UBC Social Ecological Economic Development Studies (SEEDS) Student Report

# An Investigation into Brewpub Operations in the New SUB


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APSC 262 Sustainability Project Report

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# ABSTRACT

This paper examines sustainable operations of brewpubs with a triple bottom line assessment applied to provide recommendations to the proposed AMS brewpub. Consisting of a social, environmental, and economical analysis, the triple bottom line assessment thoroughly examines the sustainability of this issue. Operations of the brewpub are broken up into six key areas, ingredients, recipes, brewing process, cleaning, packaging, and recycling spent grains after brewing with a triple bottom line analysis applied to each section. Our analysis shows that for each of the six sections, sustainable operations are attainable for all three of the indicators. Socially, sustainability is better for the people involved directly and indirectly with the brew pub, environmentally, sustainability does not have to involve social and economic compromises, and economically, sustainability will provide the opportunity to save money on operational costs in the long run. By implementing sustainable practices throughout the construction and operation of the brewpub, the AMS and the new SUB can become leaders in sustainable brewing

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# 1.0 INTRODUCTION

Sustainability has always been one of the core values of UBC. To incorporate the concept of sustainability into the building design, water and energy practices, waste management and more. This APSC 262 Sustainability Project is one way to investigate into the most sustainable practices for different technologies and facilities on Campus and help the relevant stakeholders to make informed decisions. The supply management, UBC Farm and the student union are the three main areas of the sustainability project. Our group researches into the student union's brewpub operation in the new SUB. The brewpub in the new SUB is going to be open in 2014 and will become the only university student union microbrewery in this country. Sustainability has a huge importance in it as sustainability is the theme of the new SUB and the brewpub serves as a public image of it. Our team takes on the responsibility of the triple bottom line analysis of different aspects of the brewpub's operation and tries to come up with the most sustainability practices for them. Specifically, we investigate into six areas and divide the reports into six sections which include the sourcing of ingredients, sustainable recipes, brewing process, cleaning methods, product packaging and waste management. For each one of them, a triple bottom line analysis is carried out and suggestions about the most sustainable practices are made in the end of each section.

# 2.0 SOURCES OF INGREDIENTS

In this section of the report, the sourcing for the Brewpub's main beer ingredients: hops, malts and yeast are discussed. For each one of the three major ingredients, two best suppliers that stand out among other suppliers are introduced. The triple bottom line evaluation criteria are explained before the body of this section. In the end of this section, a recommendation that includes the suggestions of preferred suppliers for each type of ingredients is given. One thing to note here is that since this part is mostly a market business research rather than an academic research, the main information gathering approach is emails, phone interviews and site visits to brewing companies and ingredient suppliers. As a result, this section contains does not contain as many quotes or citations. The product catalogue and other first-hand information are attached in the appendix for reference.

For environmental aspect, we mainly look at the growing condition and quality of ingredients. In addition, we also look at the location which is associated with the shipping distance and $CO^2$ emission. For social aspect, we look at the sustainable practices of the company. For economic aspect, total cost which includes the shipping cost and price is the determinant factor that we consider. One thing to note here is that the environmental factors and social factors do not really apply to yeast, because yeast is a kind of fungi which is not produced from land. On the other hand, the use of yeast is very small in the production of beer. Malts and hops are our focus. So for yeast, we just have two general paragraphs describing the companies.

*Canada Malting Company (Malts)*

Canada Malting is the largest Canadian malting company. It provides malt products to brewers and distillers and food processors all around the world. It produces malts from 2-Row and 6-row base to Wheat, Munich, Distiller's and Rye malts. The grains for the malts are grown throughout Canadian Prairie Provinces namely Alberta, Saskatchewan and Manitoba.

*Great Western Malting Company (Malts)*

Great Western Malting is the oldest malting company in the western US. It has business relationships with brewing industry and food industry in North and South American countries and some Asian countries. Great Western produces 2-Row base malts, Wheat, Munich, Vienna and Crystal malts. Their malt grains are mainly grown in western US. In addition to the regular brewers' malts, Great Western Malting also produces USDA-certified organic malts, including base, Munich, Wheat and Crystal malts.

*UBC Farm (Hops)*

UBC Farm is situated just in the South of UBC campus within a coastal hemlock forest. It encompasses 34 hectares of integrated farm and forest lands. This farm produces a range of annual and perennial crops mixed with animal production. Not surprisingly, hops are among the farm's product catalogue and could potentially become the brewpub's supply.

*Left Fields Farm(Hops)*

Left Field Farm is a farm located in Sorrento, BC. It features in a variety of organic hops grown from its own farm or other BC farms. It also provides non-organic hops sourced from Washington State and Oregon State in the US for brewers to have access to more varieties. In total, it provides over 20 different types of organic and inorganic hops.

*White Labs (Yeast)*

White Labs is a yeast and fermentation company that has been in the industry for over 30 years. It is located in San Diego, CA, USA. The company provides product and service to brewers, winemakers and distillers in the fermentation industry. It provides in total five brewing yeast including the most popular ale yeast and lager yeast. As the name suggests, White Labs is also a research institute conducting many chemical researches in the fermentation area. For yeast it has specific quality control standards listed in their Certificate of Quality Assurance. They could also produce special yeast products provided the requirements by customers.

*Fermentis (Yeast)*

Fermentis is a business unit of the France bread-making yeast and yeast extracts company. It specializes in the sales and development of yeasts and yeast products to the beer, wine, spirits and industrial ethanol industries. It has over 10 types of yeasts for the brewing of lager, pilsen and specialty beers and ales. The yeast of Fermentis is HACCP certified. In addition, the yeast is tested in a reproduced actual brewing conditions such as the EBC tubes to ensure the quality.

## 2.1 Source of Ingredients on Social Impacts

Sustainability is one of the Canada Malting Company's core values. This company uses an advanced management system that sets clear operational and sustainability goals, which are monitored and reviewed weekly. These goals include metrics for water, energy, carbon footprint, waste, and by-product generation. To meet those goals and further reduce the energy use and carbon footprint, the company recovers biogenic heat generated by the germinating grain and heat from malting process. It also recycles the wastewater into high-grade water for nearby industrial plants to use.

Sustainability is also greatly valued by Great Western Malting. It uses a similar management and monitoring technology and energy saving practices as that of Canada Malting's. Since this ingredients sourcing part has a compare and contrast nature, so the social aspect is not repeated here.

UBC farm has strategic sustainability goals and actions. One goal is "making UBC a living laboratory in environmental sustainability by combining its sustainability leadership in teaching, research, and operations" (UBC Farm 2012). Another one is "creating a vibrant and sustainable community supported by exemplary governance" (UBC Farm 2012). For social programs, the farm has a Children's Learning Garden, Aboriginal programming, farm markets, and volunteer program.

