# Technical Question T13: “Brewing Process Question” – Mashing

Shooting for around 400 words per BJCP website and Hommel’s results.

<https://www.bjcp.org/course/Class4Lesson1MashingProcessTechniques.php>

**Explain What Happens in the Mash:**

In the mash, the milled, cracked kernels of grain are soaked in hot water at various temperatures to activate enzymes which perform a variety of conversions on the material(starches) held within the kernels. The primary traditional phases are Acid rest(95-120F), Beta Glucanase Rest(110F), Ferulic Rest(110F), Protein Rest(113-127F)and Saccharification rest.(130-158F). Because of the quality of modern malts we primarily worry about protein rests and saccharification rests. During the protein rest; Proteins are broken down in to amino acids, polypeptides and peptides which are essential for yeast growth and development. This occurs at 113-127F and can last from 15-60 minutes. Saccharification has 2 enzymes we talk about. Beta Amylase and Alpha Amylase. Beta Amylase thrives from 130 to about 150F and cleaves the ends off starches to create the sugars fermentable by brewers yeast. Alpha Amylase thrives from 149F-158F and cleaves the non-fermentable dextrins(starch chains) which build on the body of beer. The timing of each step is based on temperature as you raise the temperature from lowest target rest all the way through mash out temp which occurs at 168F. At 168F and above all enzyme activity is denatured and can’t be reactivated. So the mash is over at that point.

**Three Mashing Techniques:**

**Single Infusion Mash -** Most common and simple mashing technique used today. Involves adding water at a temperature appropriate for starch conversion. Typically 148-158F so that Beta Amylase and Alpha Amylase are active in a range which will make a good wort for target beer style.

**Step Mash –** Water is added but the temperature is increased through steps by external heating(direct fire) or by adding boiling water additions to the mash. Developed to mimic the temperature raises of a decoction mash.

**Decoction Mash –** A traditional Eurpoean method. The mash water is added to the grist for the initial mash temperature for the first rest temperature. . To reach next rest temperatures involves raising the temperature of the mash by taking off a portion of the mash, raising its temperature to a saccharification temperature for a time, then boiling it to release starches, then returning it to the main mash to raise the overall mash temperature. Typically done in 1 to 3 steps.

**Advantages and Disadvantages:**

**The advantage of single infusion mash** is that it’s very simple, doesn’t require much labor and does great for simple beer styles like American pale ale or English pale ales or stouts. It’s disadvantage is you don’t have much control beyond the one step and it can be less effective in converting under modified malt.

**The advantage of step mash** is you have more flexibility in moving through the different ranges of temperatures that promote specific enzyme activity. The disadvantage is that it doesn’t offer the promotion of melanoidin formation the same way a decoction will. It’s also a little more work than a simple single infusion.

**The advantage of a decoction mash** – With decoctions you have the most flexibility in brewing with unmodified malts. Promotes melanoidin formation necessary for many beers. Disadvantages are it’s extremely labor intensive and raises the risk of scorching or ruining beer if inexperienced.

# Technical Question T13. “Mashing”

#  Explain what happens during the mashing process, including times and temperatures as appropriate. Describe three different mashing techniques and the advantages and disadvantages of each. Address the following topics:

|  |  |
| --- | --- |
| **50%** | **Explain what happens in the mashing process, including times and temperatures as appropriate.** |
| **30%** | **Identify and describe three mashing techniques.** |
| **20%** | **Identify and describe three different mashing techniques and the advantages and disadvantages of each.** |

**1) Mashing Basics**

 \* Mashing is the process of heat and soaking malt to hydrolyzing enzymes and gelatinizing starches within.

 *\* Enzyme action breaks down proteins and starches* within the mash for optimum yeast health and nutrition.

 \* “Rests” at certain temperatures, for certain lengths of time, favor the action of various enzymes.

 - Rest temperature ranges can overlap.

 \* Mashing creates fermentable sugars in the wort.

 \* Mashing gives you full control over wort composition.

 \* M.A.L.T. = More Alcohol, Lower Temperature.

**2) Milling**

 Milling is a pre-cursor to mashing.

 \* It crushes the contents of the kernels, increasing the amount of surface area available for hydolyzation and enzyme action.

 \* Grain husks form a filter bed which helps clarify mash run-off during lautering and sparging.

 \* If grains are milled too coarsely (a coarse “crush”) the following problems can occur:

 - increased dough-in time.

 - reduced enzyme efficiency.

 - reduced extract yield.

 \* If grains are milled too finely (a “fine crush”) the following problems can occur:

 - increased risk of stuck mash.

 - trouble with wort clarity.

 - bits of husk carried into wort during sparging (resulting in polyphenol extraction during wort boil, which causes protein haze and astringency).

