contains at least 1 ingredient that meets the conditions above, if the food is a pre-packaged meal
		Protein	Protein rating of 20 or more and contains at least 25% more protein, totalling at least 7g more than the food to which it is compared**
Good source of	At least 15% of the recommended daily intake	Vitamins/Minerals	At least 15% f the recommended daily intake except at least 30% of the recommended daily intake for vitamin C
High in High source of	The food contains at least 4 g of fibre	Fibre	At least 4 g of fibre* if no fibre or fibre source is identified in the statement or claim OR At least 4 g of each identified fibre or fibre from an identified source* if a fibre or fibre source is identified in the statement or claim OR Contains at least 1 ingredient that meets the conditions above, if the food is a pre-packaged meal
Excellent source Very high Very high in Very high source Rich Rich in	The food provides a very large amount of the nutrient	Protein	Protein rating of 40 or more*
		Fibre	At least 6g of fibre* if no fibre or fibre source is identified in the statement or claim OR At least 6 g of each identified fibre or fibre from an identified source* if a fibre or fibre source is identified in the statement or claim OR Contains at least 1 ingredient that meets the conditions above, if the food is a pre-packaged meal
		Vitamins/Minerals	At least 25% of the recommended daily intake except at least 50% of the recommended daily intake for vitamin C
Light	The food is processed/modified	Energy	At least 25% less Calories than the food to which it is compared*

	so that it contains at least 25% less of the nutrient when compared with a similar product	Fat	At least 25% less fat than the food to which it is compared*
Lean	Contains 10% or less fat	Fat	The food is meat or poultry that has not been ground, a marine or fresh water animal or a product of any of these
Extra Lean	Contains 7.5% or less fat	Fat	The food is meat or poultry that has not been ground, a marine or fresh water animal or a product of any of these
* Per reference amount and serving of stated size (specific amount of food listed in Nutrition Facts table) OR per 100g if the food is a pre-packaged meal ** Per reasonable daily intake			

APPENDIX A.6: Recommended Nutrient Intake (United States)

Table A.A.6.1. Recommended macronutrient, mineral and vitamin intakes for females and males ages 4+, for citizens of the United States. Replicated from: (67 p. 133)

MACRONUTRIENTS, MINERALS & VITAMINS		Age-Sex Groups												
		M/F 2-3	F 4-8	F 9-13	F 14-18	F 19-30	F 31-50	F 51+	M 4-8	M 9-13	M 14-18	M 19-30	M 31-50	M 51+
Calorie Level Assessed	**Source of Goal[a]**	1,000	1,200	1,600	1,800	2,000	1,800	1,600	1,400	1,800	2,200	2,400	2,200	2,000
Macronutrients														
Protein (% kcal)	AMDR	5-20	10-30	10-30	10-30	10-35	10-35	10-35	10-30	10-30	10-30	10-35	10-35	10-35
Protein (g)	RDA	13	19	34	46	46	46	46	19	34	52	56	56	56
Carbohydrate (% kcal)	AMDR	45-65	45-65	45-65	45-65	45-65	45-65	45-65	45-65	45-65	45-65	45-65	45-65	45-65
Carbohydrate (g)	RDA	130	130	130	130	130	130	130	130	130	130	130	130	130
Fiber (g)	14g/ 1,000 kcal	14	17	22	25	28	25	22	20	25	31	34	31	28
Added Sugars (% kcal)	DGA	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Total lipid (% kcal)	AMDR	30-40	25-35	25-35	25-35	20-35	20-35	20-35	25-35	25-35	25-35	20-35	20-35	20-35
Saturated Fatty Acids (% kcal)	DGA	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
18:2 Linoleic acid (g)	AI	7	10	10	11	12	12	11	10	12	16	17	17	14
18:3 Linoleic acid (g)	AI	0.7	0.9	1.0	1.1	1.1	1.1	1.1	0.9	1.2	1.6	1.6	1.6	1.6
Minerals														
Calcium (mg)	RDA	700	1,000	1,300	1,300	1,000	1,000	1,200	1,000	1,300	1,300	1,000	1,000	1,000[b]
Iron (mg)	RDA	7	10	8	15	18	18	8	10	8	11	8	8	8
Magnesium (mg)	RDA	80	130	240	360	310	320	320	130	240	410	400	420	420
Phosphorus (mg)	RDA	460	500	1,250	1,250	700	700	700	500	1,250	1,250	700	700	700
Potassium (mg)	AI	2,000	2,300	2,300	2,300	2,600	2,600	2,600	2,300	2,500	3,000	3,400	3,400	3,400
Sodium (mg)	CDRR	1,200	1,500	1,800	2,300	2,300	2,300	2,300	1,500	1,800	2,300	2,300	2,300	2,300
Zinc (mg)	RDA	3	5	8	9	8	8	8	5	8	11	11	11	11

APPENDIX A.7: Manitoba Craft Breweries and Year Established

Table A.A.7.1. Manitoba Craft Breweries and the year in which they were established. All MB breweries established within the past 5 years (2017-2021) are marked in blue, which accounts for 74%.

	Brewery Name	Address	Year Established	Ref.
1	Barn Hammer Brewing Company	595 Wall Street, WPG, MB	2016	(112)
2	Bookstore Brewing (Oxus)	1180 Sanford Street, WPG, MB	2021	(113)
3	Brazen Hall	800 Pembina Hwy, WPG, MB	2017	(114)
4	Dastardly Villain	726 Osbourne Street, WPG, MB	2020	(115)
5	Devil May Care Brewing Company	330-830 King Edward St. WPG, MB	2018	(116)
6	Fort Garry Brewing	130 Lowson Cres. WPG, MB	1994	(117)
7	Good Neighbour Brewing Co.	116 Sherbrook St. WPG, MB	2021	(118)
8	Half Pints Brewing Co.	550 Roseberry St. WPG, MB	2006	(119)
9	Kilter Brewing Co.	450 Rue Deschambault, WPG, MB	2018	(120)
10	Lake of the Woods Brewing Co.	221 Carlton St WPG, MB	2019	(121)
11	Little Brown Jug Brewing Company	336 William Ave. WPG, MB	2016	(122)
12	Low Life Barrel House	595 Wall Street, WPG, MB	2019	(123)
13	Nonsuch Brewing Co.	125 Pacific Ave. WPG, MB	2018	(124)
14	One Great City Brewing Company	1596 Ness Ave. WPG, MB	2017	(125)
15	Oxus Brewing Company	1180 Sanford St. WPG, MB	2017	(126)
16	Sookram's Brewing Company	479-B Warsaw Ave. WPG, MB	2019	(127)
17	Stone Angel Brewing Co.	1875 Pembina Hwy. WPG, MB	2017	(128)
18	Torque Brewing	330-830 King Edward St. WPG, MB	2016	(129)
19	Trans Canada Brewing Co.	1290 Kenaston Blvd. WPG, MB	2017	(130)
20	Black Wheat Brewing	402 10th St. Brandon, MB	2021	(131)
21	Interlake Brewing Co.	72 1st Ave. Gimli, MB	2022	(132)
22	Rendezvous Brewery	368 Stephen St. Morden, MB	2020	(133)
23	Farmery Estate Brewery	480 MB-5, Neepawa, MB	2012	(134)

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Appendix B: Project Concept

General Information:
Project: Exploring the Potential of Upcycling Craft BSG in Winnipeg, MB
Name: Marika Boryen, Iain Davidson-Hunt
Partner Name: Brian Westcott (Barn Hammer)
Date: January 26, 2022

Justification/Need:

Food and beverage production yields high waste as producers try to meet quality standards for consumers, and/or when ingredient inputs become large volumes of waste products such as barley (and other) grains used in brewing beer. It is our goal with the overall project, partnered with Brian of Barnhammer, to explore the potential of diverting craft brewers spent grain (BSG) in Winnipeg from conventional waste streams (landfill, compost, ruminant animal feed) by employing concepts from circular economy and food upcycling. We will ultimately identify the barriers brewers face in dealing with spent grain and consider possibilities of upcycling the food to other human food production cycles. To the benefit of local breweries, potential uses aim to overcome barriers and render spent grains a potentially valuable product input as opposed to a burden as waste. While there are large efforts globally to move towards a more plant-based diet, it is essential that we consider the value of spent grain remaining in the human food production cycle as they are highly nutritious. If we do not proceed with this project, brewers spent grain in Winnipeg will continue to be conceived as a waste product and a burden to remove from the brewery property, thus not realizing the true nutritional value and potential of the product.

Project Description:

The project is centered around exploring the potential of upcycling craft BSG in Winnipeg, MB, by determining: (1) if there is sufficient quantity of BSG in Winnipeg to render upcycling plausible, (2) what local breweries currently do with their spent grain, (3) what are the barriers brewers face in using/moving/storing spent grain, (4) if/which breweries are interested in upcycling potential, (5) who the potential users are of BSG as an input, (6) the intermediate steps required to link BSG with potential users, and (7) the energy/CO_2 emission differences of current management strategies compared with that proposed.

As there are considerably more breweries in Winnipeg than a decade ago, the project is intended to conduct the research necessary to determine if there is sufficient quantity of BSG to generate a local demand. We will use frameworks from other cities who have BSG upcycling initiatives in place as reference for what might be doable in Winnipeg based on research findings. As this project is not intended to carry out upcycling activities, it will provide a comprehensive analysis of upcycling BSG to consider the potential for Winnipeg.