Left Fields is a diversified and sustainable farm, with a market garden, livestock, a hopyard, and a small orchard. The water it uses comes from its own well, spring-fed from the farm itself. The farm in integrated with Crannog Ales brewery. It reuse the brewery's by-products as livestock feed, compost and irrigation water.

## 2.2 Source of Ingredients on Environmental Impacts

Canada Malting has very diverse locations of malt supplier. This allows the company to minimize the carbon impact of our incoming grain and outgoing product transportation. The malt supply for Vancouver mostly comes from grains grown in Alberta and processed in the malt plant in Calgary. In addition, those ten country elevators are in key grain-producing areas allowing the company to get closer to farms and monitor the quality of the grains. The collected grains are examined for quality assurance purpose in their labs before it is shipped to malting facilities.

Great Western Malting has a malt plant in Vancouver, WA. It is geographically very close to Vancouver, BC. That malt plant is organic-certified and provides a range of organic malts. Its malting plants are all HACCP certified which is system used at all stages of food production and preparation processes including packaging, distribution for quality assurance. The company has a technical Center and laboratories providing standard malt analysis, fermentation testing and micro malting.

The UBC farm is a very environmental friendly place. It provides valuable habitat for a range of birds, mammals, amphibians, and reptiles not found elsewhere in the city. The farm is about 3km from the UBC brewpub which means very low carbon emission and other ecological footprint during shipping. The hops are grown in an organic manner. No fertilizers or pesticides are used on them. However the organic practice is not currently certified, but might be certified when the brewpub opens in 2014.

All of the organic hops in Left Fields Hops are locally grown and are BC Certified Organic., It conforms to the National Regime but has not got national certification yet. In addition, no hops are genetically modified. No fungicide is used during the growing process.

## 2.3 Source of Ingredients on Economic Impacts

The malts are categorized into two groups which are brewers malts and color malts. The prices of malts in the same category do not very too much. A table comparing the average price based on each type of malts of the two companies is shown is Table 2-1. Only Great Western Malting has organic malts. The price is listed for reference. The products of the two companies are distributed through the same local wholesaler, so the shipping fee is the same for both.

Table 2-1. Malt Price Comparison

| | Canada Malting | Great Western Malting |
|---|---|---|
| Brewers Malts | $1.18/kg | $1.35/kg |
| Color Malts | $1.30/kg | $1.67/kg |
| Organic Malts | | $1.80/kg |

The average price of the organic hops from Left Fields is $6.75/lb and $5.75/lb. For UBC Farm, the average price is a lot higher due to the small production which is about %18/lb. For shipping, there is basically no shipping involved in UBC Farm's hop due to the proximity. As for Left Fields, the shipping for 10kg hops is around $20.

The yeasts are categorized into three groups which are ale yeast, lager yeast and regular yeast. The prices in the same category do not very too much. For shipping, both the companies ship through international shipping companies. The shipping fees do not differ too much and are relative insignificant compared to the unit product price. Table 2-2 compares the prices of each type of yeast for the two companies

Table 2-2. Yeast Price Comparison

| | White Lab | Fermentis |
|---|---|---|
| **Ale yeast** | $130/kg | $128.5/kg |
| **Lager yeast** | $130/kg | $163/kg |
| **Regular yeast** | $130/kg | $90/kg |

## 2.4 Recommendation

For malts, Canada malting and Great Western Malting have more or less the same sustainable practices and environmental conditions. Canada Malting is recommended for brewers malts and color malts due to its lower price. Great Western Malting could provide organic malts for the brewpub. For hops, both UBC Farm and Left fields have good sustainable practices. Although, Left field is further than UBC farm, it is still within BC and the extra shipping cost does not make a big different in the total cost. Left Fields is recommended mainly because of its huge price advantage. Since the use of hop in a unit of beer is very small compared with the use of malts, UBC Farm could also be considered for small amount of hop supply as a good branding strategy. For yeast, both companies are very prestigious and have high quality products in this industry. When it comes to price, Fermentis is recommended for regular and ale yeast and White Labs is recommended for lager yeast.

# 3.0 BEER RECIPES

The purpose of the investigation is to find the top recipes and styles of beer that are most socially acceptable, economically beneficial, and environmentally friendly. Popularity is used as the indicator for the social aspect. Source location of ingredients is used for economical aspect, as the more local the source of the ingredients, the lower the cost of buying the ingredients. Energy consumption in brewing the beer is the indicator for the environmental aspect.

## 3.1 Beer Recipes on Environmental Impacts

Table 3-1 lists the recipes in order of temperature of fermentation, from highest to lowest. Since the lower the temperature, the more energy consumed by the device to keep the fermenting beer that that temperature. The highest temperature of fermentation, $75^{o}$F, is closest to room temperature, $73^{o}$F, so the beer can ferment in the room without any device to keep it at a certain temperature. Thus, recipes listed higher in the table are more environmentally-friendly in the fermentation process, compared to recipes listed lower in the list.

Table 3-1. Recipes vs. Fermentation Temperature

| Name of Beer | Fermentation temperature |
|---|---|
| **1. Blood Orange Hefeweizen** | 70-75F for 10 days |
| **2. Captain Lawrence Smoked Porter** | 69F |
| **3. EdWort's Haus Pale Ale** | 68F for 10 days |
| **3. Centennial Blonde** | |
| **4. Hoppiness Is An IPA** | 67F |
| **5. Black Scapular Dubbel** | 64F to 70F for 7 days |
| **6. Mild Mannered Ale** | 65F for 10 days |
| **7. Cascade Orange/Coriander Pale Ale** | 60F for 24 days |
| **8. Gruagache 80/-** | 58F for 42 days |
| **9. Imperator** | 56F to 48F for 28 days |

Table 3-2 lists the recipes according to the total time of boiling the ingredients in the recipes, from shortest time to longest time. The longer the boiling time in brewing the recipes, the more energy consumed in maintaining the pot at boil. As a result, more energy is consumed in brewing the beer. Looking down from Table 3-2, the Imperator recipe has lowest energy consumption, with a boil time of 30-40 minutes. However, its fermentation temperature requires the most energy. Second from Table 3-2, three recipes share the same boiling time of 60 minutes. Of the three recipes, the Black Scapular Dubbel has the highest fermentation temperature, at 64F to 70F, thus the most environmentally-friendly of the three. The third item in Table 3-2 is the "Hoppiness is An

IPA" recipe, which is fourth in Table 3-1, with fermentation temperature of 67F. At fourth place in Table 3-2, the "Blood Orange Hefeweizen" recipe, with boiling time of 90 minutes, is the most sustainable, placing first in Table 3-1. Of the two recipes at fifth place in Table 3-2, the "EdWort's Haus Pale Ale" is the most sustainable, being third place in Table 3-1. Finally, the last place in Table 3-2 is the Centennial Blonde, which is third in Table 3-1.

