



What are the Ingredients in Beer (12 oz bottle)?

1. Water (~12oz)
2. **Malted Barley** (1.2-2.4 oz or 30-65 grams)
3. Cereal Adjunct (corn or rice)(0.0 to 0.6 oz)
4. Hops (~0.005 oz: 0.14 gram)



Why is Malted Barley Used in Brewing?

- Fermentable extract:
 - the starch in barley malt is converted to sugar during brewing.
 - In turn, the yeast converts the sugar to ethanol and carbon dioxide
- Enzymes:
 - The malting process develops enzymes that are needed in the brewing process to:
 - Convert starch to sugars (extract)
 - Convert protein to amino acid
 - Cereal adjuncts (corn/rice) contribute starch, but have no enzymes!

Why is Malted Barley Used in Brewing?

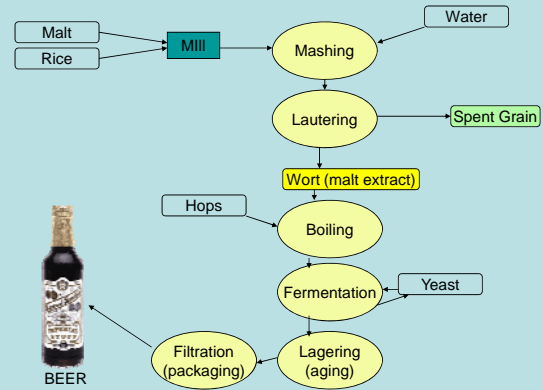
- Yeast Nutrients: The yeast must grow and multiply for fermentation. Malt provides nutrients:
 - Vitamins, minerals and amino acids
- Beer Character:
 - Most if not all color is from the malt
 - Much of the beer's flavor is from the malt
 - Beer foam is largely from the malt
 - Beer "body" or "mouthfeel" is from the malt

Malting

- Steps
 - Steeping (soaking)
 - Germination
 - Kilning (drying)
- Time (7-8 days)
- Objectives
 - Change the endosperm into a form that is more easily used in brewing (**modification**).
 - Develop flavors and color



Overview of Brewing



Malting Barley and Malt Quality

- Malting barley and malt are subject to more quality tests, than perhaps any other field crop.
- Definition of quality to the producer, maltster and brewer may be slightly different
 - Different criteria for profitability
 - Agronomics and disease resistance
 - Maltability
 - Brewing performance and beer quality



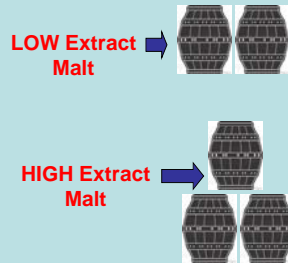
Malting Barley and Malt Quality

- Only varieties that are *recommended* for malting are purchased.
 - These varieties have undergone extensive testing, and the general quality is known.
 - Environmental variation causes quality variation
- Tests performed at the point of purchase or delivery are largely **Predictive** in nature
 - Tests must be quick
 - Simple
 - **Predict quality** without malting and brewing the sample
- Other tests are for **Deleterious Factors**
 - Vomitoxin
 - Sprout
 - etc



Remember: Extract is Key!

- Extract is the material that is solubilized from the malt during brewing
 - Most is carbohydrate
- ~79-81% of the malt is extractable.
 - Depends on variety, environment, and malting
- A major economic factor, and many other quality parameters are important because of their impact on extract



Quality Parameters

- Variety
 - Kernel plumpness and kernel weight
 - Protein
- Predictive Tests
 - Germination and sprouting
 - Skinned and broken kernels
 - Mold and Fusarium Head Blight

Variety

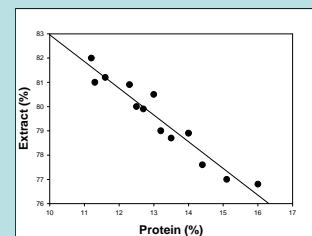
- Different brewers prefer different varieties
 - Single varieties or varietal blends are used
- Each variety has unique malting & brewing characteristics
 - Barley varieties must be malted separately, even though the final malt may be blended
- Barley varieties must not be blended
 - Blends can be identified by biochemical techniques (DNA or protein based)



<http://www.ambainc.org/>

Protein

- **High protein generally means lower fermentable extract**
 - There is an inverse relationship between protein and starch in the barley kernel
 - High protein barley tend to be thinner
 - More husk and less endosperm (starch)