Resource and Cost Estimates:

General resource and cost estimates are as follows:

Background Research	$0.00 *(UofM Libraries Access)*
Online Survey's	$408.00 *(SurveyMonkey Subscription)*
Calendly Account	$120.00 *($30.00/Month) (Interview Scheduling)*
Zoom Interviews	$0.00
Data Analysis	$0.00
Final Report	$0.00 *(UofM Microsoft 365 Accounts)*
Final Meeting	$500.00 *(Networking Event & Findings)*
Office Supplies	$200.00
Printed Materials	$979.58 *(For Networking Meeting)*
Total Preliminary Estimate:	$1907.58

Timeframe:

Total Project Duration: January 2022 to November 2022
Breakdown as follows:

1.	Integrated Project Plan Completed & Approved (Includes: Concept, Charter, Schedule, Resource Plans, Managing Relationships, Risk Management, Quality Management, Budget, Change Management, Background Information Report, Appendices)	*March 2022 (End)*
2.	Ethics Approval (6-8 Weeks)	*May 2022*
3.	Canada Website Review (During Ethics Approval)	*May 2022*
4.	Surveys and Interviews (8 Weeks)	*June/July 2022*
5.	Data Analysis	*August 2022*
6.	Final Report (6-8 Weeks)	*October 2022*
7.	Final Event & Networking Meeting	*November 2022*

Planning Estimates:

The estimated/known deadlines of the project are as follows:

1.	Integrated Project Plan – Final Copy	*March 18, 2022*
2.	Committee Meeting – Project Review/Approval by:	*April 1, 2022*
3.	Ethics Submission (April 1, 2022) & Approval by:	*May 27, 2022*
4.	Survey Distribution (May 30, 2022) & Completion deadline:	*June 3, 2022*
5.	Interview's (Start June 6, 2022), Completed by:	*July 29, 2022*
6.	Data Analysis & Final Report	*October 28, 2022*
7.	Final Meeting & Event	*November 21, 2022*

How are your organization's other Activities Impacted?

The following time is estimated to be additional to brewery operations:

1.	Project Document Review (3 documents) x 15-30 mins	45-90 minutes
2.	Project Meetings (3-4 estimated) x 1 hr	3-4 hours
3.	Final Project Review (March)	1-2 hours
4.	Committee Meeting (March)	1 hour
5.	Survey & Interview Participation	1-2 hours
6.	Final Report Review	1-2 hours
7.	Final Meeting & Event	3-4 hours
	Total:	10.75-16.5 hours

The shown time estimates will be scheduled around brewery operations at the convenience of Brian, Iain, and myself to minimize/eliminate any disruptions to operations. Project execution will be completed by Marika before scheduled deadlines and submit to the required parties for review within an allotted time frame to diminish any disruptions to brewery operations.

Readiness for Next Steps:

Essential Contacts:
University of Manitoba – Food Science Department

- James House (Consult with and secure the final Committee Member)

Other Resource Needs or Supports:
None identified at this time.

Appendix C: Schedule Details

Activity List

The following activity list is the breakdown of activities numerically organized in the Work Breakdown Structure and depicted in the Sequence Network Diagram. The Activity list serves as a living project document, used to document the start and finish of tasks, thus tracking their actual duration compared with their estimated duration.

Table A.C.1. Project activity list.

WBS No.	Deliverable	Work Package	Est'd Duration	Date Initiated	Date Complete	Actual Duration	Comments
10.0	Research						
10.1	Website Review		8 Weeks				May 2, 2022 – June 24, 2022
10.1.1		List all Canadian Craft Brewers	1 Day				
10.1.2		Visit all Websites for Review	6 Weeks				
10.1.3		Document Brewery Email Addresses					
10.1.4		Compile Data	2 Weeks				
10.1.5		Analyze Data					
10.2	Survey		2 Weeks				July 4, 2022 – July 15, 2022
10.2.1		Obtain Survey Monkey Account	1 Hour				
10.2.2		Create Survey	1 Week				
10.2.3		Compile Brewery Email Addresses	1 Day				
10.2.4		Distribute Survey	1 Day				
10.2.5		Compile Survey Data	2 Weeks				
10.2.6		Analyze Data	1 Week				
10.3	Interviews		11 Weeks				July 18, 2022 – Sept. 30, 2022
10.3.1	WPG Craft Brewers		6 Weeks				
10.3.1.1		Obtain Calendly Acc.	1 Hour				
10.3.1.2		Upgrade Zoom Acc.	1 Hour				
10.3.1.3		Create Interview Schedule	1 Week				
10.3.1.4		Schedule Brewer Interviews Online	1 Hour				Interviewees Schedule Interviews online for Convenience with Link
10.3.1.5		Conduct Interviews	6 Weeks				Same Weeks as Potential Users
10.3.1.6		Compile and Transcribe Data	1 Day				Transcription Done Immediately - Same Day as Interview for QA
10.3.1.7		Analyze Data	5 Weeks				Analyze simultaneously with Potential User Interview Data
10.3.2	MB Potential Users for Upcycled BSG		6 Weeks				
10.3.2.1		Create Interview Schedule	1 Week				
10.3.2.2		Research Potential MB Users for Upcycled BSG	1 Week				
10.3.2.3		Contact Potential Users & Schedule Interviews Online	1 Hour				Interviewees Schedule Interviews online for Convenience with Link

10.3.2.4		Conduct Interviews	6 Weeks				Same Weeks as Brewers
10.3.2.5		Compile and Transcribe Data	1 Day				Transcription Done Immediately - Same Day as Interview for QA
10.3.2.6		Analyze Data	5 Weeks				Analyze Simultaneously with Brewer Interview Data
20.0	Final Report						Oct. 6, 2022 – Nov. 4, 2022
20.1		Compile All Research Data from 10.0	1 Day				
20.2		Analyze All Research Data and Compare	3 Weeks				
20.3		Write Final Report on Findings					
20.4		Design Upcycling Framework for WPG	1 Week				
30.0	Focus Group						Nov. 21, 2022 – Nov. 27, 2022
30.1	Plan Focus Group						Nov. 21, 2022 – Nov. 25, 2022
30.1.1		Schedule Meeting Date	1 Day				
30.1.2		Book Equipment Rentals	1 Day				
30.1.3		Write Focus Group Questions	1 Week				
30.1.4		Print Materials	3 Days				
30.2	Hold Focus Group						November 27, 2022
30.2.1		Meeting Set-Up	1 Day				
30.2.2		Conduct Focus Group	1 Day				
30.2.3		Analyze FG Feedback and Data	1 Week				
40.0	GHG Emissions						Dec. 5, 2022 – Dec. 30, 2022
40.1		Document BSG Waste Routes in WPG	2 Days				
40.2		Calculate Approx. GHG Emissions of Waste Routes	3 Days				
40.3		Calculate Approx. GHG Emissions of Upcycling Chain	3 Days				
40.4		Compare GHG Emissions of Supply Chains	2 Days				
50.0	Final Framework & Short Report						Dec. 5, 2022 – Dec. 30, 2022
50.1		Incorporate Feedback & Finalize Framework	1 Week				
50.2		Conduct Required / Additional Research	1 Week				
50.3		Write Short Report	2 Weeks				

Work Breakdown Structure

The Work Breakdown Structure is a hierarchal diagram depicting the tasks associated with each objective/ deliverable of the project. It serves as the breakdown of "work packages" required and allows for the development of: (A) The Activity List, which estimates task durations, and (B) The Sequence Network Diagram, which allows for the organization of dependent tasks within the project. The Work Breakdown Structure is the unfolding of the broader deliverable requirements outlined in the Project Charter.

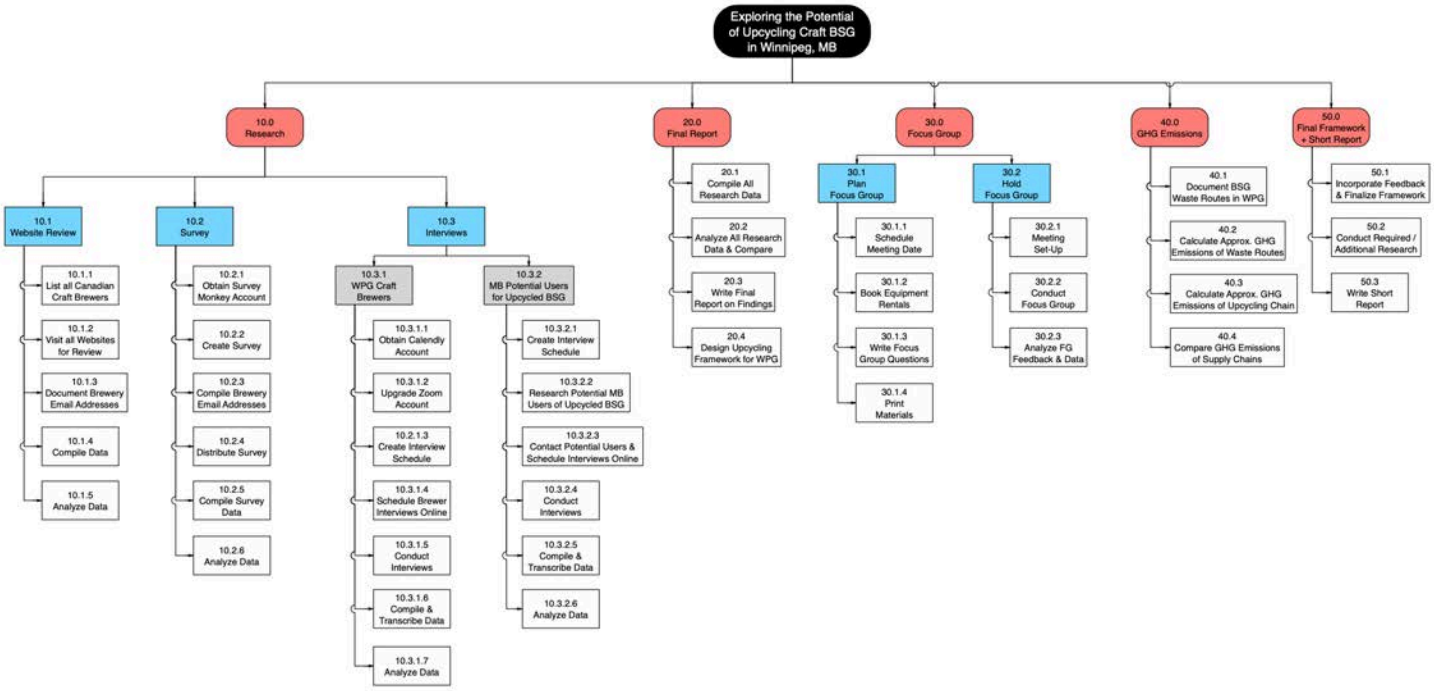

Figure A.C.1. Work breakdown structure (WBS).