Table 3-2 Recipes vs. Boiling Time

| Name of Beer | Energy Consumption |
|---|---|
| 1. Imperator | 30 – 40 minutes |
| 2. Mild Mannered Ale | 60 minutes |
| 2. Black Scapular Dubbel | |
| 2. Gruagache 80/- | |
| 3. Hoppiness Is An IPA | 75 minutes |
| 4. Captain Lawrence Smoked Porter | 90 minutes |
| 4. Blood Orange Hefeweizen | |
| 5. EdWort's Haus Pale Ale | 110 minutes |
| 5. Cascade Orange/Coriander Pale Ale | 110 minutes |
| 6. Centennial Blonde | 115 minutes |

Table 3-3 shows the comparison of Tables 3-1 and 3-2. The first and second columns are the names and ranks of the recipes. The third column shows the average of the two tables, which is calculated by taking the average of the rank of both tables. The smaller the average value, the higher the recipe on the list, and thus, the more sustainable. According to the results, the most sustainable beer recipe is the "Blood Orange

Hefeweizen" with an average rank of 3.888). The second place would be a tie between the "Black Scapular Dubbel" and "Captain Lawrence Smoked Porter" with an average rank of 4.444.

Table 3-3. Recipes in Rank System

| Name of Beer | Rank in Table 1 | Average Rank |
|---|---|---|
| **1. Imperator** | 9 | (1/6+9/9)/2*10 = 5.833 |
| **2. Mild Mannered Ale** | 6 | (2/6+6/9)/2*10 = 5.000 |
| **2. Black Scapular Dubbel** | 5 | (2/6+5/9)/2*10 = 4.444 |
| **2. Gruagache 80/-** | 8 | (2/6+8/9)/2*10 = 6.111 |
| **3. Hoppiness Is An IPA** | 4 | (3/6+4/9)/2*10 = 4.722 |
| **4. Captain Lawrence Smoked Porter** | 2 | (4/6+2/9)/2*10 = 4.444 |
| **4. Blood Orange Hefeweizen** | 1 | (4/6+1/9)/2*10 = 3.888 |
| **5. EdWort's Haus Pale Ale** | 3 | (5/6+3/9)/2*10 = 5.833 |
| **5. Cascade Orange/Coriander Pale Ale** | 7 | (5/6+7/9)/2*10 = 8.055 |
| **6. Centennial Blonde** | 3 | (6/6+3/9)/2*10 = 6.666 |

## 3.2 Beer Recipes on Economic Impacts

Table 3-4. Recipe Ingredients and Nearest Source Location

| Beer Recipe | Ingredients | Closest Source Location |
|---|---|---|
| **Blood Orange Hefeweizen** | Light Liquid Wheat Malt Extract | Vancouver, BC (Canada Malting Company) |
| | medium size blood oranges | Vancouver, BC |
| | Hallertau Hop Pellets | Vancouver, BC (Canada Malting Company) |
| | Saaz Hop Pellet | Vancouver, BC (Canada Malting Company) |
| | Wyeast 3068 or 3638 or White Labs WLP 300 or 380 | Vancouver, BC (White Labs) |
| **EdWort's Haus Pale Ale** | 2-Row Pale Malt | Vancouver, BC (Canada Malting Company) |
| | Vienna Malt | Vancouver, WA (Great Western Malting Co.) |
| | Crystal 10L Malt | Chilton, WI (Briess) |
| | Cascade (6.6%) | BC, Canada (The Country Malt Group Hops) |
| | Danstar Nottingham Ale Yeast | West Vancouver (Danstar) |
| **Cascade Orange/Coriander Pale Ale** | Maris Otter Malt | BC, Canada (Bairds Malt) |
| | Vienna Malt | Vancouver, BC (Great Western Malting Co.) |
| | Crystal Malt 10°L | Chilton, WI (Briess) |
| | Cascade (5.5%) | BC, Canada (The Country Malt Group Hops) |
| | Orange zest | Vancouver, BC |
| | Coriander crushed | Vancouver, BC |
| | Whirlfloc | Vancouver, WA (Brewers Supply Group) |
| | Fermentis Safale (S-04) Yeast | Vancouver, WA (Brewers Supply Group) |
| **Gruagach 80/-** | 2-Row Malt | Vancouver, BC (Canada Malting Company) |
| | Crystal Malt (80L) | Vancouver, BC (Bairds Malt) |
| | Melanoidin Malt | Vancouver, BC (Great Western Malting Co.) |
| | Aromatic Malt | Vancouver, BC (Best Malz) |
| | Peated Malt | Vancouver, BC (Thomas Faweett & Sons LTD) |
| | Black Patent | Vancouver, BC (Dan's Homebrewing Supplies) |
| | East Kent Goldings | England |
| | Wyeast 1728 - Scottish Ale Yeast | Hood River, Oregon (Wyeast Laboratories) |
| **Centennial Blonde** | Pale Malt (2 Row) US | Vancouver, BC (Canada Malting Company) |
| | Cara-Pils/Dextrine | Vancouver, BC (Great Western Malting Co.) |
| | Caramel/Crystal Malt - 10L | Chilton, WI (Briess) |
| | Vienna Malt | Vancouver, WA (Great Western Malting Co.) |
| | Centennial (9.50%) | Vancouver, BC (The Country Malt Group Hops) |
| | Cascade (7.80%) | BC, Canada (The Country Malt Group Hops) |
| | Danstar Nottingham Ale Yeast | West Vancouver (Danstar) |

