Environmental Studies
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A Life Cycle Assessment of a Home Brew

Introduction:

A Life Cycle Assessment, or LCA, is a way to look at the full system and life of a product. They are becoming a bit more common as more information is gathered and stored in large LCA databases to have a full scope of a product's environmental impact. LCAs are challenging and are still not completely formulated, nor regulated. In order to be able to compare one product to another, it is necessary to have a similar, or same, scope that the other has. A scope is how detailed or vague one gets when working on an LCA. A scope could go so far as to look at the carbon footprint and manufacturing of farm equipment used to till the land an ingredient of a product was grown, or as close-up as the carbon footprint of the processing of that ingredient. LCAs, when performed professionally, take quite a long time and require a lot of skill, forethought, and access to information.

A beer LCA that we were fortunate enough to find was by the Climate Conservancy for New Belgium Brewing Company for their Amber Ale. According to their report, there have only been a few attempts at creating a beer LCA. We used the New Belgium LCA as a guideline for ours, though theirs is more thorough.

Our boundaries for our Life Cycle Assessment of our "Sugar Shack Porter" home-brew include acquiring and transporting materials, brewing operations, and waste disposal and use. Most of the materials we used in the brewing and bottling process were materials we had previously acquired and used for brewing, so there were only a few raw materials that went into it.

<u>Raw Materials for brewing</u>: Malt, hops, yeast, sap, wood, and water.

<u>Materials for brewing operations already owned</u>: Stainless steel brew kettle, stainless steel kettle (small), mash tun (modified cooler), plastic tubing, thermometer, propane burner, propane tank, stainless steel wort chiller, 2 short garden hoses, plastic fermentation bucket w/ spigot and lid, plastic airlock, vodka, timer, scale, and sanitizer.

<u>Materials for bottling, recycled and owned:</u> Previously used bottles, plastic tubing, bottle filler, bottling bucket, small saucepan, bottle capper, labels, and dishwasher.

<u>Raw materials for bottling:</u> Caps, maple syrup

Entity/Brewing operations:

Our brewing operations were fairly simple. We went to the Sugar Shack Rebecca Carlson built and chopped wood to use for heating the stove. Wood has a very low carbon footprint. It's taking carbon from a renewable, active part of the carbon cycle rather than an inactive fossil fuel. Electricity was not used in the shack. One eighth of a gallon of gasoline was used to pump the water into the chiller, which is fairly negligible. There was a negligible amount of manufacturing waste (spent grain was saved and used, hops were composted, and waste water was washed down the sink).

Upstream: *Acquired raw materials and pre-processing of those materials.*

Malt

To brew our beer we used 11 lbs of packaged malt from the Briess Malt & Ingredients Company for the "Sugar Shack Porter" brew. The Briess Company is headquartered in Wisconsin and has been around for over 130 years. Briess is women-owned, USDA certified to produce organic ingredients, and kosher certified. To retrace the steps of our malt we will go back to the barley seed.

Farm

There are several steps to growing barley that emit carbon. First, the farmer has to order the barley seeds, if they have not saved seeds from their previous year (which is encouraged for a more sustainable LCA). The transportation of these seeds contributes to the total amount of carbon emissions, depending on the distance the seed is shipped. Once the farmer has the seed they can plant about 20 seeds per square foot of soil. Since Briess Company is certified organic their farms do not produce the carbon emissions that come from pesticide and fertilizer application. Tractor use for planting and harvesting is a huge contributor to carbon emissions on the farm. Since New Belgium LCA showed that the carbon emissions from malt farming and processing only contributed to 6% of total carbon emissions, we can conclude that the carbon emissions for the farming and processing of malt for Briess contribute less than 6% due to their organic practices and local business.

Processing

Once the barley leaves the farm, it is transported to one of the Briess Malthouse Plants, also located in Wisconsin. The barley goes through three main steps to become the delicious malted barley we used in our Sugar Shack Porter: Steeping, germinating, and drying and roasting. In the New Belgium LCA, steeping emitted 2.8 g of CO_2, germinating emitted 26.4 g of CO_2, and drying and roasting emitted 182 g of CO_2. The processes are very similar between New Belgium and Briess, therefore we can say that drying and roasting is the largest carbon emitter, followed by germinating and steeping.

The following is the Briess Company's explanation of the three main steps to the malting process:

Steeping
During steeping water is absorbed by the raw barley kernel and germination begins. Steeping starts with raw barley that has been sorted and cleaned, then transferred into steep tanks and covered with water.

For the next 40-48 hours, the raw barley alternates between submerged and drained until it increases in moisture content from about 12% to about 44%. The absorbed water activates naturally existing enzymes and stimulates the embryo to develop new enzymes. The enzymes break down the protein and carbohydrate matrix that encloses starch granules in the endosperm, opening up the seed's starch reserves, and newly developed hormones initiate growth of the acrospire (sprout).