Sequence Network Diagram

The Sequence Network Diagram is a flowchart developed to organize dependent tasks within the project, and aids in scheduling tasks. Tasks dependent on a previous task are marked with an arrow, serving as a visual guide to the progression of the project. The completion of certain tasks allows the start of another, and others allow various tasks to begin. The projects required research data completion steps are marked with blue rectangular boxes, which are the desired products of the project as outlined in the Project Charter. Project milestones are marked with Red Rounded Rectangles and mark significant accomplishments associated with project progression. Milestones are used to ensure the project schedule is being completed on time. The Sequence Network Diagram is shown in smaller segments for easy reading of tasks. Connecting points are marked with an orange star. Following the segments is the full diagram of the project Sequence Network.

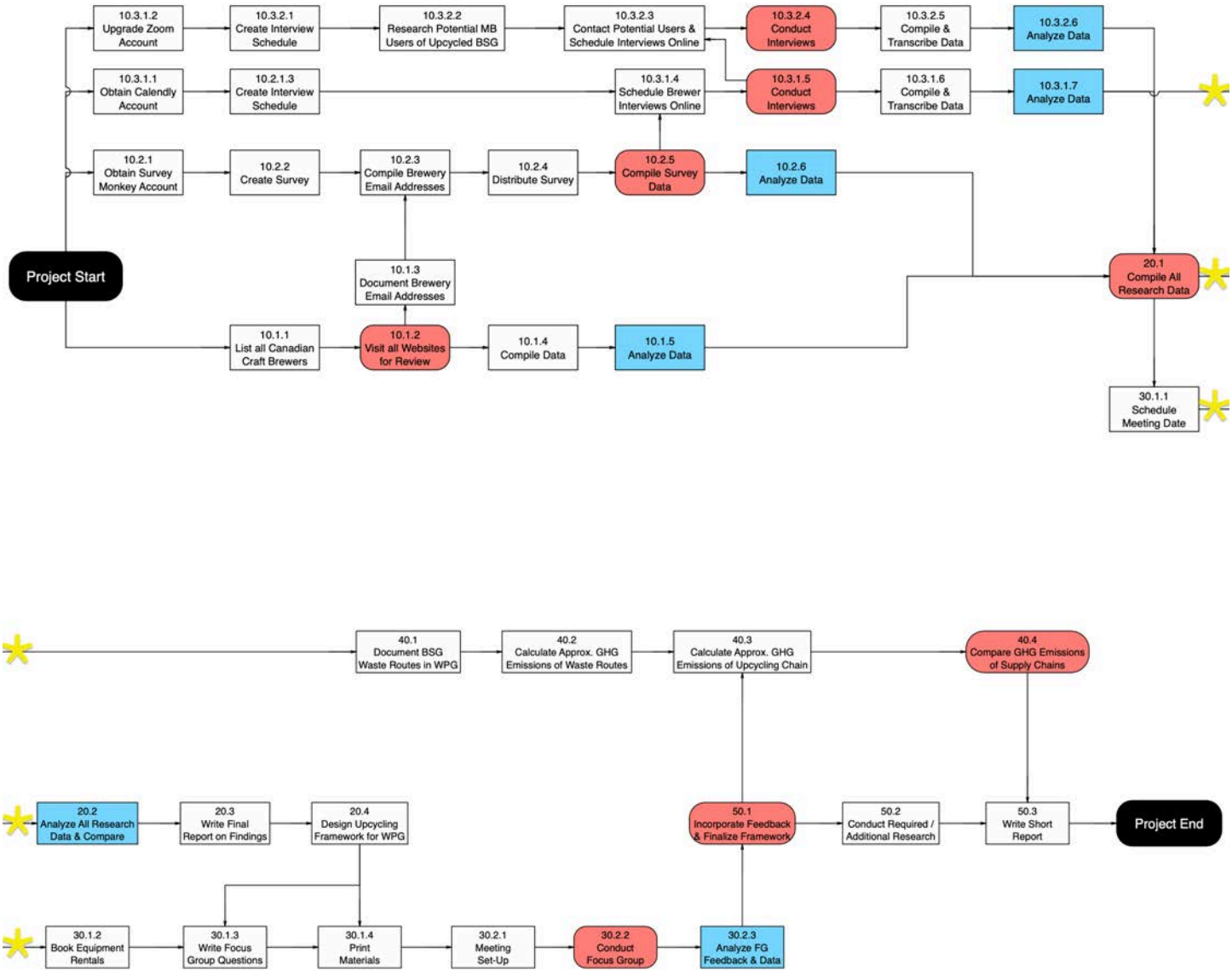

Figure A.C.2. Sequence network diagram.

Project Milestones

Project milestones mark significant accomplishments associated with project progression and have been drawn from the Sequence Network Diagram provided above. The following table is a living project document used to list the expected completion date of a Milestone and mark the actual completion date. Milestones are used to ensure the project schedule is being completed on time. Early completion of milestones may allow for a dependent task to be completed at an earlier date, but late milestones jeopardize the project schedule.

Table A.C.2. Project milestones tracking.

WBS No.	Milestone	Expected Completion Date	Actual Completion Date	Comments
0.0	Project Start	May 2, 2022		
10.1.2	Complete Canadian Craft Brewery Website Review	June 24, 2022		
10.2.5	Compile Canadian Craft Brewers Online Survey Data (Have all surveys returned)	July 15, 2022		
10.3.1.5	Complete all Interviews with Winnipeg Craft Brewery Owners	August 26, 2022		
10.3.2.4	Complete all Interviews with Potential Users of Upcycled BSG in Manitoba	August 26, 2022		
20.1	Have all Research Data Analysis' Combined for Further Analysis in Final Report & Framework	September 30, 2022		
30.2.2	Execute Focus Group	November 27, 2022		
50.1	Finalize Upcycling Framework for BSG having incorporated Feedback from Focus Group (Framework Complete)	December 9, 2022		
40.4	Complete Formal Comparison of GHG Emissions of Conventional and Upcycling Supply Chains of BSG	December 16, 2022		
0.0	Project End	December 30, 2022		

Critical Path Chart and Calculations

The Critical Path is the shortest possible duration of the project and is calculated from the addition of all dependent project tasks with no float time. Tasks with zero float time must start and end on the scheduled dates and cannot be moved in the schedule. Critical Path calculations are provided in the table following the diagram, with activity float time displayed in the far-right column. Project early start/early finish dates and late start/late finish dates are calculated at the end of the table. Critical Path activities are marked with red rectangular boxes in the following flowchart, while dependent tasks with float time are marked with white rectangular boxes. All tasks that require completion prior to applying for ethics are marked with blue rectangular boxes. When making the schedule, tasks with float time can be scheduled at a convenient time within the date range to allow workload to be spread out evenly, ensuring all work is done with the upmost quality.

