
Wort Production

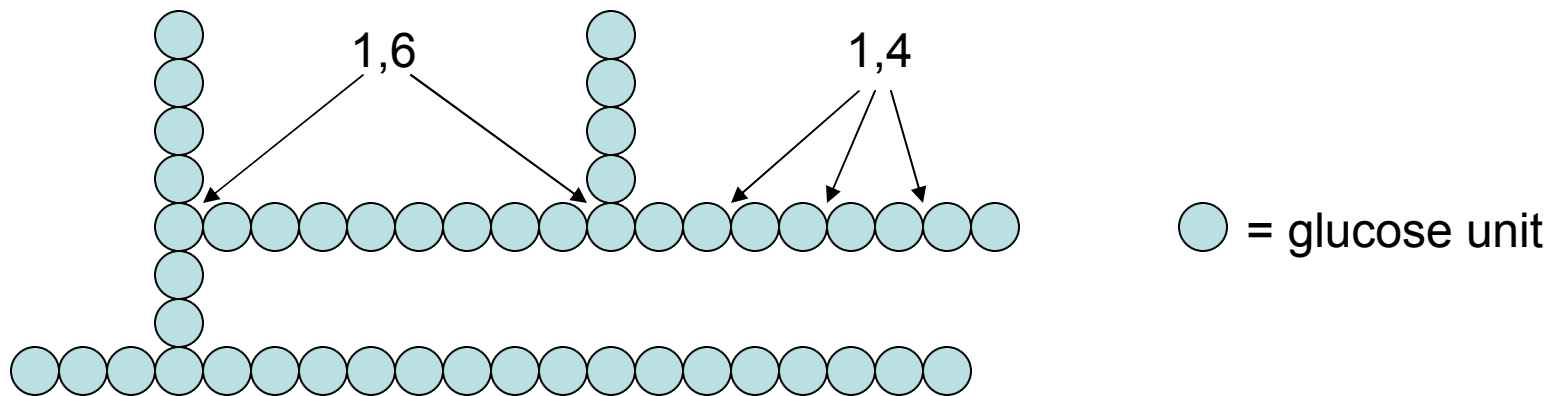
Andy Hejl

Why Mash Grains?

- Mashing grains is a critical step in brewing
 - Gets starches and proteins into forms usable by yeast
 - A continuation of process started in malting
- Can control many aspects of final beer
 - Body, head retention, yeast health

Schematic of Starch Molecules

- Starch molecules are a biopolymer
 - Individual components are single glucose molecules
- Glucose molecules can be linked in two ways
 - 1,4-linkages – can be broken down by amylases
 - 1,6-linkages – cannot be broken down, branch points



Diastatic Power

- Diastatic power is the ability of malts to self-convert
- Higher kilning of malts denatures enzymes
- Measured in Degrees Lintner
- Base malts have higher diastatic power
 - Pilsner – DP 130
 - 6-row barley – DP 160
 - Can use base malts in conjunction with adjunct grains
- High-dried malts are at limit of self-converting
 - Munich – DP 30

Why Enzymes Have Temperature Ranges

- Enzymes catalyze chemical reactions
 - In brewing they are mostly breaking down compounds
- Key is balance of activity against lifetime
- High temperatures – enzymes act quickly but die quickly
- Low temperatures – enzymes act slowly but live long

- This means that there is an optimum range where we get the most out of the enzymes before they die

Mash Steps – Acid Rest

- Phytase – 86-126°F
 - Phytase converts phytin to phytic acid
 - Drops the mash pH
 - More useful in undermodified, pale malts
- β -Glucanase – 98-113°F
 - β -glucans are gums found in barley cell walls
 - Improves lautering and beer clarification
- Step usually not necessary with fully modified malts
- Both of these enzymes can be destroyed by kilning

