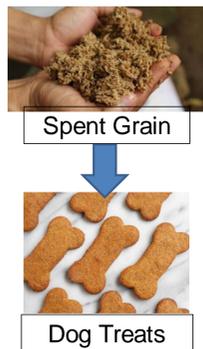


## Introduction

The production of beer, as seen in Figure 2, produces large amounts of spent grain, yeast, and hops as byproducts that usually go to waste. A brewery's decision to utilize byproducts and other forms of process waste can greatly influence the economic market and the state of the environment. These byproducts, if not disposed of properly, can have negative impacts on ecosystems and thus efforts to limit the amount of waste is critical. This project considers some of the ways to use brewery waste, such as for composting, as fertilizer, or to make food products. As shown in Figure 1, the use of spent grain to make dog treats was considered as a possible way to use brewery waste products. An added benefit to the use of spent grain in food products could be that selling the spent grain could provide additional income for the processing plant.



**Figure 1.** A simple schematic showing the spent grain that could be used to make dog treats.

## Research

Optimize the use of brewery waste byproducts in the food industry.

### Objectives:

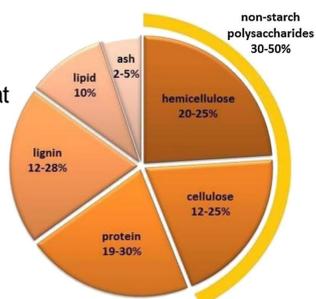
- Utilize as much spent grain as possible from brewery waste for dog treats.
- Explore different formulations of wet spent grain vs. dried spent grain
- Compare nutrition of spent grain dog treats to commercial dog treats

### Tasks:

- Collect spent grain from brewery waste
- Dry the spent grain or use wet spent grain
- Analyze nutritional content of the wet spent grain vs. dry spent grain
- Determine if the nutritional content of the spent grain can be used for dog treats or other functional ingredients for food.

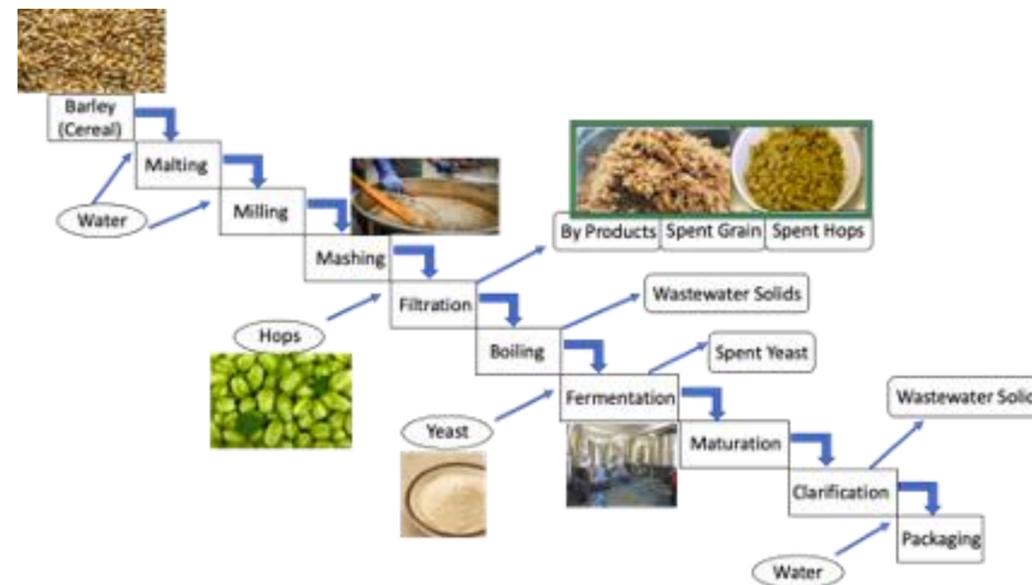
### Data Analysis:

- For every gallon of beer that is brewed, 1-2 pounds of wet spent grains are produced as by-product.
- Wet spent grain must be used immediately. Dried spent grain can be stored for later use. (3)
- Spent grain dog treats contain 3 times as much fiber as oat-based dog treats.