Critical Path Chart

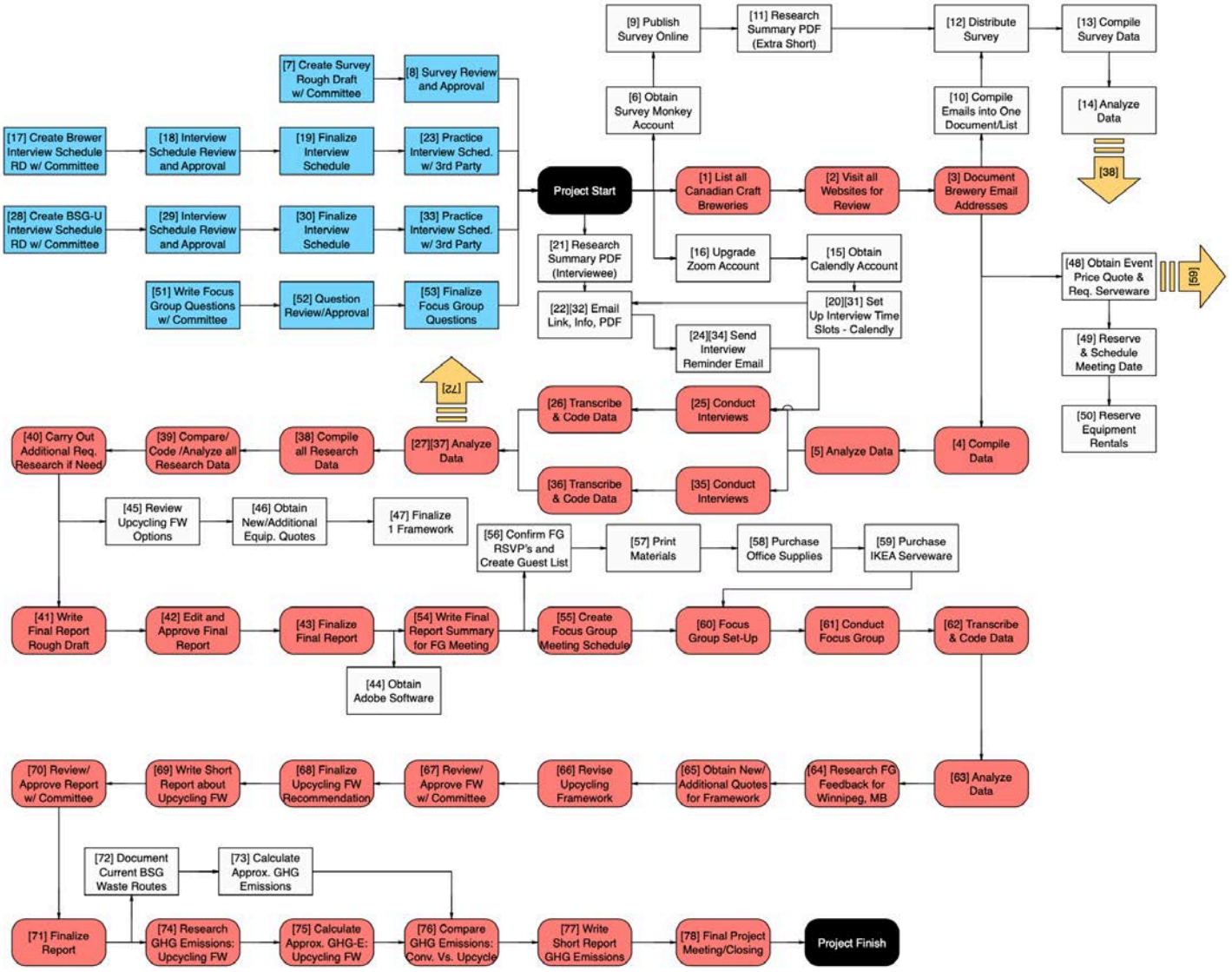

Figure A.C.3. Critical path chart

Critical Path Calculation

Table A.C.3. Critical path calculations.

#	Activity Description	Dependency	Duration	Early Start	Early Finish	Late Start	Late Finish	Float Time
0	Project Start	-	0 Days	May 2	May 2	-	-	0 Days
1	List all Canadian Craft Breweries	-	1 Day	May 2	May 2	-	-	0 Days
2	Visit all Website for Review	1	6 Weeks	May 3	June 9	-	-	0 Days
3	Document Brewery Email Addresses	2	1 Day	June 10	June 10	-	-	0 Days
4	Compile Data	2	1 Week	June 13	June 17	-	-	0 days
5	Analyze Data	4	1 Week	June 20	June 24	-	-	0 Days
6	Obtain Survey Monkey Account	-	1 Hour	May 2	May 2	June 24	June 24	54 Days
7	Create Survey Rough Draft w/ Committee	-	1 Week	April 18	April 22	April 25	April 29	7 Days
8	Survey Review/Approval	7	1 Day	April 22	April 22	April 29	April 29	7 Days
9	Publish Survey Online	8	1 Day	May 2	May 2	June 24	June 24	54 Days
10	Compile Brewery Email Addresses into 1 Document and Email List	3	1/2 Day	June 10	June 10	June 24	June 24	14 Days
11	Create Research Summary PDF (Survey Version – Extra Short)	-	1 Day	May 2	May 2	June 23	June 23	53 Days
12	Distribute Survey	9,10	2 Weeks	June 27	July 8	July 4	July 15	7 Days
13	Compile Survey Data	12	2 Days	July 9	July 10	July 16	July 17	7 days
14	Analyze Data	13	1 Week	July 11	July 15	July 18	July 22	7 days
15	Obtain Calendly Account	-	1 Hour	May 2	May 2	June 24	June 24	54 Days
16	Upgrade Zoom Account	-	1 Hour	May 2	May 2	June 24	June 24	54 Days
17	Create Brewer Interview Schedule Rough Draft w/ Committee	-	1 Week	April 18	April 22	April 25	April 29	7 Days
18	Interview Schedule Review/Approval	17	1/2 Day	April 22	April 22	April 29	April 29	7 Days
19	Finalize Interview Schedule	18	1/2 Day	April 22	April 22	April 29	April 29	7 Days
20	Set up Interview Time Slots in Calendly	15	1/2 Day	May 2	May 2	June 24	June 24	54 Days
21	Create a Research Summary PDF – Interviewee Version	-	1 Day	May 2	May 2	June 24	June 24	54 Days
22	Email Brewers with PDF, Interview Schedule link and Prep Information	20,21	1 Day	June 27	June 27	July 15	July 15	19 Days
23	Practice Interview Schedule on 3rd Party	19	1 Day	April 30	April 30	May 1	May 1	1 Day
24	Send Interview Reminder Email	22	1/2 Day	July 15	July 15	July 17	July 17	2 Days
25	Conduct Interviews	22	3 Weeks	July 18	Aug 5	-	-	0 Days
26	Transcribe & Code Data	25	1 Week	Aug 29	Sept 2	-	-	0 Days
27	Analyze Data	26	3 Weeks	Sept 5	Sept 23	-	-	0 Days
28	Create BSG Users Interview Schedule Rough Draft w/ Committee	-	1 Day	April 18	April 22	April 25	April 29	7 Days
29	Interview Schedule Review/Approval	28	1/2 Day	April 22	April 22	April 29	April 29	7 Days
30	Finalize Interview Schedule	29	1/2 Day	April 22	April 22	April 29	April 29	7 Days
31	Set up Interview Time Slots in Calendly	15	1/2 Day	May 2	May 2	June 24	June 24	54 days
32	Email BSG Users with PDF, Interview Prep Information & Schedule Link	21,31	1 Day	June 27	June 27	August 1	August 1	36 Days
33	Practice Interview Schedule on 3rd Party	30	1 Day	April 30	April 30	May 1	May 1	1 Day

34	Send Interview Reminder Email	32	1/2 Day	July 15	July 15	July 17	July 17	2 Days
35	Conduct Interviews	32	3 Weeks	Aug 8	Aug 26	-	-	0 days
36	Transcribe & Code Data	35	1 Week	Aug 29	Sept 2	-	-	0 Days
37	Analyze Data	36	3 Weeks	Sept 5	Sept 23	-	-	0 Days
38	Compile all Research Data	5,14,27,37	1 Day	Sept 23	Sept 23	-	-	0 Days
39	Compare, Code and Analyze all Research Data	38	1 Week	Sept 26	Sept 30	-	-	0 Days
40	Carry out Additional Required Research if Needed	39	1 Week	Sept 26	Sept 30	-	-	0 Days
41	Write Final Report Rough Draft	40	3 Weeks	Oct 3	Oct 21	-	-	0 Days
42	Edit/Approve Final Report	41	1 Week	Oct 24	Oct 28	-	-	0 Days
43	Finalize Final Report	42	1 Week	Oct 31	Nov 4	-	-	0 Days
44	Obtain Adobe Software	-	1/2 Day	Aug 1	Aug 1	Sept 30	Sept 30	61 Days
45	Review Upcycling Framework Options	40	1 Week	Oct 3	Oct 7	Oct 17	Oct 21	14 Days
46	Obtain Quotes for all Related Framework Equipment/Other	45	1 Week	Oct 10	Oct 14	Oct 24	Oct 29	14 Days
47	Finalize 1 Upcycling Framework	46	1 Week	Oct 17	Oct 21	Oct 31	Nov 4	14 Days
48	Obtain Event Price Quote & Determine Missing Eating Ware	-	1 Day	April 4	April 4	April 22	April 22	19 Days
49	Reserve & Schedule Meeting Date	48	1 Day	April 4	April 4	April 22	April 22	19 Days
50	Reserve Equipment Rentals	49	1 Day	April 4	April 4	April 22	April 22	19 Days
51	Write Focus Group Questions Rough Draft w/ Committee	-	1 Week	April 18	April 22	April 25	April 29	7 Days
52	Question Review/Approval	51	1/2 Day	April 22	April 22	April 29	April 29	7 Days
53	Finalize Focus Group Questions	52	1/2 Day	April 22	April 22	April 29	April 29	7 Days
54	Write Final Report Summary for Focus Group Meeting	43	3 Days	Nov 7	Nov 9	-	-	0 Days
55	Create Focus Group Meeting Schedule	49	2 Days	Nov 10	Nov 11	-	-	0 Days
56	Confirm Focus Group RSVP's and create Guest List	22,32	1 Day	Nov 7	Nov 7	Nov 11	Nov 11	4 Days
57	Print Materials (Summary and Framework)	54,55	1 Day	Nov 14	Nov 14	Nov 18	Nov 18	4 Days
58	Purchase Office Supplies (Pens, Pencils, Notepads, etc)	55	1 Day	Nov 14	Nov 14	Nov 18	Nov 18	4 Days
59	Purchase IKEA Eating Ware	48,55	1 Day	Nov 14	Nov 14	Nov 18	Nov 18	4 Days
60	Focus Group Meeting Set-Up	55-59	1/2 Day	Nov 20	Nov 20	-	-	0 Days
61	Conduct Focus Group	60	1/2 Day	Nov. 20	Nov. 20	-	-	0 Days
62	Transcribe & Code Data	61	2 Days	Nov 21	Nov 22	-	-	0 Days
63	Analyze Data	62	3 Days	Nov 23	Nov 25	-	-	0 Days
64	Research Focus Group Feedback Feasibility in Winnipeg	63	3 Days	Nov 28	Nov 30	-	-	0 Days
65	Obtain New/Additional Quotes for Framework Requirements	63,64	2 Days	Dec 1	Dec 2	-	-	0 Days
66	Revise Upcycling Framework	65	2 Days	Dec 3	Dec 4	-	-	0 Days
67	Review/Approve Framework with Committee	66	1 Week	Dec 5	Dec 9	-	-	0 Days
68	Finalize Upcycling Framework Recommendation	67	2 Days	Dec 10	Dec 11	-	-	0 Days
69	Write Short Report about Upcycling Framework	68	1 Week	Dec 12	Dec 16	-	-	0 Days
70	Review/Approve Report with Committee	69	1 Week	Dec 19	Dec 22	-	-	0 Days
71	Finalize Report	70	1 Week	Dec 26	Dec 29	-	-	0 Days