Mash Steps – Protein Rest

- Three forms of peptides in beer
 - Large proteins – natural form, cause haze
 - Medium – Promote head formation and retention
 - Small – Improve yeast health
 - Free Amino Nitrogen
- Generally protein rest is 122-131°F
- Proteinase – 122–140°F
 - More important to forming medium weight
- Peptidases – 113-122°F
 - Breaks medium down into small peptides
- These are called “proteolytic enzymes”

Mash Steps – Saccharification Rest

- β -Amylase – 140-149°F
 - Cleaves maltose (2 glucose) units from end of chains
 - High β -amylase activity is associated with highly fermentable wort
- α -Amylase – 149-158°F
 - Cleaves bonds at random points in the chain
 - Higher temperatures leave less fermentable wort
 - More dextrins in the beer
- Starches reach maximum solubility ~150°F
- A single mash temperature can activate both enzymes
 - Called “diastatic enzymes”

Mash Temperature and Mouthfeel

- Changing mash temperature can control body
- Dextrins are largely unfermentable and stay in beer
- Higher mash temperature gives more body
 - Not necessarily more sweetness

Component	149°F Mash	158°F Mash
Sugars	76%	65%
Dextrins	24%	35%

Mash Steps – Mash Out

- Heat mash to 168°F at the end of mash
 - Above 170°F can extract tannins
- Accomplishes several things
 - Halts conversion
 - Solubilizes more sugars
 - Reduces viscosity of wort

Mash Thickness

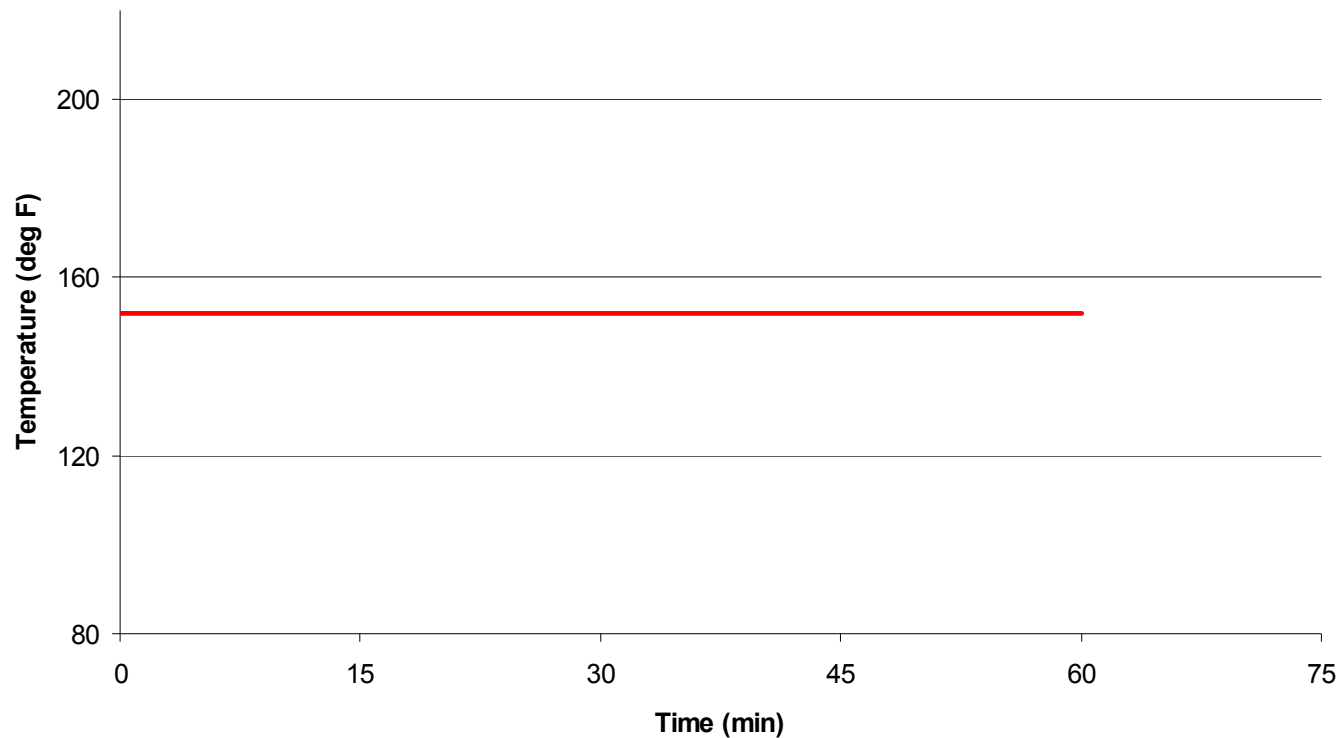
- Ratio of water : grain can impact fermentability
- Thick mash
 - 1 Qt/lb grain
 - Thick mashes favor proteolytic activity
- Thin mash
 - 1.5 Qt/lb grain
 - Thin mash favors diastatic activity to a point
- These differences are very small relative to Temperature