Steeping is complete when the barley has reached a sufficient moisture level to allow uniform breakdown of the starches and proteins. One visual indicator that the maltster uses to determine the completion of steeping is to count the percentage of kernels that show "chit". Raw barley that has been properly steeped is referred to as "chitted" barley", the "chit" being the start of the rootlets that are now visibly emerging from the embryo of the kernel.

Germinating
In a process called "steep out," the chitted barley is transferred from the steep tank to the germination compartment. Germination, which began in the steep tank, continues in the compartment where the barley kernel undergoes modification.

Modification refers to the break down of the protein and carbohydrates, and the resulting opening up of the seeds' starch reserves. Good modification requires the barley to remain in the compartment for 4-5 days. Drawing temperature-adjusted, humidified air through the bed controls germination. Turners keep the bed from compacting and rootlets from growing together, or felting.

Drying
Drying halts germination. If germination continued, the kernel would continue to grow and the growing plant would use all of the starch reserves needed by the brewer.

Base malts are kiln-dried, typically with a finish heat of 180-190° F for 2-4 hours. This develops flavors ranging from very light malty to subtle malty.

Specialty malts are dried in a kiln at higher temperatures for longer periods of time, roasted, or both. Varying the moisture level and time and temperature of drying develops the flavor and color characteristics of each specialty malt.

After these steps are completed the malt is transported to the Briess distribution center, also located in Wisconsin. From there, it is shipped to brewers all over the country!

Hops

The hops we used for our Sugar Shack Porter came from Hops Direct located in Washington. The hops are grown on Puterbaugh farms where they grow 600 acres of hops.

The carbon emissions from farming are similar to the carbon emissions from farming barley – the planting, fertilizing, and harvesting processing all emits carbon. In the New Belgium LCA the agricultural machinery used to farm hops emitted 1.1 g of CO_2, 1.2 g of CO_2 from irrigation, 0.9 g of CO_2 from soil emissions, 0.9 g of CO_2 from drying and packaging, and 0.3 g from transportation. These findings are very comparable to Hops Direct as far as farming practices and scale. Hops Direct keeps their hops in cold storage year-round, which also contributes to the total CO_2 emissions (energy for refrigerators). Even with the transportation of hops, the total carbon emission from the farming and processing of hops from the New Belgium LCA was 5.7 g of CO_2. This is a relatively miniscule amount in the whole process of brewing beer. If you wanted to brew with a lower carbon footprint you should consider growing and drying your own hops!

Sap and Syrup

To brew our beer we used the sap produced from Rebecca Carlson's maple trees on the St.Olaf natural lands. The sap is around 95% water, and so we were able to do all the same steps as regular brewing except that we replaced the water with sap. The only carbon emission from this process was that we burned wood in the sugar shack to heat up the sap. This process was extremely local and probably the most sustainable part of our beer brewing! We also put some of Rebecca's syrup the Sugar Shack Porter. The carbon emissions from the syrup are also very small, including heating the stove with wood and packaging the syrup.

Downstream: *Distribution, consumption, end disposal of Sugar Shack Porter.*

Waste Disposal

The major waste sources from home-brewing include: spent grain, spent hops, and water (cleaning, brewing, chilling).

Spent Grain still has plenty of nutrient and substantive value. It can be used as a livestock feed. Alternatively it is a great addition to a compost pile. Another cool way to use the spent grain is to bake with it. You can make bread, pretzels, pancakes, pizza dough and even dog treats with spent grain added. It adds a hearty chewy aspect to the creation and is a good way to make use of the waste. We froze enough grain to make a few loaves of bread and composted the rest.

Spent Hops are also a great addition to a compost pile and in fact the ratio of grain to hops used in the brewing process is similar to that recommended for the carbon (grain) to nitrogen (hops) ratio. We composted our spent hops.

Water is required for cleaning/sanitizing both pre and post-production (a crucial part of brewing), it is the main ingredient in the actual beer, and is used in a chilling system during production. The water with sanitizer/cleaner in it was disposed of down the kitchen sink. The water running through the chiller could be captured and used to water a garden, plants (hops!), or kept for any number of water needs. For the actual brewing process we used about 10 gallons of water to yield 5 gallons of beer. Water is lost by soaking up in the grain, evaporation during the boil, soaking into the whole leaf hops, and during the cooling process.

Conclusion:

Brewing beer can be apart of a sustainable lifestyle. Brewing your own beer has a lower carbon footprint than buying beer from a mainstream brewing company. It is important to consider the life-cycle of the beer you are purchasing – i.e., where did the malt and hops come from? Is there a beer you can buy that supports local systems and communities?

If you are aware of the origin of the ingredients that make different beers then you can make a decision that supports sustainable brewing. The best way to brew sustainably is to brew beer yourself! Brewing brings communities together and can connect people with old time practices, further diminishing our reliance on large corporations. Plus, it is so rewarding to sit back and sip a beer that you created from start to finish. Enjoy our Sugar Shack Porter!

New Belgium LCA: *www.stanford.edu/~sjdavis/NBB-FT.pdf*