PRO Tech Notes For Craft Brewers
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Enzymes in Brewing Series: Part One-Malting

In David Kapral's last issue of PRO Tech Notes (Issue 3, Volume 2) he wrote about "Brewing Calculations". Within the context of this material he referenced the **available extract content of various grains**. In reading this, I began to consider where this extract came from, noting that it is not freely available in many raw grains. Enzymes are needed to free up this extract for the brewer to use to make alcohol and to provide many of the needed nutrients for yeast growth. Without this process there would be no beer. Now how sad is that!!

Naturally Occurring Enzymes from Malting

As we begin our discussion of enzymes, many of you take this to mean commercial enzymes. Although useful tools in the industry, we should note that the malting process utilizes the naturally occurring enzymes within the grain to free up the extract for our use. In the context to follow, I will be referring to the process of malting barley. It should be noted that many other grains used in brewing can also be malted in a similar manner, thus making their extract more available to the brewing process. Lastly, in addition to freeing up the extract, the malting process gives the brewer the enzyme spectrum required to make the product fermentable, thus the basis of beer.

Malting: Balancing Carbohydrates, Proteins, and Enzymes

Malting, the process of converting barley into malt, is as old as the history of beer. Malting and brewing are based upon the presence of carbohydrates and plant protein in the barley kernels, the ability of malting to create the natural carbohydrate and protein reducing enzymes, and the production of simple sugars from the plant starch and the production of an acceptable protein spectrum from the plant proteins utilizing these enzymes. Malt is a product of the plant germination process, staged within a set of controllable parameters required to achieve consistent results for the brewer.

Carbohydrates
Common carbohydrates that we are familiar with are sugars, starches and cellulose. The basic building block of all carbohydrates is a simple sugar, glucose. All carbohydrate chains are chains of glucose bonded together. Starches are composed of the fermentable alpha glucose and cellulose is composed of the non-fermentable beta glucose. Unless specifically referenced beyond this point, all glucose is to be considered alpha glucose.

Starch and Sugars
Plant starch is the stored energy of the plant that is broken down by plant enzymes when the plant requires energy. Starch found in the barley kernel is of two types; **Amylose**, linear chains of glucose molecules and **Amylopectin**, which is a multi-branched structure of glucose chains. The Amylose and Amylopectin differ in how the glucose units are linked together. Both have 1-4 glucosidic bonds within their linear structure, holding the glucose molecules together, however, the Amylopectin also has 1-6 glucosidic bonds at branch points creating its complex structure. This difference is important to the understanding of how the breakdown of the glucose chains leads to a difference in extract and fermentability.

Proteins
Proteins are the basic raw materials in tissue and cell building essential for life. Like carbohydrates, proteins are complex chains of the simplest protein compounds, amino acids. Unlike carbohydrates, which all are built from a single compound glucose, proteins are built from 25 different amino acids. Proteins are essential to brewing to provide for the amino acids for yeast nutrition, as well as they provide flavor, mouthfeel, foam and color. Larger proteins can also lead to turbidity and sediments.

Enzymes
Enzymes are polymers of amino acids and for all intent are proteins. They are proteins with a function. They are catalysts that regulate the speed of chemical reactions involved within a living organism's metabolism, without permanently changing the reactions. The enzymes of our particular interest are the ones responsible for digesting the starch and proteins chains described above. The prominent malting and brewing enzymes are **Amylases** (carbohydrate enzymes), **Proteases** (protein enzymes), **Peptidases** (break down protein pieces into amino acids), and **Beta Glucanases & Xylanases** (cellulose enzymes).

The Malting Process
The malting process consists of three phases; **Steeping, Germination and Kilning**. After the plant growth process is activated through steeping and germination, the "green malt" is kilned (dried and roasted) to stop the growth of the barley seedlings and to develop malt flavor and color.

This issue of PRO Tech Notes will not discuss the process of malting "in depth" . Please understand that in itself it is a complex process of airflows, temperatures and moisture control designed to facilitate the controlled growth of a barley plant. Perhaps in a future edition we can discuss some of these complexities and recognize our maltster friends for the fine work they do for the brewer.

Phase One-Steeping
As stated above, the malting process consists of three phases. The first phase, steeping, is a series of full emersions of large batches of barley in constantly aerated-temperature controlled water, spaced by drain cycles, again with heavy air flow to prevent heat and CO2 build-up. The purpose of this process is to increase the internal moisture of the barley kernel to above 40% while not drowning the early growing plant or damaging it by heat or CO2 generated in the plant respiration. This increased moisture turns on the internal mechanisms in the plant to begin growth and the moisture provides a medium for the transfer of the enzymes inside the kernel to begin self-digestion, thus the growing begins. This process can take upwards of 48 hours dependent upon the quality of the barley and the temperatures of the water and air applied.

Phase Two-Germination
The second phase of malting is germination. The steeped barley is transferred into large growing beds and leveled to provide equal exposure to the environmental conditions applied by the maltster for control. The germination process is a 4-5 day process that facilitates time for the growth of the barley seedling. Large amounts of moisture-saturated and temperature-controlled air is cycled through the beds to facilitate the removal of heat and CO2 generated by the now respiring plant. An excess of either will damage the growth process and create a whole set of other issues like premature yeast flocculation (PYF), and poor or variable modification, both of which could be material for yet another article. While in the beds, turning machines are sent regularly through the growing barley to keep the rootlets from matting as well as to apply water as if to water a garden.

