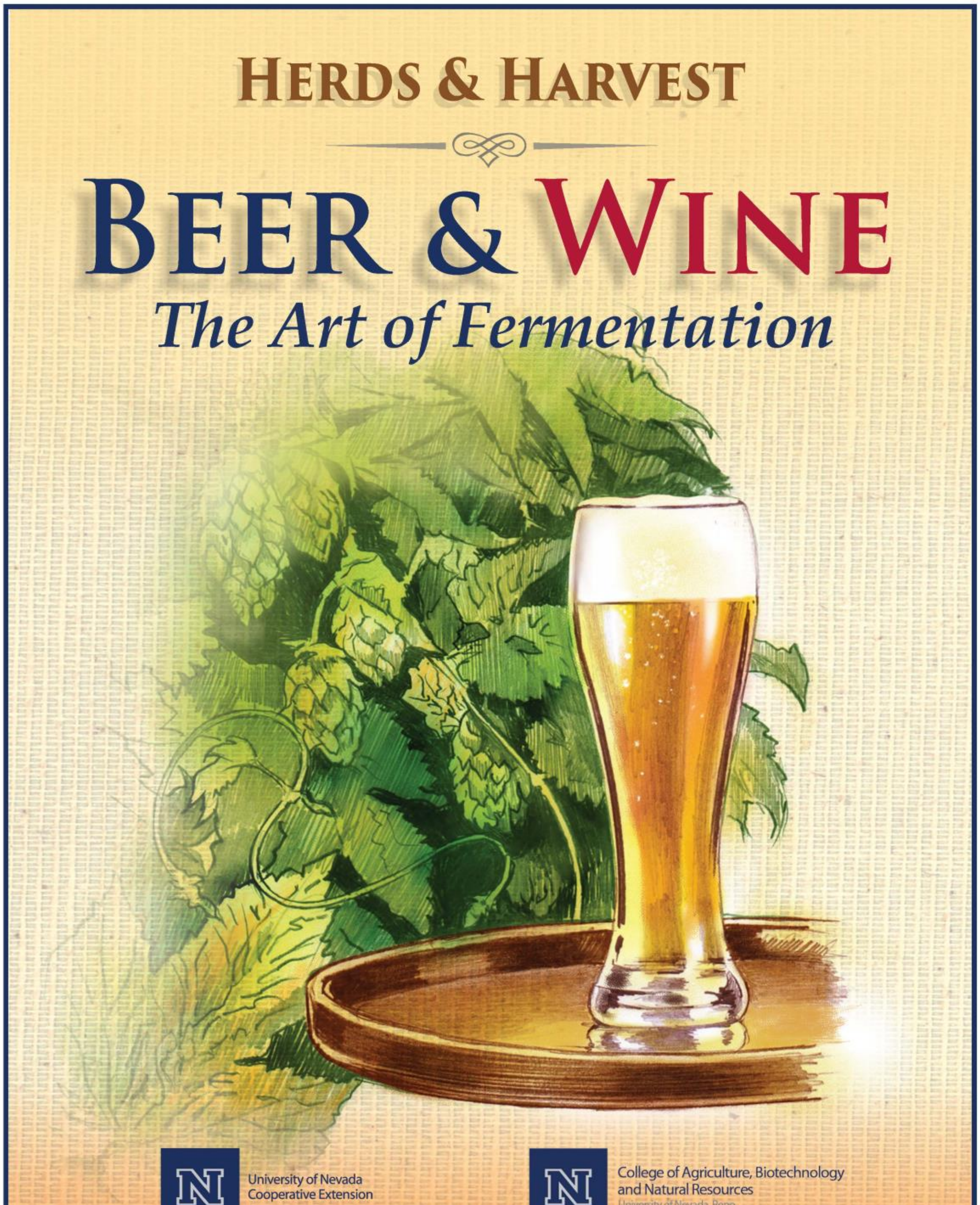


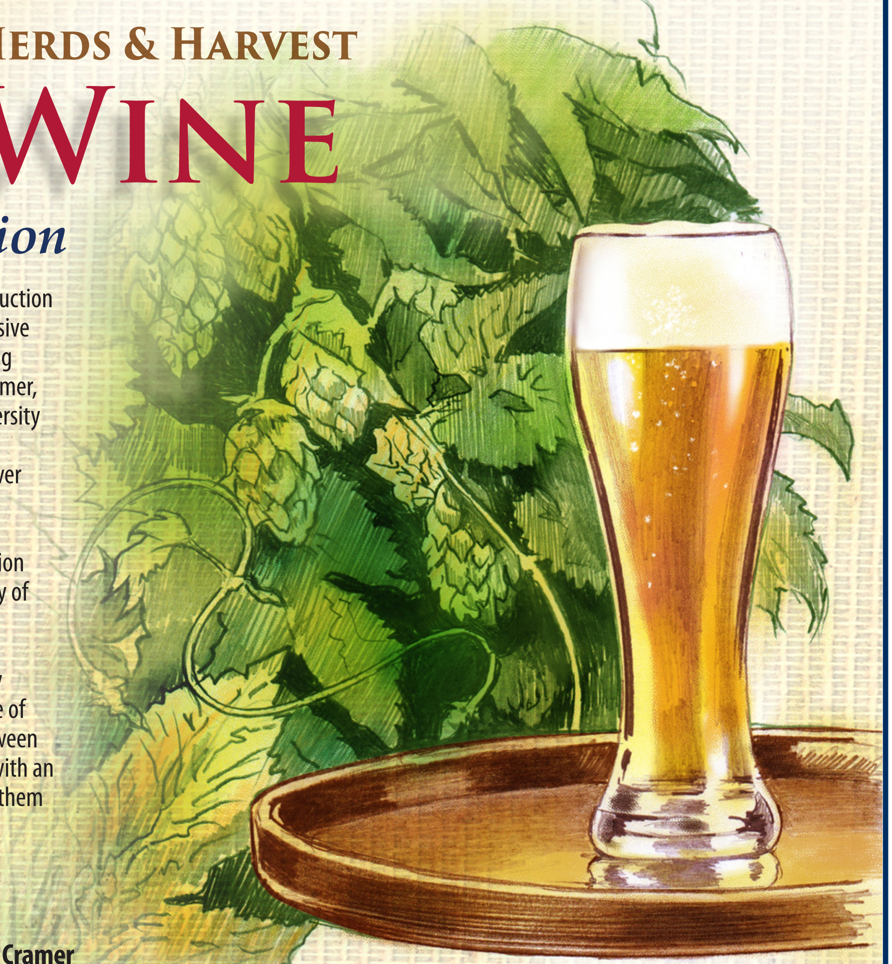
RENO, NEVADA

NOVEMBER 17, 2017

HERDS & HARVEST

BEER & WINE

The Art of Fermentation



This workshop will guide all participants through the production of wine and beer. This workshop will include a comprehensive look at both processes from start to finish. The wine making portion of the workshop will be presented by Dr. Grant Cramer, Professor of Biochemistry and Cellular Biology at the University of Nevada, Reno. Dr. Cramer has been growing grapes and making quality wine at the UNR valley road vineyard for over 20 years. He has traveled all over the world, learning wine production methods used by wine makers from various countries. John Baggett will give the beer production portion of this workshop. He is a graduate student at the University of Nevada in Biochemistry. John has two and a half years experience working at The Depot Brewery and Distillery in Reno. While there, he ran their quality control lab and new product development. He has a comprehensive knowledge of beer production methods and the stylistic differences between beer types. This workshop will provide those who attend with an understanding of the production of wine and beer, giving them the information that is needed to start fermenting!

AGENDA

- **8:45 a.m. – Introductions**
- **9:00** to **10:30 a.m. – Wine Production, Dr. Grant Cramer**
- **10:30** to **10:45 a.m. – Short Break**
- **10:45 a.m.** to **12:00 p.m. – Conclusion of Wine Production, Dr. Grant Cramer**
- **12:00** to **1:00 p.m – Lunch Provided**
- **1:00** to **2:30 p.m – Beer Production, John Baggett**
- **2:30** to **2:45 p.m. – Short Break**
- **2:45** to **4:00 p.m – Conclusion of Beer Production, John Baggett**
- **4:00 p.m. – Farewells**

About HERDS & HARVEST

The Nevada Herds & Harvest program combines a series of workshops on different topics, and provides educational business management and mentoring skill building to support Nevada agricultural producers. If you are interested in meeting with a mentor to build a specific enterprise budget for your agricultural operation, please contact the registration coordinator.