Mash pH

- Mash pH should be in range 5.2-5.4
 - Leads to wort pH of 5.0-5.2
- If pH is significantly different enzyme activity suffers
 - Enzyme activity drops quickly as pH goes up
 - If pH is low, losses aren't as great
- Can be adjusted several ways
 - Water chemistry
 - Acid rest
 - Addition of acid, acidulated malt

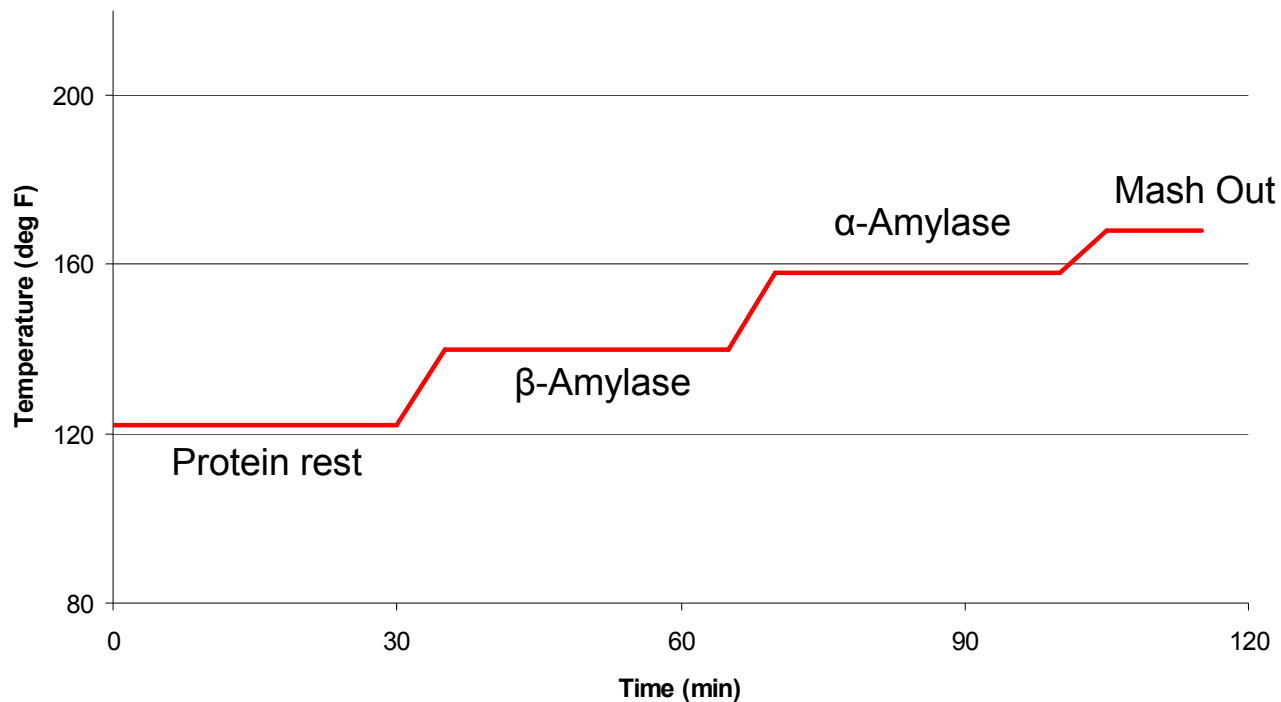
Mash Profiles – Single Infusion

- Most simple form of mashing, one temperature
- Traditional for British styles
- Requires fully modified malts