| | | |
|---|---|---|
| **Mild Mannered Ale** | Maris Otter Pale Ale Malt | BC, Canada (Bairds Malt) |
| | Crystal Malt - 60L (Thomas Fawcett) | Vancouver, BC (Great Western Malting Co.) |
| | Chocolate Malt (Thomas Fawcett) | Vancouver, BC (Malteries Franco-Belges) |
| | Fuggles (4.50%) | Vancouver, BC (The Country Malt Group Hops) |
| | Danstar Nottingham Ale Yeast | West Vancouver (Danstar) |
| **Hoppiness Is An IPA** | American 2-Row Malt | Vancouver, BC (Canada Malting Company) |
| | Munich Malt | Vancouver, BC (Briess) |
| | Crystal Malt (15L) | Vancouver, BC (Great Western Malting Co.) |
| | Crystal Malt (40L) | Vancouver, BC (Great Western Malting Co.) |
| | Horizon Hops (13% AA) | Vancouver, BC (The Country Malt Group Hops) |
| | Centennial Hops (9% AA) | Vancouver, BC (The Country Malt Group Hops) |
| | Simcoe Hops (12% AA) | Vancouver, BC (The Country Malt Group Hops) |
| | Amarillo Hops (9% AA) | Vancouver, BC (The Country Malt Group Hops) |
| | White Labs WLP001 California Ale Yeast, Wyeast 1056 American Ale Yeast, or Fermentis Safale US-05 | Vancouver, BC (White Labs) |
| **Captain Lawrence Smoked Porter** | U.S. 2-Row Malt (Canadian from Scott) | Vancouver, BC (Canada Malting Company) |
| | Weyerman Smoked Malt | Vancouver, BC (Best Malz) |
| | Dark Munich Malt | Vancouver, BC (Best Malz) |
| | Crystal Malt (80L) | Vancouver, WA (Baird) |
| | Weyermann® Dehusked Carafa® III | Vancouver, BC (Weyermann) |
| | UK Chocolate Malt (475L) | Vancouver, BC (Thomas Faweett & Sons LTD) |
| | Summit Hops (18.5% AA) first wort hop | Vancouver, BC (The Country Malt Group Hops) |
| | Crystal Hops (3.25% AA) | Vancouver, BC (The Country Malt Group Hops) |
| | White Labs WLP001 American Ale Yeast | Vancouver, BC (White Labs) |
| **Black Scapular Dubbel** | Continental Pilsner Malt | Vancouver, BC (Weyermann) |
| | Munich Malt | Vancouver, BC (Canada Malting Company) |
| | Aromatic Malt (20L) | Vancouver, BC (Best Malz) |
| | CaraMunich (60L) | Vancouver, BC (Weyermann) |
| | Special "B" Malt (120L) | Vancouver, WA (Brewers Supply Group) |
| | Belgian Dark Candi Syrup (60L) | Los Angeles, CA (dark candi, inc) |
| | Cane (Table) Sugar | Vancouver BC |
| | Tettnang Hop (4% AA) | Vancouver, BC (The Country Malt Group Hops) |
| | White Labs WLP530 Abbey Ale Yeast or Wyeast 3787 Trappist High Gravity Ale Yeast | San Diego, CA (White Labs) |
| **Imperator** | Weyermann Munich Type II Malt (Dark Munich) | Vancouver, BC (Best Malz) |
| | Weyermann Boheminan Pilsner Malt | Vancouver, BC (Weyermann) |
| | Weyermann CaraAroma | Vancouver, BC (Weyermann) |
| | Weyermann CaraMunich Type II | Vancouver, BC (Weyermann) |
| | Weyermann CaraMunich Type III | Vancouver, BC (Weyermann) |
| | Hallertau Hops (4.5% AA) | Vancouver, BC (The Country Malt Group Hops) |

In Table 3-4, the location of the ingredients for respective recipe indicates the transportation cost, which governs the economic feasibility of the recipe.

### 3.3 Recommendation

According to Table 3-4, two of the ingredients of the “Black Scapular Dubbel” recipe are shipped from California, while the “Smoked Porter” has one ingredient sold in Washington State, which is closer and would be more convenient in obtaining the ingredients. As a recommendation, the “Blood Orange Hefeweizen”, “Captain Lawrence Smoked Porter”, and “Black Scapular Dubbel” recipes are most environmentally-friendly in terms of energy consumption in the brewing and fermentation process.

# 4.0 BREWING PROCESS

Brewing process of beer involves a multiple stage of heating and cooling. The energy reduction opportunity in the brewing process is staggering. Many academic reports have been done regarding to the energy recycle between the heating and cooling process. However, since the process is a complex unit operation, the operation method and the maintenance schedule are both as important as the energy recycle. In this section of the report, different components of the energy reduction factor are categorized into Alternate Sources of Energy, Boiler, Steam and Condensate System, Insulation, Refrigeration and Cooling System, HVAC, Process Gases, and Electric Motors and Pump. By applying the triple bottom lines, these components are exanimated to produce a report on how to manage a brewing process.

## 4.1 Brewing Process on Social Impact

Many components of the brewing process require certain supplier for resource, such as beer ingredients, carbon dioxide, and fuel. By adjusting the hardware and process, the market of the supply can be shifted. For example, if the bio gas from the anaerobic digester in the effluent treatment is reused, the market for diesel fuel might be switched to bacteria cultivation. For the boiler, the fuel for steam generation can take accounts for up to 40% of the total utility cost with a rate around 28 liter of diesel per kiloliter of beer (Brewers Association of Canada, 10’). This shift of market trend is inevitable; reducing the use of traditional fossil fuel is the main purpose of our modification.

Beside bio gas, the innovated process of the Combined Heat and Power System (Wittemann, 09’), also influence the market trend on the supply, especially on the ingredient. The technology’s main attraction is to convert the excess steam back into energy to fuel the boiler; this specific method limits the maximum temperature that can be reached by the boiler. Certain ingredient requires a much higher temperature for boiling, which can be over 100 degree Celsius. With a maximum temperature of 90 degree Celsius from the combined system, the brewing process is now limited to fewer options of ingredients. If the system is adapted by majority of the brewery, the market for high temperature malt will be shrunk.

Another similar example is the Carbon Dioxide Recovery System, which recycle the carbon dioxide produced from the boiler. The type of social impact discussed above is necessary, which will slowly eliminate the alternatives that are not as feasible.

### 4.2 Brewing Process on Environmental Impact

Recent studies have been focusing on the reduction of energy consumption in the brewing process; from operation, maintenance, and resource recycle, a brewery can achieve a much more feasible and sustainable process. Major aspects of operational energy reduction include insulation, and equipment configuration. Insulation can be complicated in a brewery, since different unit of tanks can have a huge temperature difference. From an interview with a local brewery in Kamloops, it seems the room temperature control practice can achieve the highest efficiency (Beardsell, 12'); by allocating tanks with same temperature requirement in a same room, the brewery can have a lower energy loss due to heat transfer between the tank and the environment. Equipment configuration involved in many different components of the brewery. First of all, the size of the electric motors and heat pumps should be tailored to the production level; this will allow the brewery to achieve a certain capacity, meanwhile it should not have waste energy from oversize equipment.