HERDS & HARVEST™

University of Nevada Cooperative Extension

College of Agriculture, Biotechnology and Natural Resources
University of Nevada, Reno

Register online:
https://beerandwineproduction.eventbrite.com

Date, time and location:

November 17, 2017
from 8:45 a.m to 4 p.m.

Washoe County Cooperative Extension
4955 Energy Way
Reno, NV 89502

Cost of Workshop: $10 per person (includes lunch)

For more information, call:

Catrinna Berginnis
Registration Coordinator
berginnisc@unce.unr.edu
Mineral County Cooperative Extension
(775) 945-3444 Ext. 1033

John Baggett
Program Instructor, Department of Biochemistry and Cellular Biology, University of Nevada, Reno
hmfln_sj`_eecrr>ek_gj,amk
(775) 784-4204

Persons in need of special accommodations or assistance must call or notify Staci Emm at 775-475-4227. This program was funded by the USDA, National Institute of Food and Agriculture.

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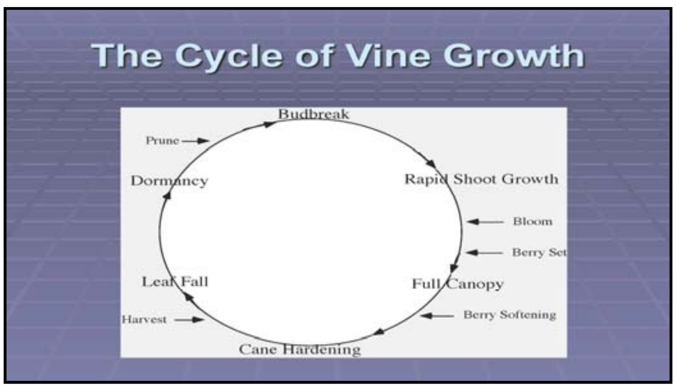
TABLE OF CONTENTS

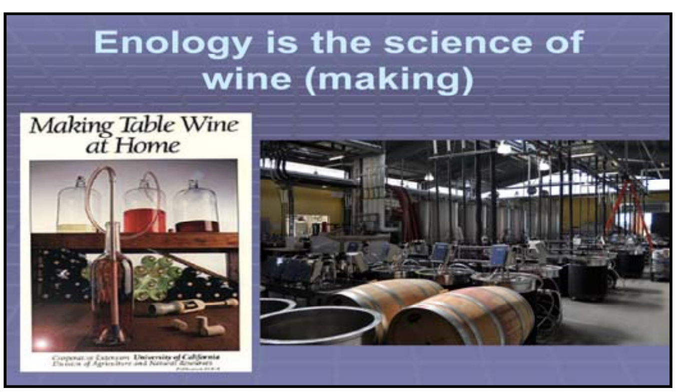
Wine Making

Grant R. Cramer
Department of Biochemistry and Molecular Biology
University of Nevada, Reno
Fall 2017

What are Viticulture and Enology?

Viticulture is the Science of Grape-Growing

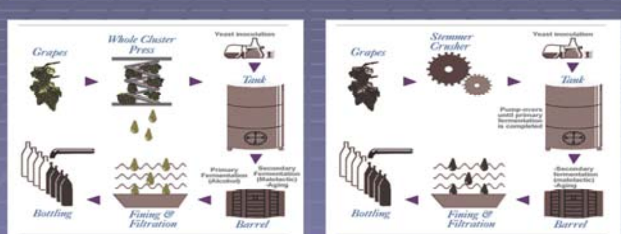

The Cycle of Vine Growth
Budbreak
Prune
Dormancy
Rapid Shoot Growth
Bloom
Berry Set
Full Canopy
Berry Softening
Leaf Fall
Harvest
Cane Hardening