Mash Profiles – Step Mash

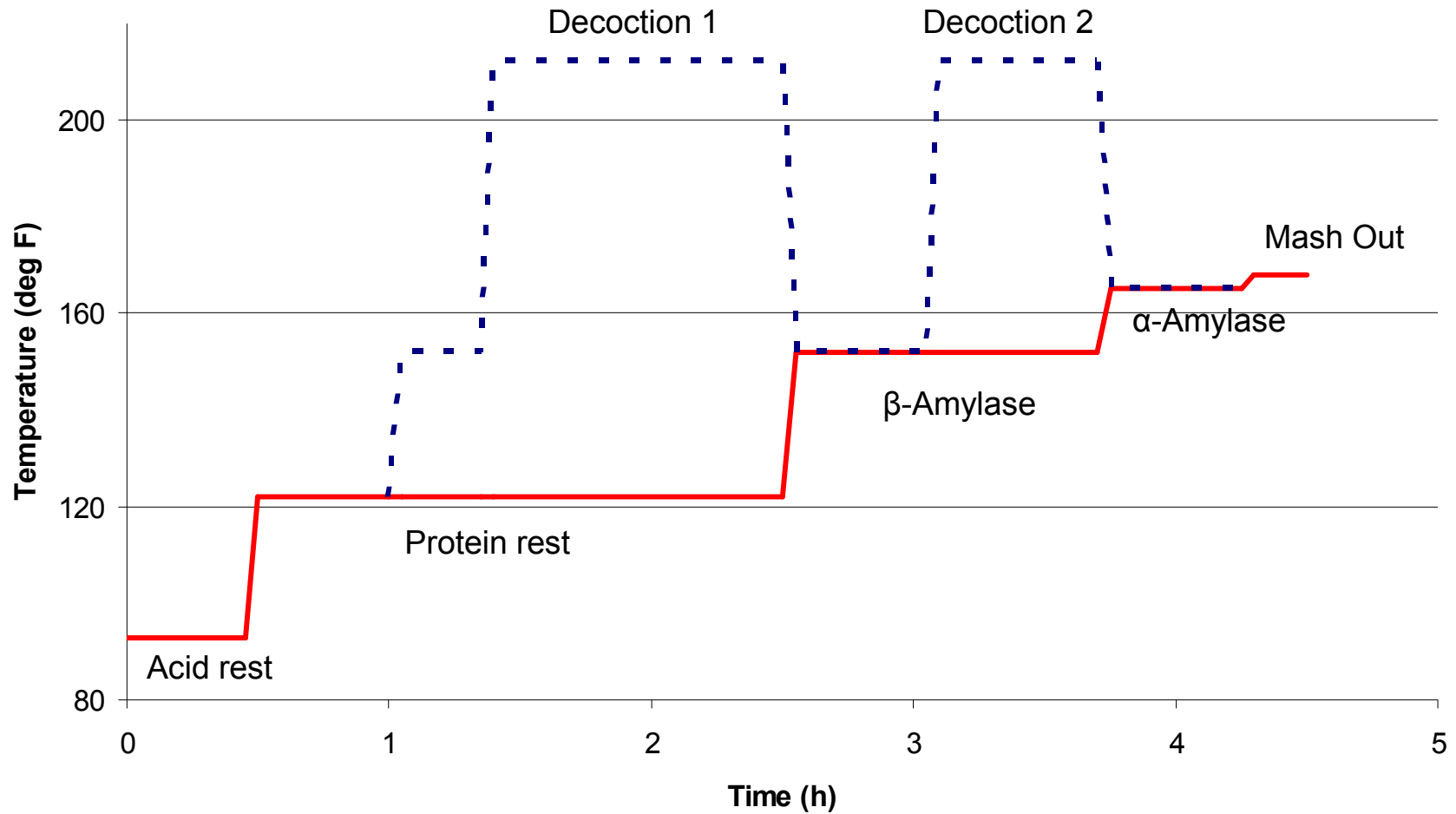
- Mash temperature raised through several steps
- Temperature raised by direct heat or water infusion
 - More complex system needed
- Can use undermodified malts