**3) Mash Requirements**

 A) **pH range: 5.2-5.8.** You usually need toadjust water chemistry to get you water into this range: additions of mineral salts, acids, or use of dark or acidulated malt.

 - Test using pH strips or pH meter.

 - Higher pH causes trouble with tannin extraction, reduced enzyme efficiency.

 - Lower pH causes reduced enzyme efficiency.

 - Modern buffering solutions (e.g., Five Star 52™) get pH into optimum range without need for acid additions or salt additions.

 B) At least 50 mg/l Ca++ for optimum mash efficiency.

 ***C) Starch Conversion Test:*** To get optimum extract yields and to check for full conversion.

 *- Iodine test:* Take a drop of liquid from the mash and put it on a white porcelain plate. Add a drop of iodine (Iodophor™ will work) to it. If the sample turns dark purple, starch conversion is incomplete.

 - Most homebrewers don’t bother. With well-modified malts, a mash of 30-90 minutes guarantees full conversion.

 - Incomplete starch conversion can result in starch haze.

4) Mashing Steps

 Using a step mash regime, all these steps are possible, although they aren’t always necessary. With an infusion mash, only dough-in and saccharification are possible.

 **A)** ***Dough-In (10-15 °F higher than 1st rest temperature):*** *Grist is mixed with water, hydrolyzing enzymes and allowing them to work.* \* Water temperature drops to desired rest temperature as it is cooled by room-temperature grist. \* ~1.3 quarts water/lb. grist. \* Break clumps so no dry grist remains. \* Mix thoroughly to get temperature even.

 **B)** ***Acid Rest (95-120 °F, for 60-120 minutes):*** \* Phytase breaks down phytin in grain husks, producing phytic acid, Mg++ & Ca++. \* Reduces mash pH in pale, undermodified grains & low Ca++ water. \* Creates yeast nutrients. \* *Not necessary with modern malts and proper water treatment.*

 **C)** ***Beta Glucanase/Starch Rest (~110 °F for 15-30 minutes):*** \* *Betaglucanase reduces hemicellulose & gums* (Beta glucans) in cell walls which can contribute starch haze & cause stuck mash.\* Only needed for under-modified or high-protein (e.g., wheat, oats) malt only. \* *Usually run concurrently with Protein Rest and/or Ferulic Acid Rest.*

 **D)** **Ferulic Acid Rest (~110 °F for 15 minutes, at pH < 5.7):** \* Liberates ferulic acid, precursor to 4-vinyl guaiacol, in wheat malt. \* Slightly aids in production of clove flavor for German wheat beers (although yeast strain and fermentation temperature is more important). \* Only need to mention this if you’re a smartass trying for a master score!

 **E)** **Protein Rest (113-127 °F for 15-60 minutes):** Protease enzymes (proteinase & peptidase) degrade large (albuminate) proteins into smaller fractions such as polypeptides, and degrade polypeptides into peptides & amino acids, essential for proper yeast growth & development. \* Important when mashing undermodified or high-protein (e.g., wheat) malts. \* Generally not necessary with fully-modified malts. \* Excessively long protein rest (1+ hour) can result in thinner body and reduced head formation and retention. \* Skipping protein rest can result in stuck mash or excess body, haze and storage instability in finished beer.

 **F)** **Saccharification/Starch Conversion Rest:** \* Diastatic enzymes (alpha and beta amylase) degrade starches into dextrins and fermentable sugars.\* Different enzymes work optimally at different temperatures. \* Altering temperature favors one over the other. \* Mash at 150 °F to get a balance between the two types of enzymes. \* Enzymes produce monosaccharides (glucose, fructose, mannose, galactose), disaccharides (maltose, isomaltose, fructose, melibiose, lactose), trisaccharides (maltriose) and oligosaccharides (AKA dextrins = glucose chains).

 **I. *Beta Amylase Rest (130-150 °F for 15-90 minutes. Denatured at 164 °F):*** Favors the action of Beta Amylase which cleaves 1-6 bonds at the reducing ends of starch chains to produce monosaccharides. *\* Yields wort very low in dextrins, high in fermentables* \* *Produces thinner-bodied, drier, more alcoholic,* more “digestible” beer, with *poorer head formation and retention.*

 **II Alpha Amylase Rest (149-158 °F for 15-90 minutes, denatured at 168 °F):** Favors the action of Alpha Amylase which randomly cleaves 1-4 bonds of starch chains to produce oligosaccharides. \* Yields wort higher in dextrins, and lower in fermentables \* Produces fuller-bodied, sweeter, less alcoholic, starchier beer with better head formation and retention.

 **G)** **Mash-Out (**168 °F for 5-15 minutes): \* Denatures enzymes, stops starch conversion. \* Reduces viscosity, aids mash run-off. \* Mash temperature should not exceed 168 °F to avoid tannin extraction.