Phase Three-Kilning
After the controlled growth, the green malt is transferred to a kiln where heated dry air is applied to dry the grain in a manner as to stop growth while preserving as much of the enzyme activity as possible. In the later stages of drying the heat is increased and the flavor and color development is enhanced. There are various methods and times of heat application used in order to facilitate broad ranges of colors and flavor used by the brewer, yet another opportunity for future discussion.

Self-Digestion from Enzyme Creation
During the growth of the barley kernel, which is occurring in the late stages of steeping and throughout germination, the objective of the growing plant is to self-digest its kernel to provide energy and nutrients for its growing. This self-digestion occurs through the growing plant's creation of a series of enzymes designed to breakdown the kernels starches and proteins. The maltster's objective is to control and harvest this process. In simple terms, the amylase activity for starch breakdown is minimized to prevent fermentable extract loss for the brewer, while the beta glucanase & xylanase (cellulose breakdown) and protease/peptidase (protein breakdown) activity is maximized to soften the kernel and expose the starch for brewer extraction in mashing.

Obviously there is a great deal of expertise and control that goes into this process. Coming out of the malting process we have now "modified" the barley to have the presence of carbohydrate digesting enzymes as expressed as Alpha Amylase content and Diastatic Power (DP) within the maltster's analytical profile of their finished

product. Additionally we will see an increase in soluble protein and more importantly an increase in the soluble over total protein (S/T) ratio as a direct expression of the barley modification. Lastly we will see a reduction in the beta glucan content and the wort viscosity as expression of cellulose digestion. Obviously if your independent focus was to only consider extract, you would be looking to maximize each of these changes. **But as we all know, what is important is balance.** This balance provides for the needed economies of our processes while facilitating control and consistency in creating the variety of products we enjoy.

Coming in the Next PRO Tech Notes: How to Use The Malt You Receive

In my next article I will begin the discussion on how to use what the maltster has provided. We will discuss the enzymes in action and at what time and temperature points are critical to achieving what we are trying to do in making various beers. We can also begin a discussion of available extracts and how to get at them. Notably, this can be a difficult process when testing the ranges of this science.

Commercial Enzymes

From this article I plan to introduce the world of commercial enzymes. Some of you may believe the use of these an exercise in poor judgment, but it is important to note that all of these enzymes have a basis in nature and are already part of the process. The use of these commercially available enzymes is just another tool for the brewer to press the boundaries of their processes. Looking at this issue, I question how many of you have had horrible experiences trying to use Rye or Wheat in making brands? These products are heavy in beta glucans & xylans and not just any beta glucanase/xylanase combination will help. Additionally, how many of you have tried to get higher alcohols only to find you cannot do so without extensive time and thus you start to add other flavor issues to your beers? In the right quantities added at the right time, you can have the tools at your fingertips to control your processes, thus keeping the real processes that are important to your product's flavor where you want them.

Recent Posts on the BA Forum

A recent post on the BA Forum asks just this question: "how to decrease the final extract on a product by breaking 1-4 glucosidic bonds". The easy answer is to add a glucoamylase (GA), which specifically targets 1-4 bonds in Amylose chains. But the real question is: Where do you want your extract and real fermentability to end up?" In

adding a GA, the glucose levels will increase very fast as it breaks down the linear chains of Amylose. Depending upon your objective, you could either change the entire fermentation to a glucose-based fermentation, or even end up with a stuck fermentation due to glucose suppression. This can be a foreign concept, that a glucose concentration can actually hurt your fermentation, but this is a real issue and needs close attention.

Another recent discussion deals with the presence of sufficient protein expressed as Free Amino Nitrogen (FAN), needed for good yeast growth and health. As you look at different ways you can be creative with your beers, the use of raw materials, other than well-modified malts, can lead to a deficiency in what your yeast needs. Many of you use malts that are not U.S. based. Outside the U.S., most of the world grows barley with protein levels that are much lower than what is grown in the U.S.. Additionally, outside the U.S., maltsters tend not to press the modification button as hard as within the U.S..

This results in lower available FAN in the malt, and thus for your yeast. If you choose to dilute this malt with unmodified grains or other adjuncts free of sufficient protein, you can sit at protein rest all day and never reach the needed FAN levels for a healthy fermentation. But don't fear, there are commercial solutions that can be used. Enzymes can be added in such a manner as to give you the needed FAN while still preserving enough large protein fractions for the wonderful foam retention your expertise deserves.

Watch for the May Issue!
I hope you will join me on this journey as we discuss the important enzymes in brewing. I also look forward to any questions or comments you may have regarding the content provided.

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The author, Mark Sammartino has over 35 years experience in the brewing industry. Some of his experience includes:

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Additionally, Mr. Sammartino is a consultant with Brewing Consulting Services, LLC **The company provides a wide range of practical operational advice and solutions to clients in the Craft Brewing industry.** The group also includes Founder, David Kapral and Associate, Pat Frost. Collectively this group has 100 years of experience in the industry.

Contact Mark Sammartino if you would like to discuss the issues raised in the article or if you want to explore further assistance from the firm of which he is a member:

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Ed Michalski (left) with brother Dave, checking specs for a customer

If you need brewing equipment repaired, or re-engineered to work better, faster or more cost-effectively, contact Ed Michalski, CEO, at PRO Engineering and Manufacturing, Inc.

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