72	Document and Map Out Current BSG Waste Routes in WPG	27	1 Day	Oct 3	Oct 3	Nov 30	Nov 30	59 Days
73	Calculate Approximate GHG Emissions of Waste Routes	72	1 Day	Oct 3	Oct 3	Dec 1	Dec 1	60 Days
74	Research GHG Emissions of Upcycling Framework Components	68	3 Days	Dec 19	Dec 21	-	-	0 Days
75	Calculate Approximate GHG Emissions of Upcycling Chain	74	1 Day	Dec 22	Dec 22	-	-	0 Days
76	Compare GHG Emissions of Current vs. Proposed Routes	73,75	1 Day	Dec 23	Dec 23	-	-	0 days
77	Write a Short Report on GHG Emissions Differences	76	1 Week	Dec 26	Dec 29	-	-	0 Days
78	Hold Final Project Meeting to Approve all Deliverables and Review	71,78	1 Day	Dec 30	Dec 30	-	-	0 Days
			Total:	May 2	Dec 30	-	-	0 Days

Appendix D: Resource Needs Assessment & Skills Inventory

Resource (Skills and Knowledge) Needs Acquisition Plan:

The project "Exploring the Potential of Upcycling Craft BSG in Winnipeg, MB" requires a variety of skills and knowledge in order for all objectives and deliverables to be completed with the highest quality standards. As outlined below in the *Resource (Skills and Knowledge) Needs Assessment*, all skill and knowledge requirements are held by the project partners therefore no additional individuals/companies are required.

Resource (Skills and Knowledge) Needs Assessment:

Table A.D.1. Resource (Skills and Knowledge) needs assessment.

Activity / Task	Quantity	Skill/Knowledge Requirement	Team Member (Name)	Contract (Name/Company)	Approximate Cost ($/Time)
List all Canadian Craft Brewers	1	Online Directory by Province	Marika		$0.00
Visit all Websites for Review	1200+	Google Search + Website Review	Marika		$0.00
	1	Research Skills	Marika		
Document Brewery Email Addresses	1	Website Review – Contact Info.	Marika		$0.00
Compile Data	1200+	Statistical Analysis and Themes	Marika		$0.00
Analyze Data	1	Data Analysis	Marika		$0.00
Obtain Survey Monkey Account	1	Account Set-Up	Marika		$0.00
Create Survey	1	Online Survey Creation	Marika		$0.00
	1	Required/Appropriate Questions	Marika/Iain		
Compile Brewery Email Addresses	1	(From Website Review)	Marika		$0.00
Distribute Survey	1	Email Link to Survey	Marika		$0.00
Compile Survey Data	1200+	Statistical Analysis and Themes	Marika		$0.00
Analyze Data	1	Data Analysis	Marika/Iain		$0.00
Obtain Calendly Acc.	1	Account Set-Up	Marika		$0.00
Upgrade Zoom Acc.	1	Account Set-Up	Marika		$0.00
Create Interview Schedule	1	Data Needs Assessment	Marika		$0.00
	1	Required/Appropriate Questions	Marika/Iain		
Schedule Brewer Interviews Online	23	Brewery Contact Info (Referrals)	Brian		$0.00
	1	Online Schedule Set-Up	Marika		
Conduct Interviews	1	Interview Schedule + Follow-Up	Marika		$0.00
	1	Interviewer	Marika		
Compile and Transcribe Data	23	Transcription Proofread	Marika		$0.00
Analyze Data	23	Data Analysis	Marika		$0.00
Create Interview Schedule	1	Required/Appropriate Questions	Marika/Iain		$0.00
		Food Science Expertise	Committee	UofM	$0.00
Research Potential MB Users for Upcycled BSG	1	Literature Review	Marika		$0.00
	1	MB Directory + Google Search	Marika		
Contact Potential Users & Schedule Interviews Online	10+	Food Processors Contact Info.	Marika/Brian		$0.00
	1	Online Schedule Set-Up	Marika		
Conduct Interviews	10+	Interview Schedule + Follow-Up	Marika		$0.00
	1	Interviewer	Marika		
Compile and Transcribe Data	10+	Transcription Proofread	Marika		$0.00
Analyze Data	1	Data Analysis	Marika		$0.00
Compile All Research Data from 3 Methods	1	Data Analysis	Marika		$0.00
Analyze All Research Data and Compare	1	Data Analysis	Marika		$0.00
	1	Statistical Analysis and Themes	Marika		
Write Final Report on Findings	1	Writing Skills	Marika		$0.00
Design Upcycling Framework for WPG	1	Research Skills	Marika		$0.00
	5+	Equipment Quotes	Marika		$0.00
	1	Basic Graphic Design	Marika		$0.00
Schedule Meeting Date	1	Event Planning	Marika/Brian/ Iain		$0.00
Book Equipment Rentals	1	Organization	Marika		$0.00

Write Focus Group Questions	1	Required/Appropriate Questions	Marika/Iain/ Brian	$0.00
Print Materials	1	Organization	Marika	$0.00
Meeting Set-Up	1	Organization	Marika/Brian	$0.00
Conduct Focus Group	1	Research Skills	Marika/Iain	$0.00
	1	Communication Facilitation	Marika	$0.00
	2	Event Hosting	Marika/Brian	$0.00
Analyze FG Feedback and Data	1	Data Analysis	Marika/Iain/ Brian	$0.00
Document BSG Waste Routes in WPG	1	Data Analysis	Marika	$0.00
	1	Research Skills	Marika	$0.00
Calculate Approx. GHG Emissions of Waste Routes	1	Research Skills	Marika	$0.00
Calculate Approx. GHG Emissions of Upcycling Chain	1	Research Skills	Marika	$0.00
	5+	Equipment Quotes	Marika	$0.00
Compare GHG Emissions of Supply Chains		Data Analysis	Marika	$0.00
Incorporate Feedback & Finalize Framework	1	Data Analysis	Marika/Iain/ Brian	$0.00
	1	Basic Graphic Design	Marika	$0.00
Conduct Required / Additional Research	1	Research Skills	Marika	$0.00
Write Short Report	1	Writing Skills	Marika	$0.00
			Approx. Total:	**$0.00**

Skills and Knowledge Inventory of Team/Partner/Volunteers:

Table A.D.2. Skills and knowledge inventory of team/partner/volunteers.

Person	Job Title	Skills/Training	Years	Education
Marika Boryen	Project Manager / Student	Quantitative Research + Data Analysis Qualitative Research + Data Analysis Communication/People Skills Manager Experience Project Management Adult Teaching Computer + Microsoft Office Organizational Skills	10.0 0.5 15.0 3.0 0.5 0.5 13.0 15.0	Bachelor's of Food Science (2018) Graduate Teaching Program (2022) Master's of Natural Resource Management (2023 Expected)
Iain Davidson-Hunt	Project Team Member / Advisor	Knowledge of Practicum Process Qualitative Research Craft Brewing Local Supply Chains	19.0+	Ph.D. NREM (2003) M.N.R.M. (1995) B.Sc. Crop Science (1988)
Brian Westcott	Project Partner / Operations Manager, Barn Hammer Brewing Company	Working in Craft Breweries in Canada Business Co-Owner Business & Brewery Operations Brewery Inputs/Outputs Craft Brewery Contacts	16.0	MSc Brewing and Distilling (2007) Heriot-Watt Edinburgh BSc Biology (2003 University of Calgary

Resource Needs (Materials, Supplies and Equipment) and Procurement Plan:

As listed below in the *Resource Needs (Materials, Supplies and Equipment) Assessment*, a large portion of the project can be executed with personal equipment held by the project manager, mainly; an internet connection and student access to UofM libraries for research, a personal laptop with all basic programs (word, excel, PowerPoint), and a cell phone. Additional materials, supplies and equipment that is not already owned will be procured by the following methods:

1. Online Account/Subscriptions – A membership to SurveyMonkey (unlimited online surveys), Calendly (Convenient meeting scheduling online), Adobe software (Graphic Design Programs) and upgraded version of Zoom (unlimited length of meetings and transcription capabilities) will be acquired from their respective websites by the project manager as they are available to anyone who pays for a membership.
    a. SurveyMonkey – https://www.surveymonkey.com
    b. Calendly – https://calendly.com
    c. Adobe - https://www.adobe.com/ca/
    d. Zoom – https://zoom.us
2. Gas – If there are potential interviewees that cannot be reached with significant effort by email or phone, there may be need to meet in-person to secure an interview. In this case, the personal vehicle of the project manager will be used and some gas allowance may be required.
3. Equipment Rentals – The required equipment (Projector, projector screen, projector stand and computer cables) will be booked by telephone from RealTime upon confirmation of the Focus Group meeting date.
4. Printed Materials & Pens/Pencils – The brochures and printed short reports of research findings will be ordered online prior to Focus Group date from Staples with enough time to re-order if necessary or order any additional desired materials. Office supplies such as pens and pencils required for Focus Group meeting will be acquired at the time of printing pick-up.
5. Plates/Cups/Utensils – Any additional serve-ware required for Focus Group food/snacks/beverages will be acquired from IKEA upon meeting confirmation with Barn Hammer.
6. Event Space/Rental – Meeting space for the Focus Group will be arranged with the project partner (Brian - Barn Hammer) prior to beginning interviews to give sufficient notice to interviewees and arrange equipment and materials to execute Focus Group.
7. Additional Food/Drinks – As a part of Focus Group event rental confirmation, details outlining available food and beverages will be confirmed to further discuss any additional food beverages required. If additional foods/beverages will be acquired by the project manager on the meeting date from Superstore or any business that carriers the required products.