**Figure 3. Spent Grain Composition.**  
Reference Source (5)

## Process Description



**Figure 2. Beer Production Process.** During the production of beer, barley grain is malted, milled, mashed and filtered with water. The next step is filtration with the addition of hops. After filtration, a large amount of organic waste material is produced from this process, spent grain and spent hops. The filtered material is then boiled, and yeast is added before the fermentation process. The yeast is removed after fermentation and spent yeast is another byproduct. The production continues with maturation, clarification and packaging.

\*Adapted Schematic created from Reference Source (3).

## Sensitive Unit

A sensitive unit for converting brewery waste into dog treats is a mycotoxin sometimes found in spent grain byproducts. Mycotoxins grow in the form of fungi on barley that is used for brewery purposes. Most of the mycotoxins are thermo-stable which means that they can survive the entire malting and brewing processes. This poses a threat to dogs if contaminated spent grains are used in the production of dog treats. Therefore, it is critical to make sure spent grain byproducts are not contaminated with mycotoxins when they are being reused in the production of dog treats.

### Potential Effects of Mycotoxins on Profits:

- The presence of mycotoxins in brewery waste prevents it from being used to make food products for animals or humans, resulting in a loss of potential profit from these food products.
- There is not a viable way to remove these mycotoxins and make the byproducts usable again because these mycotoxins are thermo-stable and survive all stages of malting and brewing (6).
- The possible presence of mycotoxins also decreases the marketability of products made from spent grain and can have a negative impact on profits (6).

### Potential Effects of Mycotoxins on the Health of Dogs:

- Mycotoxins have "carcinogenic properties" that may have a negative influence on the body (6).
  - May lead to infertility, kidney failure, cancer, or death (6).
- The most common mycotoxin found in spent grain byproducts is *F. Graminearum*, which may lead to a loss of appetite and/or vomiting in animals(6).

It should be noted that mycotoxins do not need to be ingested to cause health effects; mycotoxins may be airborne, therefore it is vital to handle with care and the appropriate PPE (personal protective equipment) (6).

Figure 4 conveys the difference between healthy malt and malt that has been contaminated with a mycotoxic fungus.



**Figure 4.** Image (a) depicts uninfected malt and image (b) depicts malt infected with *F. graminearum*. Image (b) was taken from (6).

## Potential Impacts on Ecosystems Services

### Potential impact of spent grain:

- Spent grain is likely to be rapidly colonized by microorganisms including bacteria and fungi. (1)
- Large quantities of the microorganism-populated spelt dumped into the environment can disrupt natural living system. (1)
- Spent grain is a cheap livestock-feed alternative, which offers an economic advantage for farms. (5)
- Spent grain provides nutritional benefits to both humans and animals. (5)
- Combining spent grain with wastewater from the brewery process allows for successful composting which is a safe, non-toxic form of disposal. (5)
- Spent grain can be utilized for energy synthesis through biogas production, drastically reducing the effect of methane emissions by conversion into CO<sub>2</sub>. (5)

### Potential impact of spent yeast:

- Yeast contains a high quantity of nucleic acids. (1)
- In animals containing monogastric GI systems, nucleic acids can cause issues with digestion that can lead to insufficient absorption and utilization of proper nutrients.(1)
- Spent hops is an efficient fertilizer alternative that is cheaper and less harmful to the environment than artificial fertilizers.(2)
- The natural essential oils of spent hops can deter insects from crops.(3)

### Potential impact of spent hops:

- The impact of hops comes from the compound 2-methyl-3-buten-2-ol that is in hops, which degrades acids in waste. (1)
- Degradation of acids causes hypnotic and sedative qualities when consumed. (1)
- Spent yeast provides nutritional benefits to animals as a high source of protein.
- Spent yeast is a valuable ingredient in many manufactured foods such as bread and other baked goods. (2)
- Spent yeast can be utilized within the dairy industry due to its high mineral and vitamin content.(3)

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