Maintenance of the equipment needs to be scheduled frequently. Any inefficient equipment operating in the brewery can reduce the feasibility of the process. Blown-down heat loss is an example of a poorly maintained boiler; the steam from boiling the malts may contain fine grain. With the condensation introduced back into the steam system, the fine grain might contaminate the hot water in the pump. As the concentration of the particle increase, the pump's performance can get worse. In addition, maintenance on the insulation is just as necessary to have a good insulation control. A good maintenance contributes to the reduction on greenhouse gas by increasing the efficiency of the equipment.

Lastly, resource recycle is the essence of a sustainable project. By harvesting as much resource as it can, the brewery can reduce its net consumption. An innovated design for resource recycle is the Ultramizer boiler, which incorporate a Transport Membrane Condenser. In figure 4-1 below, the steam gas flows into the channel with tubes of membrane which extract water molecules from the steam gas, and transport the condensation back into the boiler for operational use. The process map of the condenser describes a simple flow of fuel gas into the boiler with the steam condensate return to the de-aerator.

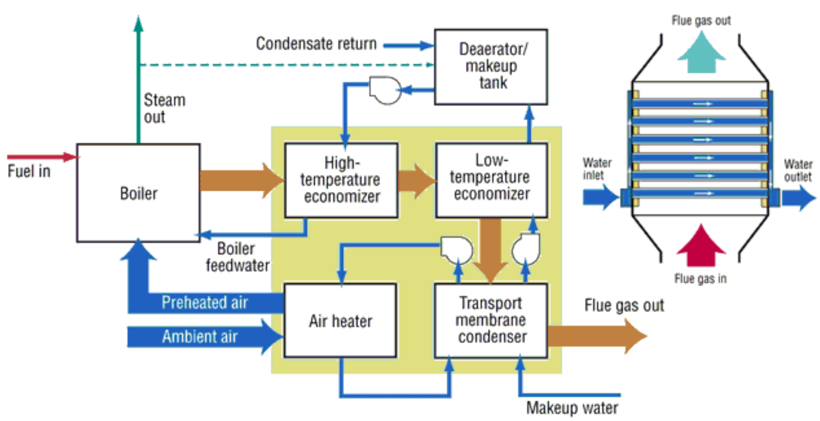


Figure 4-1. Transport Membrane Condenser (HPAC Engineering, 12')

### 4.3 Brewing Process on Economic Impact

The most attractive reasoning for a sustainable brewing process is that the environmental resolves depends on the reduction and recycle of energy and resource; the adjustment on the process usually grant a positive impact on the environment and the economic balance of the brewing process. And just like the environmental aspect, the economic impact is governed by operation, maintenance, and resource-recycle. Table 4-1 and 4-2 below indicates how a leakage of an air and water pipe can cause a huge lost in the revenue; full scale maintenance is advised.

Table 4-1. Air Leakage Cost (Brewers Association of Canada, 10')

| Hole Diameter | Air Leakage | Cost $/month |
|---|---|---|
| 1 mm | 1 L/s | 14 |
| 3 mm | 10 L/s | 150 |
| 5 mm | 27 L/s | 417 |
| 10 mm | 105 L/s | 1655 |

Table 4-2. Water Leakage Cost (Brewers Association of Canada, 10')

| Leakage Rate | Monthly Loss ($m^3$) | Monthly Cost ($) |
|---|---|---|
| One Drop per Sec | 0.13 | 1 |
| Two Drops per Sec | 0.4 | 2 |
| Drops Merginig into a Stream | 2.6 | 10 |
| 1.6mm Diameter Stream | 9.4 | 38 |
| 3.2mm Diameter Stream | 29.5 | 118 |
| 4.8 Diameter Stream | 48.3 | 193 |
| 6.4mm Diameter Stream | 105 | 420 |

Relating the economic scope back to the environmental impact, Ultramizer is brought to discussion for the conclusion of this section. Cost of a 300 HP Ultramizer Base Unit is around $100,000. The payback period with this purchase is around one to five years depending on the production rate (Cannon, 12'). Cost of an Ultramizer is 20-50% more than traditional condensing system with a 3-5% in fuel saving.

## 4.4 Recommendation

Scheduled maintenance can increase the feasibility of the brewery; if the maintenance is not performed regularly, the overall operation cost can increase. Combined Heat and Power System is recommended since the suggested recipe requires a lower temperature. Operational principle of the Combined Heat and Power System is the same as the steam system in UBC; the practice experience definitely supports the installment of the Combined Heat and Power System. Ultramizer is also recommended due to the short payback period. With a scope focusing on low fuel consumption, Ultramizer should be the choice for boiler.

# 5.0 CLEANING

Cleaning is an essential part of the brewing process, ensuring that the brewing equipment is clean and sanitised to prevent contamination and cross contamination. When brewing, the brewmaster tries to create an ideal environment for the yeast to convert the carbohydrates and sugars in the mash into alcohol, unfortunately this environment is also beneficial to unwanted yeasts and micro-organisms. In the event of contamination or cross contamination the brewmaster loses control of the bacterial and yeast content of the brew leading to an undesired product or spoiled batch. By cleaning and sanitising the brewing equipment the brewmaster has total control over the final product. ("Cleaning and sanitation," )

There are two main methods used in industry, the more traditional method of washing the brewing equipment by hand, and Clean In Place (CIP), primarily used in larger breweries.

*Hand Cleaning vs. CIP*

The CIP method of cleaning and sanitizing involves the recirculation of cleaning and rinsing agents to reduce the amount of human interaction with the cleaning chemicals and reduce the materials used involved in the cleaning process. Used mainly in larger breweries the CIP system consists of holding tanks for the cleaning and sanitising agents as well as recaptured water, circulation pumps, spray heads, and associated valves, all controlled by a local PLC. (Benthem, 2011)

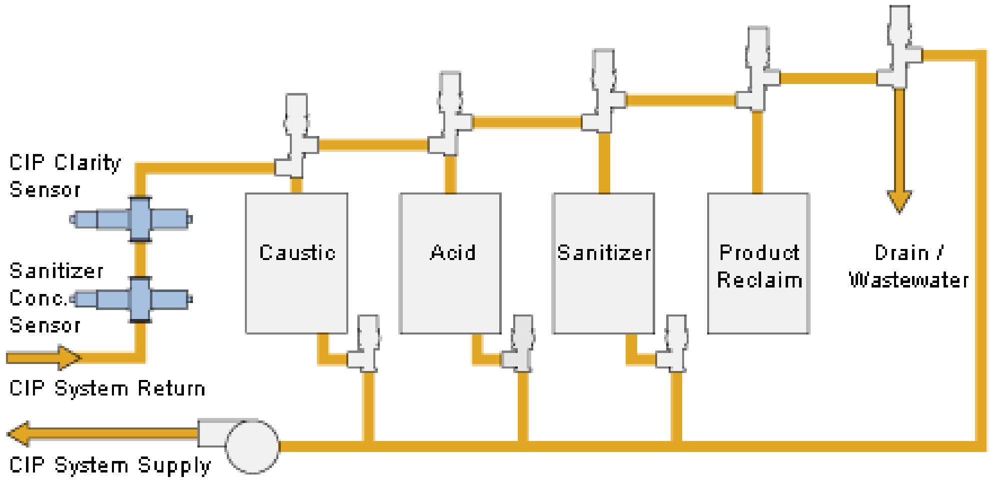


Figure 5-1. Example CIP System.