Resource Needs (Materials, Supplies and Equipment) Assessment:

Table A.D.3. Resource (Materials, supplies, and equipment) assessment.

Activity / Task	Quantity	Materials/Supplies/Equipment	Available / Procure	Approx. Cost ($/Time)
List all Canadian Craft Brewers	1	(Computer, Internet, Phone)	Available	$0.00
Visit all Websites for Review	1	(Computer, Internet, Phone)	Available	$0.00
Document Brewery Email Addresses	1	(Computer, Internet, Phone)	Available	$0.00
Compile Data	1	(Computer, Internet, Phone)	Available	$0.00
Analyze Data	1	(Computer, Internet, Phone)	Available	$0.00
Obtain Survey Monkey Account	1	(Computer, Internet, Phone)	Available	$0.00
	1	SurveyMonkey Online Account	Procure	$408.00
Create Survey	1	(Computer, Internet, Phone)	Available	$0.00
Compile Brewery Email Addresses	1	(Computer, Internet, Phone)	Available	$0.00
Distribute Survey	1	(Computer, Internet, Phone)	Available	$0.00
Compile Survey Data	1	(Computer, Internet, Phone)	Available	$0.00
Analyze Data	1	(Computer, Internet, Phone)	Available	$0.00
Obtain Calendly Acc.	1	(Computer, Internet, Phone)	Available	$0.00
	1	Calendly Online Account	Procure	$76.40

Upgrade Zoom Acc.	1	(Computer, Internet, Phone)	Available	$0.00
	1	Zoom Account (Small Business Membership)	Procure	$108.00
Create Interview Schedule	1	(Computer, Internet, Phone)	Available	$0.00
	1	Calendly Account	Procure	*N/A*
Schedule Brewer	1	(Computer, Internet, Phone)	Available	$0.00
Interviews Online	100 L	Gas (In-Person Introductions)	Procure	$200.00
	1	Calendly Account	Procure	*N/A*
Conduct Interviews	1	(Computer, Internet, Phone)	Available	$0.00
	1	Zoom	Procure	*N/A*
Compile and Transcribe	1	(Computer, Internet, Phone)	Available	$0.00
Data	23+	Zoom Transcription	Available	*N/A*
Analyze Data	1	(Computer, Internet, Phone)	Available	$0.00
Create Interview Schedule	1	(Computer, Internet, Phone)	Available	$0.00
Research Potential MB Users for Upcycled BSG	1	(Computer, Internet, Phone)	Available	$0.00
Contact Potential Users &	1	(Computer, Internet, Phone)	Available	$0.00
Schedule Interviews	100 L	Gas (In-Person Introductions)	Procure	$200.00
Online	1	Calendly Account	Procure	*N/A*
Conduct Interviews	1	(Computer, Internet, Phone)	Available	$0.00
	1	Zoom	Procure	N/A
Compile and Transcribe	1	(Computer, Internet, Phone)	Available	$0.00
Data	23+	Zoom Transcription	Available	N/A
Analyze Data	1	(Computer, Internet, Phone)	Available	$0.00
Compile All Research Data from 3 Methods	1	(Computer, Internet, Phone)	Available	$0.00
Analyze All Research Data and Compare	1	(Computer, Internet, Phone)	Available	$0.00
Write Final Report on Findings	1	(Computer, Internet, Phone)	Available	$0.00
Design Upcycling	1	(Computer, Internet, Phone)	Available	$0.00
Framework for WPG	1	Adobe Creative Cloud Membership	Procure	$279.96
Schedule Meeting Date	1	Barn Hammer Event Schedule + Date	Procure	*N/A*
Book Equipment Rentals	1	Projector + Screen (RealTime) (1 Day)	Procure	$225.00
Write Focus Group Questions	1	(Computer, Internet, Phone)	Available	$0.00
Print Materials	25	Brochures (Staples) ((25 = $22.49) x 2)	Procure	$44.98
	50	Report (Staples) (3 pages x $1.47 x 50)	Procure	$73.50
Meeting Set-Up	1	Meeting Space (Event Booking) *Barn Hammer*	Available	*Unknown*
	1	Booked Equipment for Presentation	N/A	*N/A*
	50	Plates/Cups/Utensils	Procure	$100.00
Conduct Focus Group	50	Food/Drinks	N/A	*N/A*
	50	Printed Materials	N/A	*N/A*
	50	Pens/Pencils	Procure	$50.00
	1	Event Schedule	Procure	*N/A*
	1	Focus Group Questions	N/A	$0.00
Analyze FG Feedback and Data	1	(Computer, Internet, Phone)	Available	$0.00
Document BSG Waste Routes in WPG	1	(Computer, Internet, Phone)	Available	$0.00
Calculate Approx. GHG Emissions of Waste Routes	1	(Computer, Internet, Phone)	Available	$0.00
Calculate Approx. GHG Emissions of Upcycling Chain	1	(Computer, Internet, Phone)	Available	$0.00
Compare GHG Emissions of Supply Chains	1	(Computer, Internet, Phone)	Available	$0.00
Incorporate Feedback &	1	(Computer, Internet, Phone)	Available	$0.00
Finalize Framework	1	Adobe Creative Cloud Membership	N/A	*N/A*
Conduct Required / Additional Research	1	(Computer, Internet, Phone)	Available	$0.00
Write Short Report	1	(Computer, Internet, Phone)	Available	$0.00
			Approx. Total:	$1,765.84
				+ *Event Costs TBD*

Appendix E: Managing Relationships – Details

This document indicates the parties that have interest in the success of this project, as well as those who are affected by the outcome, whether it be positively or negatively. We first consider the parties directly involved in the execution of the project, meaning those that are essential to the success of research activities. Next the document considers parties external to the project who have interest in the outcome as it affects them or their business in some way. The third section of the document addresses the mechanisms, timing and frequency of the anticipated communication methods needed to manage relationships in the most positive way possible throughout the project. The Project Charter outlines the activities involved in executing the project and therefore serves as a beginning point of interested parties addressed in the first three tables. The fourth and final section of the Managing Relationships document indicates the intended audience of promotion following project completion, aimed at acquiring interest and funding for framework implementation.

Considerations for Engagement with Advisor, Committee, Partner and Team

Table A.E.1. Considerations for engagement with advisor, committee, partner, and team.

Name or Office	Nature of Interest	Type of Engagement Needed
Iain Davidson-Hunt	As a project advisor and co-manager, Iain has invested his time, knowledge, and resources into this project. As so, Iain has been directly involved in project planning and therefore has personal interest in the successful outcome.	- Document Sharing - Must approve each project document to ensure that the final IPP is complete and of the highest quality. - Email – Regular and constant communication is needed. All questions and project communication can be done via email to ensure project schedule is progressing as planned and that issues, concerns and/or questions are dealt with immediately. - Data – All data and analysis will be verified and receive input from Iain, and he will therefore be updated with all research activities throughout project. - Advisor – As the project advisor, Iain requires updates on project progression, research activities, report writing, involvement in research questions, etc. meaning that he must know everything that the project manager (Marika) knows about the project.
Brian Westcott	As the project partner, Brian has invested time, industry knowledge, and his name in this project. As his brewery (Barn Hammer) is the 'face of the project', he has a personal desire to uphold his reputation and to support meaningful research within his industry. Further, Brian has personal interest in the success of this project as it has potential to benefit the craft brewers of Winnipeg, thus includes him personally.	- Email – Regular and constant communication is needed in order to ensure that all members of the project committee are up to date on project progression, as well as to address questions and/or concerns. - Partner – As the project partner, Brian is not responsible for ensuring that all project tasks are completed on time, but must be aware of project progression through regular updates. Project progression will also require signatures at the completion of various steps to ensure he is satisfied with the outcome. - Deliverables – All completed deliverables must be provided to Brian for review and approval before finalizing and receiving a final copy.
Food Science Committee Member	As a committee member, this individual is investing time, knowledge and resources throughout the project and therefore has personal interest that their efforts are not wasted. As a committee member, their name and reputation are involved which adds to their interest in a meaningful and quality outcome.	- Integrated Project Plan – As a committee member, approval of the IPP is required and will therefore be provided a copy for review and feedback. - Email – The member will be included in all project communications to ensure they are up to date on project progression. - Data & Research – As a specialist in their field, this committee member will be involved in research question formulation and data review to ensure accuracy.