Mash Profiles – Decoction Mash

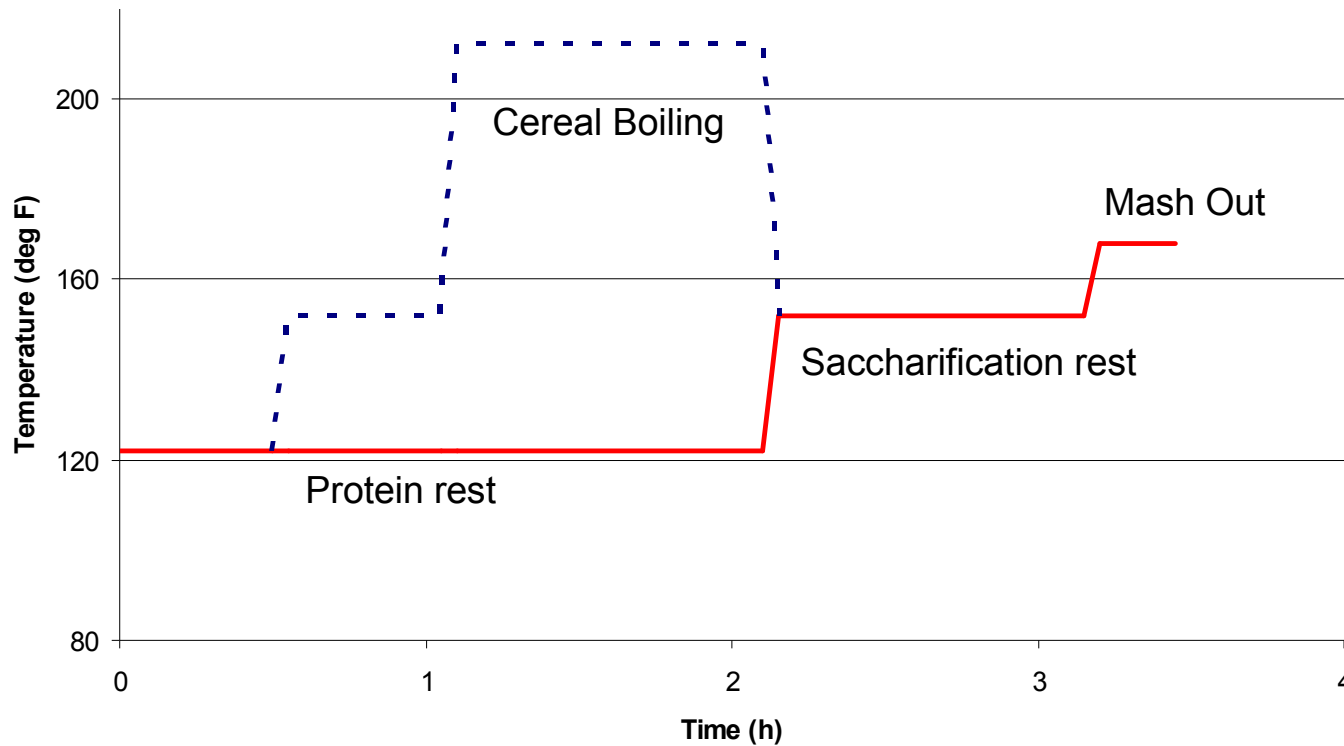
- Decoction is a traditional German brewing technique
- Thick portions of mash removed from main mash
- Decoction boiled and readded to reach next mash rest
- Advantages
 - Allows undermodified malts
 - Improves efficiency
 - Promotes formation of melanoidins
- Disadvantages
 - Much more time and labor intensive
 - Can pull more tannin from husks