**5) Mashing Techniques**

 The four major types of mashing are listed below. Remember you only need to know three for the exam!

**A) Infusion Mash**

 **Describe:** Grist is mixed with hot water at starch conversion temperatures and is allowed to rest at that temperature for the entire duration of the mash.

 **Advantages:** Requires a minimum of labor, time, energy, equipment & skill. Suitable for use of well-modified malts.

 ***Disadvantages:*** \* *Little control over mash temperature* after dough-in (except to add more water). \* Prevents use of undermodified malt. \* Limits use of adjunct grains (if they require a cereal mash or protein rest).

B) Step Mash (AKA Temperature-Controlled Mash, Step Infusion Mash)

 ***Describe:*** The mash is held at various temperatures for specific periods of time, starting with the lowest temperature rest on the schedule. *When the first rest is completed, the mash is then directly or indirectly heated to raise it to the next rest temperature.*

 ***Advantages:*** *\* Increased control over wort composition.* \* Allows use of undermodified malts. \* Allows use of high-protein/gummy adjunct grains and malts. \* Allows mash-out without adding water.

 ***Disadvantages:*** \* *Requires extra time, equipment, labor and skill.* \* Directly heating the mash tun can potentially scorch mash. \* Adding hot water to mash tun to raise temperatures can result in excessively thin mash, raise pH out of proper range or result in wort with insufficiently high specific gravity.

**C) Decoction Mash**

 **Describe:** A simple, traditional German form of temperature-controlled mash where part of the mash is removed from the main mash tun, heated to boiling in a separate container, held there for a certain amount of time and then returned to the mash to raise overall mash temperature.

 Steps are as follows: 1. Dough in at first desired rest temperature. 2. Remove a third of thick portion of the mash. 3. In another kettle, briefly raise the decoction temperature saccharification temperatures (2-5 minutes). 4. Boil the decoction for 15-30 minutes, stirring constantly and adding water as necessary to avoid scorching. 5. Mix the decoction back into the main mash to raise overall temperature. Mix thoroughly to avoid hot spots in the mash. 6. Repeat up to 2 times.

 The formula for raising the mash temperature using a decoction is:

**Decoction volume =** total mash volume x (target temp - start temp) / (boil temp - start temp)

 \* *Triple decoction mashes* were traditionally used for Bohemian Pilsner, Traditional Bock, Doppelbock and Munich Dunkel.

 \* *Double decoction mashes* were traditionally (in the 19th and 20th centuries) used for other styles of German beers. Until recently, variations on the double decoction mash were used for most styles of German beer.

 \* A single decoction mash is mostly commonly used to get to mash-out when otherwise using an infusion mash. It is well-suited to modern, well-modified continental lager and amber malts.

 ***Advantages:*** \* *As for Step Mashing.* Additionally: \* Explodes starch granules. \* Breaks down protein matrix in undermodified malt. \* Improves extraction efficiency when using undermodified malt. \* Promotes formation of melanoidins. \* Can caramelize sugars (but at risk of scorching). \* Allows brewing without thermometer (since adding a decoction back into the mash naturally elevates it to the next rest on the schedule of acid rest, protein rest, saccharification rest and mash-out).

 ***Disadvantages:*** *\* As for Step Mashing.* *\* Extremely labor and time intensive.* \* Requires extra equipment and space. \* Extra energy required. \* Direct fired decoction vessel required. \* Risk of scorching decoction. \* May extract higher levels of tannins & DMS precursors from grain husks.

**D) Cereal Mash (AKA Double Mash)**

 **Describe:** This technique actually consists of *two separate mashes which are blended to reach saccharification temperatures.* The main mash consists of crushed malt, while the second (cereal) mash consists of raw adjunct grains and just a bit of crushed malt. The *cereal mash boiled for 1 or more hours to gelatinize starches, then added to main mash*, which has undergone acid and/or protein rests. The increased temperature of the adjunct mash might increase the main mash temperature to saccharification temperatures, but sometimes the main mash must be heated as well.

 *Cereal mashing is used to make beers which contain unmalted adjunct grains,* assuming the brewer starts with raw grains, rather than pre-gelatinized grain flakes or grits.

 **Advantages:** \* As for Step Mashing. *\* Allows the use of inexpensive raw grains* such as maize or rice which require high gelatinization temperatures (as opposed to pre-gelatinized grain flakes or grits).

 ***Disadvantages:*** *\* As for Step Mashing.* *\* Time and energy intensive.* \* Cereals must be boiled or hot-flaked before adding to mash. \* Only appropriate for brewing beers which have a high proportion of adjunct grains.

**Describe 3 Mash Techniques**

 **A) Infusion Mash: Describe:** Mixing grain w. single temperature of water & resting at that temp for the entire mash. **Adv. & Disadv.:** Requires minimum of labor, equipment, energy & time. Prevents use of undermodified malt & limits use of adjuncts.