External Interested Party Register

Table A.E.2. External interested party register.

Interested Party	Why They Care	What They Seek from Us	What We Seek from Them	Implications for Managing the Relationships
Winnipeg Craft Brewers	The successful outcome of this project could provide business and financial benefits to the craft brewers of Winnipeg, therefore it is in their interest to facilitate and participate in research.	- Final Research findings and summarized reports - Inclusion in Focus Group for opportunity to provide feedback on framework - Copy of final framework with short report detailing benefits of BSG upcycling - Answers to questions and/or concerns throughout project	- Participation in online survey, interviews, and focus group - Open and honest responses to research questions (rich and accurate data) - Personal references to food processors with potential use for upcycled BSG to contact for research	- Email communication when needed (Interview scheduling, questions and/or concerns, provide reports, etc.) - Updates on milestones with recognition for their participation
Potential Users of Upcycled BSG (MB)	The successful outcome of this project could provide business and financial benefits to select food processors in Manitoba, therefore it is in their interest to facilitate and participate in research.	- Final Research findings and summarized reports - Inclusion in Focus Group for opportunity to provide feedback on framework - Copy of final framework with short report detailing benefits of BSG upcycling - Answers to questions and/or concerns throughout project	- Participation in online survey, interviews, and focus group - Open and honest responses to research questions (rich and accurate data) - Personal references to other/more food processors with potential use for upcycled BSG to contact for research	- Email communication when needed (Interview scheduling, questions and/or concerns, provide reports, etc.) - Updates on milestones with recognition for their participation
Livestock Farmers Receiving BSG	A realistic and feasible upcycling framework may result in future implementation, which would lead to the end of a free/low-cost food supply for their livestock.	- Some consideration in framework planning	- What percentage of their livestock feed comes from BSG (How reliant are they on this food supply)	- Phone or email communication
Transporters of BSG from Brewery to _____	Depending on the agreement between the farmer and brewery, implementation of the proposed framework could result in a loss of payment (either way) or could result in a decrease in transport.	- An accurate analysis of how framework implementation would alter their activities	- N/A	- None required - Can contact the project manager if desired with questions and/or concerns
Individuals using BSG for Compost	The success and future implementation of this project could result in a	- An accurate analysis of how framework	- N/A	- None required - Can contact the project manager

	compost source loss, and therefore these individuals would be affected.	implementation would alter their activities		if desired with questions and/or concerns
Ingredient Suppliers of MB Processors	The success of this project with future implementation could result in a decrease in ingredient demand of those replaced partially by BSG, which would result in a financial loss.	- An accurate analysis of how framework implementation would alter their activities	- N/A	- None required - Can contact the project manager if desired with questions and/or concerns
Processing Equipment Supplier	The success of this project could result in processing/framework equipment ordered from this company.	- Honest description of what equipment cost quotes are	- Accurate cost quote with all upfront and hidden costs included - All available GHG emissions values for the quoted equipment, as well as operation energy requirements	- Phone or email communication when necessary
Government of Manitoba	The success of this project with a result of implementation would be beneficial to the provinces environmental impact reduction targets, and therefore they might have interest in promoting some local efforts or documenting success of upcycling.	- Summary of research findings - Copy of final report - Outline of framework with associated short report of environmental benefits of upcycling	- Recognition for work done - Opportunity to speak to research if being promoted publicly	- None at this time
General Public	If project leads to the implementation of upcycling BSG, the general public who buys from the associated beer and food brands have an increased sense of being environmentally conscious in the products they choose, as well as supporting local to be more sustainable.	- Honest information and facts in any public advertising of upcycling or circular economy - Delicious products - Consistency	- Brand loyalty	- None required

Managing Relationships – Planning Elements

Table A.E.3. Planning elements for managing relationships.

Interested Party with Whom You Need to Engage	Purposes	Mechanism and Fitness	Timing	Responsibility
Iain Davidson-Hunt	- Project decisions - Up to date information on project progress, concerns, issues, milestones, data - Project Planning - Data Analysis - Document Approvals - Deliverables Approval - Knowledge/advice	- Email – Convenient communication in a professional manner, keeps threads in case there is need to revisit conversations - Phone – Convenient and immediate in case communication is urgent - Zoom – Work on project documents, data analysis, longer discussions regarding project	- Weekly - More constant if needed	- Project Manager
Brian Westcott	- Project decisions - Up to date information on project progress, concerns, issues, milestones, data - Project Planning - Document Approvals - Deliverables Approval - Knowledge/advice	- Email – Convenient communication in a professional manner, keeps threads in case there is need to revisit conversations - Phone – Convenient and immediate in case communication is urgent - Zoom – Work on project documents, data analysis, longer discussions regarding project	- Weekly - More constant if needed	- Project Manager(s)
Food Science committee member	- Up to date information on project progress, concerns, issues, milestones, data - Document Approvals - Deliverables Approval - Knowledge/advice	- Email – Convenient communication in a professional manner, keeps threads in case there is need to revisit conversations - Phone – Convenient and immediate in case communication is urgent - Zoom – Work on project documents, data analysis, longer discussions regarding project	- Weekly - More constant if needed	- Project Manager(s)
Winnipeg Craft Brewers	- Summary of Research Findings - Research needs and objectives - Interview details - Focus Group communication and details	- Email – Convenient communication in a professional manner, keeps threads in case there is need to revisit conversations - Phone – Convenient and immediate in	- At time of need - Response to questions and concerns	- Project Manager(s) - Project Partner

		case communication is urgent		
Potential Users of Upcycled BSG (MB)	- Summary of Research Findings - Research needs and objectives - Interview details - Focus Group communication and details	- Email – Convenient communication in a professional manner, keeps threads in case there is need to revisit conversations - Phone – Convenient and immediate in case communication is urgent	- At time of need - Response to questions and concerns	- Project Manager(s)
Livestock Farmers Receiving BSG	- Address questions or concerns from affected individuals regarding research - Obtain information regarding their dependence on BSG	- Email - Convenient communication in a professional manner, keeps threads in case there is need to revisit conversations	- At time of need - Response to questions and concerns	- Project Manager(s)
Transporters of BSG from Brewery to _____	- Address questions or concerns from affected individuals regarding research	- Email - Convenient communication in a professional manner, keeps threads in case there is need to revisit conversations	- At time of need - Response to questions and concerns	- Project Manager(s)
Individuals using BSG for Compost	- Address questions or concerns from affected individuals regarding research	- Email - Convenient communication in a professional manner, keeps threads in case there is need to revisit conversations	- At time of need - Response to questions and concerns	- Project Manager(s)
Ingredient Suppliers of MB Processors	- Address questions or concerns from affected individuals regarding research	- Email - Convenient communication in a professional manner, keeps threads in case there is need to revisit conversations	- At time of need - Response to questions and concerns	- Project Manager(s)
Processing Equipment Supplier	- Obtain equipment cost quotes - Obtain GHG emissions and energy requirements of desired equipment	- Email - Convenient communication in a professional manner, keeps threads in case there is need to revisit conversations	- At time of need	- Project Manager(s)
Government of Manitoba	*None at this time (Potential funding or grants with project completion for implementation)	N/A	N/A	N/A
General Public	- Highlight research findings and benefits of upcycling - Promote supporting local businesses and environmental benefits	- Social Media - Word of Mouth	- End of project if desired	- Project Manager(s) - Project Partner

Product/Service Promotion Plan

What is the overall Goal of the Project?

The overall goal of this project is to 'Explore the Potential of Upcycling Craft BSG in Winnipeg, MB' in an effort to make local food system changes to support global climate change initiatives.

Why the Promotion Plan is Needed – What is it intended to Achieve?

Promotion would be needed after research and framework are complete and finalized to educate the general public of the benefits of upcycling and operating with a circular economy in general.
Promotion of research findings would also aid in securing funding and support for future implementation.

Intended Audience(s):

- Local Craft Breweries & Food Processors
- Other Local Businesses looking to reduce their Environmental Impacts
- MB Government, Funding Organizations/Opportunities/Investors
- General Public

Key Messages:

1. The process of making a highly sought-after beverage yields _____lbs of high-value "waste" products every year, while huge amounts of energy/resources are being used to produce new products that are largely negatively impacting our planet because we haven't taken time/thought of how to implement circular economy concepts in production cycles.
2. The production of new products uses an increasing number of resources that contribute to the escalating levels of "garbage" polluting the environment, when "waste" products have plenty of life and potential left.
3. Brewers spent grain has plenty of life and too high value to simply become cattle feed after brewing.
4. Give new meaning to "Spent Grain Waste" by using it as an environmentally friendly input into other food products for human consumption that ensure a sustainable future.
5. Local Businesses care about the future our City and Citizens.