Protein

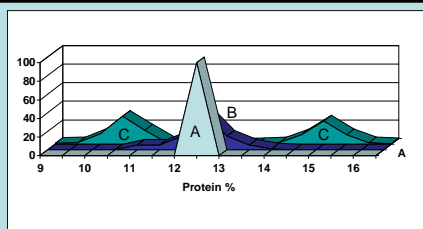
- **High Protein**

- Haze in beer
- Beer color is too dark
 - Problem with very light colored beers
 - Protein is involved in formation of malt color
 - Malt color is difficult to control with high protein



Protein

- Blending of barley to meet protein specifications causes big problems in processing
 - Protein effects water uptake rate and the time of germination in malting
 - Blending of high and low protein results in a very non-homogenous malt
 - Some kernels are completely modified, while others are not finished
 - Lowers extract and can cause problems in brewing



- The above 3 samples of barley each show 12.5% protein.
- When 100 kernels from each sample were individually analyzed for protein, and the above distributions were seen.
 - Sample A is 100% homogeneous. All kernels are 12.5% This is what we want!
 - Sample B shows of distribution of kernels from 11% to 14%. This is natural situation.
 - Sample C is clearly a blend of a high protein and a low protein sample!

How Much Protein is Acceptable?

- That depends
- Brewers have different specifications:
 - Beer type and process
 - 100% malt beers require low protein
 - Adjunct beers can tolerate higher levels
 - Adjuncts (corn or rice) contribute no protein, and thus dilute the barley protein to some degree (20 -50% adjunct use in different beers)
 - The use of barley with >13.5% protein is difficult

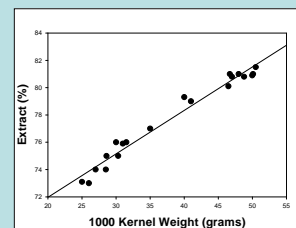
Protein: Its not all Negative!

- Some protein is required for:
 - Foam
 - Color
 - Flavor
 - Yeast nutrition
- Too low protein is rarely a problem in our region



Kernel Size and Weight

- **Plump and heavier kernels generally have higher fermentable extract**
 - There is a positive relationship between kernel plumpness/1000 kernel weight and extract
 - Thin kernels have more husk and less endosperm (starch)
 - Extract is lower



Germination

- Malting is a germination process. If the kernel does not germinate, there are problems:
 - “dead” kernels don’t modify in malting and extract is reduced
 - “dead” kernels can cause filtration problems (beta-glucans)
 - “dead” kernels may be prone to mold growth
 - >95% germination is desirable

Sprouting

- Environmental conditions promote germination (sprouting) in the field.
- Problems are similar as with poor germination.
- Sprouted barely can re-germinate, but the viability of grain drastically decreases with time
 - Sprouting limits storage times for malting barley



Skinned and Broken Kernels

- ½ of the broken kernel does not germinate
 - Reduced extract, filtration problems, mold
- Husk is important in protecting the shoot during germination
 - When the husk is skinned the shoot is often exposed and easily broken. This halts germination.



Mold

- Barley/malt that is heavily infested with mold can:
 - Reduce germination and extract
 - Cause off-flavors
 - Produce toxins that can be extracted into beer



Fusarium

- Fusarium head blight is a problem because:
 - Affects malting quality (e.g. increases color)
 - Produces DON (vomitoxin)
 - DON is extractable to beer
 - Health risk
 - Consumer perception of risk
 - Can cause beer gushing



Beer Gushing



Beer Gushing



Gushing

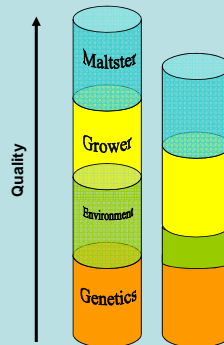


Consistency of Quality

- Art and Science of Brewing
- Modern brewing is really a chemical engineering operation
 - Multiple brewing lines
 - Around the clock operations
 - Thousands of barrels of daily production
 - Batch to batch deviations in in malt quality can disrupt this schedule, and be the cause of major headaches
- Consistency of quality is extremely important to the brewer



Final Note



- Malt quality is influenced by several major components; *from the field to the brewhouse*
- If one component is not favorable, less than optimal quality results