 **B) Step Mash: Describe:** Mashing in w. a low temp. of water. Raise mash temp. to achieve conversion goals by adding boiling water to mash or directly/indirectly heating mash tun. **Adv. & Disadv.:** Allows flexibility in use of different temp steps. Allows use of undermodified malts. Req. more resources (labor, time, equipment).

 **C)** **Decoction Mash: Describe:** 1. Dough in. 2. Remove a thick third of mash. 3. Raise decoction briefly to saccharification temp. 4. Boil decoction 15-30 minutes, stirring constantly, adding water to avoid scorching. 5. Mix decoction back into main mash to raise temp. 6. Repeat up to 3 times. **Adv. & Disadv.:** Explodes starch granules. Breaks down protein matrix in undermodified malt. Improves extraction efficiency Promotes formation of melanoidins. Caramelizes sugars. Allows brewing without thermometer. Most labor & time intensive. Requires extra equipment. Risk of scorching decoction. May extract higher levels of tannins & DMS precursors from grain husks.

**Question T11 “Diastatic and Proteolytic Enzymes” Sample Answer**

|  |  |  |
| --- | --- | --- |
|  | Proteolytic | Diastatic |
| Works on: | Proteins | Starches |  |
| Subset | Proteolytic | Beta Amylase | Alpha Amylase |
| Temp. | 113-127 °F | 130-150 °F | 149-158 °F |
| Describe/Explain | \* Proteinase breaks down proteins into smaller fractions such as polypeptides – necc. for good head retention.\* Peptidase breaks down polypeptides into peptides & amino acids, essential for proper yeast growth & development | \* Starches are gelatinized |
| \* Beta amylase enzymes breaks off maltose units from reducing ends of starches\* Unable to break down largest units of starches\* Denatured above 154 °F | \* Alpha amylase enzymes breaks 1-4 links from starches at random\* Unable to break down into smallest units of starches\* Denatured above 167 °F |
| Effects | \* Reduces cloudiness\* Too long a protein rest can reduce head & body. | \* Creates more fermentable wort, thinner bodied beer | \* Creates more dextrinous wort, thicker bodied beer |

**Question T13 “Mashing” Sample Answer**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Mashing Step | Temp. | Time | Active Enzymes | Description |
| Milling Grain | n/a | n/a | n/a | Grinding grain to crush kernels & expose starches |
| Dough-in | 10-15 °F < than 1st rest |  |  | \* Mixing grist w. water \* 1.3 qt./ lb. grist \* Break all clumps so no dry grist remains |
| Acid Rest | 95-120 °F | 60-120 min. | \* Phytase | Breaks down phytin in grain husks, producing phytic acid, Mg++ & Ca++. Reduces mash pH in pale, undermodified grains & low Ca++ water. Creates yeast nutrients. Not necc. w. modern malts, proper water treatment. |
| Beta Glucanase/Starch Rest | ~110 °F |   | Betaglucanase | For under-modified malt only. Reduces hemicellulose & gums (Beta glucans) in cell walls which can contribute starch haze & cause stuck mash. |
| Ferulic Acid Rest | ~110 °F | 15 min.  | n/a | At pH < 5.7. Liberates ferulic acid, precursor to 4-vinyl guaiacol. Slightly aids prod. of clove flavor for German wheat/rye beers (but yeast strain & ferment. temp. more important). Not necc. for other styles. |
| Protein Rest  | 113-127 °F | 15-60 min. | Proteinase & Peptidase = Proteolytic enzymes | Breaks down proteins into smaller fractions such as polypeptides. Breaks down polypeptides into peptides & amino acids, essential for proper yeast growth & development. Aids head form. & retent. Reduces risk of stuck mash. |
| Saccharification | \* Breaks down starches into dextrins & fermentable sugars.Produces:\* Monosaccharides: Glucose, Fructose, Mannose, Galactose \* Disaccharides: Maltose, Isomaltose, Fructose, Melibiose, Lactose \* Trisaccharides: Maltriose \* Oligosaccharides: “dextrins” = glucose chains. |
| Beta Amylase | 130-150 °F | 15-90 min. | Beta Amylase | \* Subset of Diastatic enzymes \* Yields wort very low in dextrins, high in fermentables \* Breaks maltose units from reducing ends of starches. \*Works slower than Alpha Amylase |
| Alpha Amylase | 149-158 °F | 15-30 min. | Alpha Amylase | \* Yields wort high in dextrins, lower in fermentables \* Randomly breaks 1-4 links from starches. |
| Mash-Out | 168-172 °F | 5-15 min. |  | \* Denatures enzymes, stops conversion \* Reduces viscosity, aids run-off of mash. \* Reduces risk of stuck mash. |