Mash Profiles – Decoction Mash



Mash Profiles – Cereal Mash

- Used with starchy adjuncts that are not gelatinized
 - Rice, corn, barley – unmalted



Lautering/Sparging

- Lautering is separating sweet wort from spent grains
- Initially run off wort and recirculate until clear (Vorlauf)
 - Improves clarity, prevents astringency
- Sparging – rinsing the grain bed
 - Continuous sparging – fly sparging
 - Batch sparging
- Sparge water should be kept 160-170°F
 - Higher temperatures improve efficiency
 - Above 170°F can extract tannins from grains
 - Excess sparging will extract tannins
 - Keep runoff above 1.010 and below pH 6

Wort Boiling

- Boiling wort serves many purposes
 - Sanitizes the wort
 - Extracts, isomerizes alpha acids
 - Stops enzymatic activity
 - Coagulates proteins in hot break
 - Evaporates undesirable compounds
 - Promotes formation of melanoidins, caramelization
 - Evaporates water, increasing gravity
- Usually 60-90 minutes is sufficient boiling time
- Boiling should be vigorous “rolling boil”

Dimethyl Sulfide (DMS)

- One of the most common off-flavors in beer is DMS
 - Vegetal, cooked corn aroma
- Produced from S-methyl methionine (SMM) precursor
 - Conversion happens above 180°F
 - SMM found in malt, less SMM with more kilning
 - Pilsner malt has highest concentrations
- Avoidance
 - Use a 90 minute uncovered boil with Pilsner malts
 - This converts SMM to DMS and boils off
 - Chill wort quickly to avoid producing more DMS

Hot Break

- Hot break is coagulation of proteins in boil
 - Under heat the proteins denature and clump up
- Poor hot break can negatively impact clarity of beer
 - More proteins result in chill haze
- To promote hot break boil hard for at least 1 hour
 - May remove the hot break during boil or after
 - Keep pH of wort around 5.2 for best break

Wort Chilling

- After boil, beer should be quickly chilled to pitching temp
- With slow chilling several problems could occur
 - Contamination
 - Production of DMS
 - Poor Cold Break, reduced clarity

Cold Break

- Cold break is made up of protein and tannin complexes that form during chilling of the wort
- Forms around 140°F and will continue as beer is chilled
- Can be improved with kettle finings
 - Irish Moss, Whirlfloc in last 15 minutes of boil
- Cold break should be removed before fermentation
 - Reduction of fusels, sulfur compounds
 - Provides clearer beer
- Small amounts of cold break can help yeast health
 - Should be plenty unless you chill very far

Brewing Process Questions

- *Explain what happens during the mashing process. Describe three mashing techniques and the advantages and disadvantages of each.*
- Goals of mashing process
 - Breakdown starches, proteins, set fermentability
- Different steps – acid, protein, saccharification, mash out
- Three techniques
 - Single infusion, step mash, decoction mash
- Advantages/Disadvantages
 - Ease/complexity, malt requirements, flavor profiles, efficiency gains, tannin extraction

Brewing Process Questions

- *Describe and explain the role of diastatic and proteolytic enzymes in the brewing process and how they affect the characteristics of the finished beer.*
- Diastatic enzymes
 - α - and β - amylase, temperature ranges, action
 - How do these affect mouthfeel, fermentability?
- Proteolytic enzymes – temperature range
 - Proteinases – form medium polypeptides
 - Peptidases – form small peptides, amino acids, FAN
 - Clarity, head retention, yeast health

Brewing Process Questions

- *What is meant by the term hot break and cold break? What is happening and why are they important in brewing and the quality of the finished beer?*
- Definitions and composition of hot break and cold break
- How to promote good break
 - Vigorous boil, kettle finings, rapid chilling
- What do good breaks add to beer?
 - Clarity, cleaner flavor, stability