Retrieved from http://www.optek.com/Application_Note/General/English/3/Clean-In-Place_(CIP)_Applications.asp

The typical CIP cycle includes the following steps;

1) Pre-Rinse: Surfaces to be cleaned are rinsed to remove any loose material and to pre-heat the stainless steel. Water for this step is provided by the reclaimed water from steps 3 and 4, and is released from the system to be processed or disposed of.

2) Cleaning Cycle: Residual material is removed from surfaces by a shower of cleaning solvent from a nozzle connected to the CIP system. The cleaning solvent is an alkaline chemical solution that has been heated to aid in removal of solids. The cleaning solvent is recirculated in the system to maximize its effectiveness before being disposed of.

3) Rinse: Surfaces are rinsed to remove traces of the cleaning solvents. Water from this stage is recaptured for use in step 1.

4) Sanitize: All surfaces are sprayed with a sanitizing agent to neutralize any remaining cleaning agent and to kill and remaining yeast or microorganisms. Again recirculated to maximize its effectiveness, the spent sanitizer is collected for use in step 1.

## 5.1 Cleaning on Social Impacts

CIP has an advantage over traditional cleaning methods as there is lower chance of exposing workers to the chemicals used in the cleaning process. During the CIP cleaning process workers only have the opportunity to come into contact while loading chemicals into their holding tanks, after that every other step is autonomous and the chemicals and fumes are contained within the system. Hand cleaning requires that the workers handle the chemicals more often and are exposed to any fumes. (Johnson, 1998)

## 5.2 Cleaning on Environmental Impacts

The CIP system has the potential to be a far superior system in ecological terms, using up to 33% less chemicals, 50% less water, and with the right chemistry, releasing no harmful chemicals into the environment. The re-circulatory nature of the CIP process leads to less chemical use because the chemicals used can have a higher concentration than those used for hand cleaning, making them more efficient. The chemicals can also be more easily used to their full potential as they are repeatedly re-circulated until they lose effectiveness, helping to neutralize them in the process. Water usage can also be decreased by as much as 50% over hand cleaning by adding a holding tank within the CIP system to hold water from the final rinse phase of cleaning. This water can then be used in the first rinse phase of the next cleaning cycle instead of unnecessarily using perfectly clean water. using less chemicals more efficiently and conserving water. (Benthem, 2011)

With the right chemistry in the cleaning and sanitizing phases the spent cleaning agents released from the CIP system can be completely neutralized without the use of any buffers prior to release. For example, if sodium hypochlorite (bleach) is used for the cleaning phase and hydrogen peroxide for the sanitizing phase, and the spent chemicals are mixed prior to release the only byproducts of the reaction will be water, oxygen, and table salt (*Hydrogen peroxide*).

$NaOCl + H_2O_2 \rightarrow O_2 + NaCl + H_2O$

**5.3 Cleaning on Economic Impacts**

Although the initial hardware cost of the CIP system far outweighs the cost of the traditional method, the system can pay itself off in several ways in the long run. Being autonomous the CIP system can run unattended saving employee labor in the cleaning process and allowing employees to perform other preparatory tasks for the next batch of beer, increasing the overall efficiency of the operation. The recirculatory nature of the system also leads to a more efficient use of the cleaning chemicals as they can be repeatedly applied until they are no longer effective reducing the chemicals required by as much as 30%. CIP systems can also run without heating the cleaning chemicals, as is sometimes used in the traditional method to speed up the cleaning process, saving money on heating (Benthem, 2011).

# 6.0 PACKAGING

If the SUB brewpub wishes to expand the availability of its beers outside of the pub packaging will need to be considered. There are three main options for packaging, cans, bottles, and growlers, each catering to different markets and requirements. Bottles and cans are a staple of the brewing industry and are fairly self-explanatory; however some people may not be familiar with the growler format. Growlers are essentially a large glass bottle with a resalable top used to transport draft beer, common sizes include 1L, 2L, 64oz, 128oz (*Beer bottle*). Depending on the brewpubs business model some formats are preferable over others.

## 6.1 Packaging on Social Impacts

Ever since brewers started packaging beer in cans there has been a heated debate around which format is better. Some parties insist that beer in a can has a metallic taste and that only poor quality beer comes in a can, while others state that beer bottles let in oxygen through the cap and light thru the glass ruining its flavor. Because of this debate three parties have been created, cans, bottles, and those who see the benefit in both. The two opposing sides will always remain but as more and more great beer is produced in cans, prejudices are beginning to change (Flaherty, 2009).

Since the advent of growlers, the appeal of buying one reusable package and receiving bulk beer has been growing among consumers to the point that consumer demand makes the sale of growlers in brewpubs almost unavoidable. Along with the appeal for quantity and the trendiness of growlers, this packaging is viewed favorably among consumers as being the greenest packaging option ("The ultimate in," 2008). Despite the increase in customer satisfaction and the opportunity to move more beer, many brewmasters have a negative view of growlers for good reason. Food laws make the sale and servicing of growlers a headache, because of these laws brewmasters cannot give cleaning instruction due to liability concerns, resulting in brewmasters being asked to fill growlers which have been improperly cleaned or not cleaned at all. The filing of an unclean growler is seen by brewmasters as an insult towards their product, however the refusal to fill growlers results in negativity from the customer. Beer in growlers also has the possibility for mishandling such as overexposure to light and oxygen, degrading the quality of the product when consumed, resulting in a less than perfect presentation to the customer. (D. Beardsell, personal communication, February 21, 2012)

### 6.2 Packaging on Environmental Impacts

Depending on what packaging, distribution, and recycling model you want to adopt, cans and bottles have their own areas of advantage. The environmental analysis of the packaging options and recommendations are based on an extrapolation from the amount of non-renewable primary energy from Table 6-1. As Aluminum cans are consistently lower in all fields this recommendation based on energy usage alone is valid.

