Proteins in mashing.

Proteins are polymers, or long chains of a basic building block. In the case of proteins, the building blocks are known as amino acids. Amino acids may occur singly, in short chains known as peptides, or in longer chains as proteins.

Proteins constitute a broad class of biological compounds that are critically important in many phases of brewing. They are essential to the processes of malting and mashing and they have a direct influence on body and head formation.

A special class of proteins are called enzymes. Where most other proteins tend to have storage and structural roles, enzymes make things happen. Enzymes are catalysts, and as such, they promote chemical reactions without changing their own structure or character. Enzymes are generally given names that end with "-ase."

Enzymes play a critical role in malting and mashing. Some are responsible for the breakdown of starch into sugars. Others breakdown other molecules, including proteins into simpler products. Still others synthesize new compounds from various precursors.

The complex protein of the raw barley kernel includes some enzymes, but others are developed during malting. The critical mashing enzyme known as alpha-amylase is an example of an enzyme that is absent in raw barley but gets formed during malting.

Each enzyme catalyzes just one very specific chemical reaction. Also, enzymes generally achieve optimal performance under specific conditions of temperature and pH. When subjected to non-optimal conditions, their performance deteriorates, but it can improve again when optimal conditions are restored.

Under extreme conditions of heat or pH, enzymes can permanently lose their catalytic activity. When this occurs the enzyme is said to be denatured. In malts that have been subjected to high temperature kilning such as chocolate or crystal, most of the mash enzymes have been denatured. Munich malt is kilned at an intermediate temperature that denatures some of the amylases, but still leaves adequate enzyme activity for mashing.

For brewing, the important classes of enzymes include amylases, proteases and beta-glucanase.

Amylases include two main enzymes, designated beta and alpha. They work together during mashing to break starch down into simple sugars.

Beta-amylase works only from the end of the starch chain and "bites off" two sugars at a time. The disaccharide that it produces is maltose -- the most common sugar available from barley malt. This type of short sugar is what yeast will consume during fermentation. They have difficulty with three-sugar chains and cannot consumer larger sugars at all.

The alpha amylase enzyme isn't as selective as the beta. It can break apart starch chains at almost any point in the starch chain. As a result, it usually breaks long chains 100 to 500 sugars in length off of the starch molecule.

The work of alpha amylase speeds breakdown of starch by splitting a single starch molecule into many shorter chains that can all be attacked by beta-amylase.

When these two enzymes act on straight-chain starch (amylose), they can reduce the starch completely to fermentable sugar. This means it is possible for every bit of this type of starch to be broken down into units no more than two or three sugars long. As a result of this breakdown, all of the sugars would be fermentable by yeast.

With amylopectin -- a bushy type of starch -- the two amylases have some problems. The branch points in the starch structure are places where the alpha and beta amylase can't break up the starch chain. These left over bits of starch provide body to every beer.

These two important brewing enzymes are not destroyed by the kilning process during malting. In fact the amylases work well at temperatures of 140 deg F (60 deg C) to 158 deg F (70 deg C) typically found in a mash.

Proteases digest proteins by breaking down the bonds between amino acids. This is the mechanism by which reserves present in the barley as storage proteins are liberated. Both peptides and amino acids result from the breakdown of these proteins and they play an important part in beer chemistry. Among other things, they contribute to yeast metabolism and head retention.

The proteases include a over 40 different enzymes which act in different ways upon protein. Some cleave a single amino acid from one end, while others liberate long chains of amino acids from the larger protein.

Many of the proteases survive in malt and will be active in the mash at temperatures near 50 deg C or 122 deg F. A mash rest at this temperature can help to increase the levels of free amino nitrogen which is an essential yeast nutrient and may also improve head retention through production of additional medium sized proteins.

Beta-glucanase acts on gum-like materials in the malt to help improve lautering and beer clarity. A carbohydrate, beta-glucan is made up entirely of simple sugar molecules, just like starch. The critical difference between the two comes in the structure of the bonds between the individual sugar units.

The gum-like character of beta-glucan can increase viscosity of the wort during lautering and lead to slow run-offs. This will be especially true when grains high in beta-glucans such as wheat, rye and oats are used. Also, beta-glucans tend to be soluble in hot wort but insoluble in cold beer and thus may contribute to chill haze. If these problems are encountered (or anticipated) attention may be paid to increasing beta-glucanase activity in the mash.

Beta-glucanase is reported to work best at mash temperatures of 40 to 50 deg C or 104 to 122 deg F. The mid-point of 45 deg C or 113 deg F is often recommended for optimal beta-glucanase activity.

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