Suggested Communication Vehicles with Reasons for Choices:

1. Brewery social media – Easy to reach a large portion of local citizens, can act as a networking platform for individual posting, affordable advertising for promotion, can link to funding opportunities
2. Radio Segment on Local Radio Segments – Local sustainability initiatives can be broadcasted publicly to generate excitement around 'greening' our city, can reach a wide range of individuals, Can reach a different group than social media, recorded version will be available online for social media links and reference, can lead to increased support and networking opportunities
3. Manitoba Brewers Association – A visual and summary of findings for MBBA website news or Instagram account to promote local initiatives for sustainable food systems https://www.manitobabrewers.ca
4. Upcycled Food Association - A visual and summary of findings for Upcycled website news or to promote local upcycling initiatives, build/obtain a supportive community and receive product upcycled certification post-implementation https://www.upcycledfood.org
5. Canadian Association for Food Studies – Peer-Reviewed journal submission so research and findings become peer-reviewed (reinforces trust in conclusions), conference presentation to publicly announce research and findings and gain support in various community groups & levels (Academic, public, business, investor, etc.) https://foodstudies.info

Timing in Relation to Project Stage or Activities:

As this project is concerned with the research required to assess the best possible upcycling framework for Winnipeg, MB, a promotion plan would only be required after project completion when data and statistics are available for promotion. The promotion would be aimed at generating excitement around the sustainability efforts and funding towards implementation of framework.

Other?

Conferences and peer-reviewed journals relating to food and sustainability where project research is accepted

Appendix F: Risk Management – Details

The following in-depth risk analysis has been created for this project as outlined in Risk Management. The Risk Management Plan starts with an extensive list of possible risks associated with this project resulting from multiple comprehensive discussions with the partner brewery concerning deliverables, schedules, contracted/hired work, affected parties and the data required. The identified risks are listed in a "Probability and Impact Matrix" where risk probability and impact are carefully scored on the included scale to identify the most significant risks to the project. Those with the highest probability of occurrence are ordered by significance in a Risk Register, which is used to monitor risks throughout the project by the project manager. All risks with higher probability in this project have an associated response plan included as the last table.

Probability and Impact Matrix

The following table is a list of identified risks to the success, completion, and quality of the project Exploring the Potential of Upcycling Craft BSG in Winnipeg, MB. Risks are identified as affecting or affected by one or more of the following: Schedule, Budget, or Personnel. Of the identified risks, the probability and impact scores are multiplied to give an overall Risk Score. Those with the highest overall scores (Bolded values in the Risk Score column) are addressed in the next table, which will then also be assigned a Response Plan as outlined in the third table.

Probability and Impact scores are assigned as follows:
Very Low 0.05 Low 0.20 Medium 0.40 High 0.60 Very High 0.80

Table A.F.1. Risk management probability and impact matrix.

Risk Description	Probability	Impact	Risk Score
Schedule – Research questions (Survey, Interview, Focus Group) have missing components and therefore research objectives cannot be met and follow-up interviews are required.	0.05	0.60	0.03
Budget – The online accounts/software required increases in cost.	0.20	0.20	0.04
Schedule – A small proportion of Canadian Craft Breweries list a contact email that is checked regularly/at all.	0.40	0.40	0.16
Personnel – Less than 50% of Canadian breweries complete online survey due to missed email or lack of interest, leading data to not be representative of Canada.	0.40	0.60	**0.24**
Schedule – Desired meeting date is not available and project schedule must be shifted to accommodate.	0.20	0.20	0.04
Schedule – A low attendance rate for the Focus Group is obtained from the RSVP's and date must therefore be moved, leading to a date closer to Christmas and people are less likely to attend.	0.20	0.60	0.12
Schedule – Equipment rentals (Projector, stand, screen) are not available for the desired date.	0.20	0.40	0.08
Personnel – Canadian breweries using upcycling concepts to add value to spent grain have not mentioned activities on their website or have not specifically used the word 'upcycling'.	0.40	0.20	0.08

Schedule – The products with BSG incorporated in literature are not manufactured in Manitoba leading to a small group of potential users.	0.40	0.60	**0.24**
Personnel – The potential food processors that can use BSG as an ingredient are not obviously listed on online directories and might therefore be missed for research activities.	0.40	0.60	**0.24**
Personnel – Potential users (Food Processors) cannot provide enough detail in relation to potential use without a company directed ingredient analysis.	0.40	0.40	0.16
Personnel – The Winnipeg craft brewer's are not interested in the project objectives and less than 50% participate in interviews leading to less accurate data and a non-representative sample for data analysis.	0.20	0.80	0.16
Personnel – Interviewee's (Brewers and Potential Users) are concerned with sharing particular information in relation to their operations or are restricted by company policies to share certain information required for accurate data analysis.	0.40	0.40	0.16
Personnel – The available framework options for Winnipeg are too expensive and participants are not interested in implementation.	0.40	0.40	0.16
Personnel – The required equipment for the framework is not available in Winnipeg, MB.	0.20	0.60	0.12
Schedule – The required quotes for an upcycling Framework are not provided in time and companies are not responding to requests for quotes.	0.20	0.60	0.12
Schedule – The GHG emission data for upcycling framework equipment/components is not available/is not provided by company openly.	0.40	0.40	0.16
Schedule – The final report is not completed on time either due to additional time required for rough draft or editing turn-around needs more time.	0.40	0.40	0.16
Schedule – Printed materials are not ready in time to have available for focus group.	0.20	0.60	0.12
Schedule – Focus Group participants forget about meeting and have RSVP's yes but don't show up.	0.40	0.80	**0.32**
Personnel – Adobe software is more difficult to use than anticipated and therefore framework design cannot be done with that program.	0.20	0.60	0.12
Personnel – Focus group participants cannot provide valuable feedback related to framework due to: lack of understanding of any/multiple components, lack of interest, no ideas for improvement, etc.	0.40	0.80	**0.32**
Personnel – Focus Group feedback on framework improvements is valuable but cannot be implemented in Winnipeg.	0.40	0.40	0.16
Schedule – Final project approval meeting is pushed back due to Christmas/busy schedules, thus pushes the project end to January 2022.	0.40	0.40	0.16

Risk Register

The following table is the Risk Register, created using the top five scoring project risks identified in the first table of this document: *Probability and Impact Matrix*. The Risk Register is organized from top to bottom with the most significant risks at the top, followed by the next four. It identifies if and where the associated risk response plan is, who owns the risk, and the status of the risk (Pending, In Progress, Dealt With).

Table A.F.2. Risk management risk register.

Risk	Response Plan Created?	Location of Response Plan	Risk Owner	Status
Schedule – Focus Group participants forget about meeting and have RSVP's yes but don't show up.	Y	Table 3 of this Document (Page 21)	Project Manager	Pending
Personnel – Focus group participants cannot provide valuable feedback related to framework due to: lack of understanding of any/multiple components, lack of interest, no ideas for improvement, etc.	Y	Table 3 of this Document (Page 21)	Project Manager	Pending
Personnel – Less than 50% of Canadian breweries complete online survey due to missed email or lack of interest, leading data to not be representative of Canada.	Y	Table 3 of this Document (Page 21)	Project Manager	Pending
Schedule – The products with BSG incorporated in literature are not manufactured in Manitoba leading to a small group of potential users.	Y	Table 3 of this Document (Page 21)	Project Manager	Pending
Personnel – The potential food processors that can use BSG as an ingredient are not obviously listed on online directories and might therefore be missed for research activities.	Y	Table 3 of this Document (Page 21)	Project Manager	Pending

Appendix G: Budget Details

The table below details an exhaustive list of all activities required to successfully complete this project with the highest level of quality. The estimated costs are those most likely and are calculated from careful planning of project progression. The listed costs are accurate at the time of planning and have single or subscription costs. All research activities can be done at no cost to the project, while outside resources require some budget. Online programs and tools will be used to provide convenience to both the project team as well as interviewees, which should encourage participation if it can be done on the participants schedule. While the event space rental at Barn Hammer for the focus group is currently not finalized, it's assumed that the booking will encompass food and beverage costs, therefore budget is not expected to differ significantly from that listed. Project costs are supported in part by funding from the University of Manitoba Graduate Fellowship (UMGF).

Resource and Cost Estimates:

Table A.G.1. Resource and cost estimates.

Activity	Resources	Estimated Cost
Literature Review	Online Research – UofM Libraries (Background Information Report)	$0.00
Website Review	Online Research – Public Websites	$0.00
Online Surveys	Internet Access – Public Websites	$0.00
	Survey Monkey Account (Individual 'Advantage Annual' Account – Billed Annually)	$408.00
	Data Analysis	$0.00
Interviews	Internet & Phone – Contacting Interviewee's	$0.00
	Calendly Account – Interview Scheduling (Professional Account) (4 months x $12.00 USD = $19.10 CAD x 4)	$76.40
	Zoom Account (Small Business Membership) (4 months x $27.00 CAD)	$108.00
	Data Analysis (Zoom Transcription, Excel, Word)	$0.00
	Gas (Contacting interviewees in person)	$0.00
Final Report - Written	Internet & Phone	$0.00
Networking Meeting	Infographic – Adobe Programs (Creative Cloud All Apps Membership) (4 months x $69.99)	$279.96
	Printed Materials (Staples)	
	Brochures ((25 = $22.49) x 2)	$44.98
	Report (Short Version) (3 pages x $1.47 x 50)	$73.50
	Presentation (Laptop, Power Point, Word)	$0.00
	Projector Rental (RealTime) (Projection Package: Projector, Screen, Table = $225.00)	$225.00
	Meeting Space/Location	*Unknown*
	Beverages	
	Beer (2/person x $5.00 x 50 people)	$500.00
	Water	$0.00
	Pop	*Unknown*
	Snacks	$500.00
	Total Preliminary Cost Estimate:	$2,215.84 *+ 2 Unknown*

--- END OF ‘EXPLORING THE POTENTIAL OF UPCYCLING CRAFT BREWER BSG IN WINNIPEG, MB’ INTEGRATED PROJECT PLAN ---

Thank You

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