<u>My methodology is as follows, all data is sourced from Table 6-2 or calculated below:</u>

Effective energy per use = Energy in materials * burden of un-recycled packaging

= ((Energy New Materials + Energy Recycled Materials) / Use Rate) * (100% / %Recycle Rate)

Energy New Materials = Non-renewable primary energy * % New Material

Energy Recycled Materials = Non-renewable primary energy * (%Energy Use Recycled) * (%MaterialRecycled)

Table 6-1. Environmental Impact of Beverage Packaging (sidel, 2008)

| | Non-Renewable Primary Energy (MJ) | Global Warming Potential (100 years) (g eq.$CO_2$) | Air Acidification (g eq. $SO_2$) | Entrophication (g eq. $PO_4^{2-}$) | Water Consumption (L) |
|---|---|---|---|---|---|
| **PET Bottles** | 986 | 58 243 | 234 | 120 | 877 |
| **One Way Glass Bottle** | 1178 | 91 981 | 362 | 126 | 1394 |
| **Aluminum Cans** | 911 | 65 762 | 293 | 118 | 866 |
| **Steel Cans** | 723 | 52 770 | 216 | 117 | 824 |

Table 6-2. Environmental Assessment

| | Cans | Bottles |
|---|---|---|
| **Use Rate (UseRate)** | 1 | 15 ("Just the facts, Glass" 2004) |
| **% Post Consumer (%Material Recycled)** | 51.4% recycled content ("Just the facts, Aluminum" 2004) | 32% post consumer ("Just the facts, Glass" 2004) |
| **% New Material (%Material New)** | Calculated: 100%-%material recycled 48.6% | Calculated: 100%-%material recycled 68% |
| **Energy Saving, Recycled Material (%Energy Saving Recycled)** | 96% ("Just the facts, Aluminum" 2004) | 32% ("Recycling facts, Glass" 2004) |
| **Energy Use, Recycled Materials (%Energy Use Recycled)** | Calculated: 100% - (%Energy Saving Recycled) 4% | Calculated: 100% - (%Energy Saving Recycled) 68% |
| **Recycle Rates (%Recycled)** | 80% ("Economic impacts of," 2008) | 96% ("Economic impacts of," 2008) |

### 6.3 Packaging on Economic Impacts

Cans provide a better overall packaging format for beer due to a higher sales numbers, a lower cost of packaging, lower cost of shipment, and a quantity purchase bias over bottles. Sales numbers for cans are 2 times higher than bottles for several reasons ("Economic impacts of," 2008). Due to a lower cost of manufacturing, beer in cans can be sold to the customer at lower rates, resulting in increasing demand. Cans can also be more easily transported over bottles due to their lighter packaging, saving on shipping costs and carbon emissions(Johnson, 2011). As well, there has been research showing a quantity purchase bias of cans over bottles due to packaging shape alone. (Yang, S., 2005)

### 6.4 Recommendation

<u>Results</u>

Cans:

Energy per use = (442.7MJ+18.7MJ)* 1.25 = 576.8MJ

Bottles:

Energy per use (single) = (801.0MJ + 256.3MJ)*1.04 = 1099.6MJ

Energy per use (multi)= ((801.0MJ + 256.3MJ)/15)*1.04 = 73.3MJ

If the brewpub does not want to deal with the hassle or recollecting and sanitizing bottles then for one time use of packaging cans are 1.9 times less harmful to the environment then glass bottles. However If bottles are collected and reused they are 7.9 times more environmentally friendly then cans.

## 7.0 RECYCLING SPENT GRAINS AFTER BREWING

During the brewing process, a significant amount of spent materials will be produced, including spent mash and yeast. Using the Noble Pig in Kamloops BC as an example, for every 2000L of beer produced per week, 800L (~800kg) of spent grains will need to be disposed of (D. Beardsell, personal communication, February 21, 2012). The brew masters challenge now is how to dispose of this quantity of material using the most sustainable methods available. There are several options used in the industry, ranging from high tech bio-digesters producing biogas for use in the brewery to the more traditional methods like cooking, composting, and animal feed.

All over North America large breweries are starting to look at bio-digesters as a viable means of disposing of their waste materials and at the same time producing renewable power for their operations. The bio-digestion plant essentially consists of a large digestion tank in which controlled composting is performed; biogas is harvested off the top of the tank and can then be used as a fuel for power generators and heating. During the digestion process raw materials (i.e. spent grains) are placed into the tank along with water and bacterium, as the material is composted methane gas (60-65%) is produced with output rates of 170 scfm in some applications (Greer, 2009). Although not Ideally suited for onsite use at SUB brewpub due to the size requirements of the bio-digestion tank, this method has potential for if implemented in conjunction with the gasification plant currently under construction at UBC.

Not all breweries have the luxury of space for a bio-digester and have to rely on more conventional methods of disposing of their brewing waste, and as an alternative to the landfill brewers are turning to cooking, composting, and animal feed as replacement strategies ("Brewer's spent grain," 2011). After the grains have been used for the production of beer they still contain some nutrients making them suitable for use in cooking, and although they can only be used in low quantities due to fiber content they can be used to make signature recipes for the brewpub and SUB operations with excellent marketing potential ("Cooking with spent," ). Another method after the grains have been used for brewing is composing as they already contain moisture and nutrients for the composting process, and if used on the UBC grounds or UBC farm to help make the UBC campus carbon neutral. The grains also make an excellent food source for animals and can be used on the UBC farm or sent to a community partner.

# 8.0 CONCLUSION

As a leader in the global green movement, UBC has made and initiative to building the new SUB to the highest levels of sustainable architecture and operate it in as efficient a manner as possible. In the spirit of this effort, the AMS brewpub has the opportunity of becoming an innovator in overall sustainable brewing practices and along with research partnerships will set a name for itself among the industry. Historically breweries have made little effort to operate sustainably but as the times have changed, development and research has been done in the area. By examining efforts made by breweries around the world and taking a critical look at the whole process from ingredients to packaging, the AMS brewpub can start operations on the right foot.

Because the brewpub is being designed and constructed with sustainability in mind hardware design decisions can be made early and maintenance programs put in place to ensure efficient operation and long lifespans. Hardware design decisions such as condensers to reduce water usage and CIP systems for more efficient use of cleaning chemicals will help the brewpub maintain optimal functionality throughout its lifetime. Along with hardware, the choices in ingredients and recipes can have an equal impact on sustainability while producing a top quality product. Choosing recipes that use local organic and seasonal ingredients reduce waste from excessive transport and unsustainable and unhealthy farming practices while reducing the energy required to produce the beer by choosing recipes with increased fermentation temperatures and decreased fermentation times. After the brewing process is complete, the materials formerly considered waste can be used for power generation, fertilization, and to produce signature foods for the AMS brewpub.

With comprehensive and careful planning toward construction and operations, the

AMS brewpub will be a shining example of sustainable operations that will not only be beneficial to the environment but will produce products that are healthy for the heart and soul of the customer improving life on the campus and in the community. The road to sustainability will not be easy though, as additional financial investments are required in construction, and a dedicated maintenance program observed. With the efforts of a dedicated AMS board and the enthusiasm of volunteers from the community, the dream will become reality.

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# Appendix B: Spent Grain Recipes

**Spent Grain BBQ Burgers**

ingredients:

- 1 cup spent grain, wet (or Dried Spent Grain re-hydrated with 1/2 cup hot water)
- 1 cup cooked quinoa
- 2 eggs
- 5 tablespoons barbeque sauce
- 3/4 teaspoons salt
- 1/2 cup bread crumbs
- olive oil

Directions:

1. In a bowl combine spent grain, quinoa, eggs, salt, and barbeque sauce with a fork until eggs are broken up and mixture becomes cohesive. Stir in breadcrumbs.
2. Heat a cast-iron or heavy-bottomed skillet over medium heat and add a few tablespoons of olive oil. Because the consistency is so moist, it's helpful to scoop the mixture into the hot skillet, and use a spatula to form into rounds.
3. Let cook undisturbed for 5-8 minutes on one side, until bottom is golden brown and the burger can be easily moved. Flip and repeat on the other side. Makes about 8 sliders.

("Spent grain bbq," 2011)

**Spent Grain Pizza Dough**

Ingredients:

- 1 package active dry yeast (sorry, not ale yeast)
- 1/2 cup warm water (around 110 degrees F)
- 1 1/2 cup flour
- 3/4 cup spent grain, wet
- 1 1/2 teaspoon salt
- olive oil

Directions:

1. In the bowl of a standing mixer, gently mix yeast into water just to combine. Let sit for five minutes and it should start to bubble.
2. Add the rest of your ingredients to the bowl and knead with a dough hook for 8-10 minutes. (Alternatively, you can use a regular medium sized bowl, simply mix the dough by hand in the bowl, and transfer it to a clean, floured work surface for kneading.)
3. Remove the dough from the bowl and add a small splash of olive oil to your bowl. Place the dough back in the bowl and turn to coat in olive oil.
4. Cover with a towel and let rest in a warm spot for 2 hours.
5. Punch down dough and let rise again for 30 minutes. In the meantime preheat your oven to 475 degrees F (or as high as it will go).

6. Remove dough from bowl and place it on to a half-sized sheet pan. Using your hands, manipulate the dough to stretch it evenly over the sheet pan surface. Then, finish with sauce, cheese, and other desired toppings.
7. Bake for 20 minutes, or until crust is evenly browned on the bottom. (Use a spatula to lift up edges of the dough to check.)

("Spent grain pizza," 2011)

**Spent Grain Applesauce Muffins**

ingredients:

- 1 1/4 cups all-purpose flour
- 1/2 cup Spent Grain, dried
- 1 1/2 teaspoons baking powder
- 1/2 teaspoon baking soda
- 1/2 teaspoon cinnamon
- 1/4 teaspoon salt
- 2 large eggs
- 1 cup packed light brown sugar, plus 2 tablespoons
- 1 cup vegetable oil or melted butter
- 1 cup unsweetened applesauce

Directions:

1. Preheat your oven to 400 and set up a 12-muffin tin with liners.
2. In a small bowl mix together flour, spent grain, baking powder, baking soda, cinnamon, and salt. Set aside.
3. In a large bowl, combine eggs, 1 cup of brown sugar, and oil or butter. Whisk together until well combined.
4. Stir in applesauce, then fold in flour mixture until flour is just moistened. Divide batter among muffin cups and use remaining 2 tablespoons sugar to sprinkle as a topping.
5. Bake for 20 minutes, or until light golden brown. Cool in pan on a rack 5 minutes, before moving to a cooling rack. Best eaten while warm.

**Nutty Spent Grain Chocolate Chip Cookies**

Ingredients:

- 1/3 cup peanut butter
- 2 tbsp melted butter
- 1 cup sugar
- 1/3 cup milk
- 1 tsp vanilla
- 1.5 cups spent grains (or alternatively, 1.5 cups of your favourite grain meal, prepared and still wet)
- 2 cups whole wheat flour
- 1 tsp baking soda
- 1/2 tsp salt
- 1/2 cup chocolate chips
- 1/2 cup chopped nuts

Directions:

1. Mix in the peanut butter, regular butter, sugar, milk and vanilla. Then add the flour, baking soda and salt. Once that's all mixed, stir in the nuts and chips.
2. Bake on a greased cookie sheet at 425F for 8-10 minutes until the tops are just getting golden, but before the bottoms burn.
3. Let sit on the pan for about five minutes before transferring to wire rack to cool.

(Aleta, 2008)

**Easy Granola**

ingrediants:

- 9 cup barley grains
- 1 cup spelt or whole wheat flour
- 1 cup wheat germ
- 1 cup coconut
- 1 cup raisins
- 1 cup honey or maple syrup
- 1/2 cup oil
- 1 cup boiling water
- 1 tsp. salt
- 2 tsp. vanilla
- 1 cup of flax seeds (optional)

directions:

1. Blend together all liquid ingredients and add to dry ingredients, until well distributed.

2. Crumble the mixture and spread on to cookie sheet.

3. Start baking at 350F for 15 min., then lower heat to 200F and bake (stirring occasionally) until dry.

4. Store in covered jars.

("Cooking with spent," )

**Spent Grain Wheat Bread**

Ingredients

- 1 1/4 cups water
- 3 tablespoons honey
- 3 tablespoons butter, softened
- 1/4 cup spent grain
- 1 1/2 tablespoons powdered milk
- 1 teaspoon white sugar
- 1 teaspoon salt
- 1/2 cup rye flour
- 1 1/2 cups whole wheat flour
- 1 1/2 cups bread flour
- 1/4 cup vital wheat gluten
- 1 teaspoon active dry yeast

Directions

1. Place ingredients in the pan of the bread machine in the order recommended by the manufacturer.
2. Select whole wheat cycle
3. press Start. If using the delay timer, decrease water by 1 tablespoon.

("Spent grain wheat," )

# Appendix C: Definition of Terms

*Eutrophication* - "The process by which a body of water acquires a high concentration of nutrients, especially phosphates and nitrates. These typically promote excessive growth of algae. As the algae die and decompose, high levels of organic matter and the decomposing organisms deplete the water of available oxygen, causing the death of other organisms, such as fish. Eutrophication is a natural, slow-aging process for a water body, but human activity greatly speeds up the process." - Art, 1993

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