Enology is the science of wine (making)
Making Table Wine at Home

The Process of Making Wine

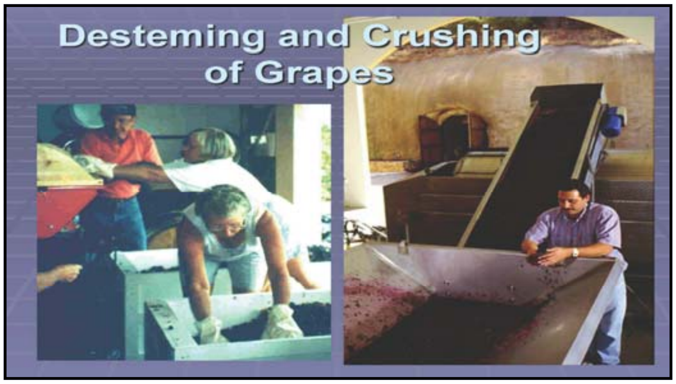
- 1. Crush and press grapes.
- 2. Add yeast to must in fermentation vessel, cover for 3 days to several weeks.
- 3.Siphon or pump wine off the sediments (lees) into clean secondary fermentation vessel.
- 4. Bottle when wine is clear and all fermentation has stopped.

White Wine-Making Red Wine-Making




Harvest


Dry ice to cool the fruit and to protect against oxidation


Desteming and Crushing of Grapes


Traditional Small Scale Press


Pneumatic Press

After crush you add SO_2 as an antioxidant and sterilant

Later add yeast to must in fermentation vessel, cover for 3 days to several weeks

Rack wine off the sediments (lees) into clean secondary fermentation vessel

White Wine Making

- Decide on the wine style you wish to make
- Harvest when grapes are ripe
- Cull debris and bad grapes
- Chill grapes if necessary
- Whole cluster press or crush (and destem)
- Add SO_2 to 30 to 50 ppm
- After crushing allow to settle overnight ~24hr at cold temperature
- Rack into new tank following morning

White Wines (continued)

- Add yeast and nutrients
- Ferment at cool temperature (60°F)
- Monitor Brix and temperature daily
- Let fermentation go to dryness or stop fermentation early for sweet wines by chilling and removing yeasts
- Initiate malolactic fermentation (MLF) after primary fermentation

White Wines (continued)

- Adjust SO_2 to 30 to 50 ppm
- Rack from lees into another tank or oak barrel
- After additional sedimentation (several months), rack again
- Rack as many times as necessary for wine to clear

Red Wine Making

- Decide on the wine style you wish to make
- Harvest when grapes are ripe
- Cull debris and bad grapes
- Chill grapes if necessary
- Crush (and destem)
- Add SO_2 to 30 to 50 ppm
- Cold soak if want greater extraction (up to 48 hours)
- Add yeast and nutrients

Red Wine (continued)

- Ferment at warm temperature (80 °F). Do not let temp exceed 85 °F.
- Pump over or punch down skins 2-3 times daily
- Monitor brix and temperature daily
- Press off skins between 2-6 brix

Red Wine Continued

- Let fermentation go to dryness or stop fermentation early for sweeter wines by chilling and removing yeasts
- Initiate malolactic fermentation (MLF) after primary fermentation

Red Wine (continued)

- Adjust SO_2 to 30 to 50 ppm
- Rack from must into another tank or oak barrel when skins sufficiently extracted (dependent upon temperature, taste and style)
- After additional sedimentation (several months), rack again
- Rack as many times as necessary for wine to clear)

Wine Adjustments

- Acidification
  - Addition of tartaric
  - Used to adjust pH (keep below 3.6)
  - Used to increase tartness of wine
- Deacidification
  - Addition of $CaCO_3$
  - Use of ion exchange resin
  - Malo-lactic fermentation

Wine Adjustments

- Sweetening
  - Addition of partial or unfermented grape juice
- Flavor Enhancement
  - Heat treatment
  - Addition of beta-glycosidase and other enzymes
  - Blending

Wine Adjustments

- Dealcoholization
  - Heating and evaporation
  - Vacuum distillation
  - Centrifugation
  - Reverse osmosis
  - Add water during fermentation
- Color
  - Ultrafiltration
  - Addition of PVPP
  - Activated charcoal

Wine Adjustments

- Blending
  - Can improve flavor, color and complexity of the wine
  - Reduction of off odors
  - Usually done in the following Spring

Adding Oak

- Aging in oak barrels or adding oak adjuncts to wine
- Adds vanilla or woody notes to wine
- Helps to soften tannins and adds to wine complexity

Oak Adjuncts

- Cheap and easy way to add oak flavor to wines

Wine Stabilization and Clarification

- Racking
  - Particles form and sediment by gravity
- Fining
  - Egg whites (reduces tannins)
  - Bentonite clay (reduces protein haze)
- Filtration
  - 3 µm rough filtration
  - 0.45 µm for sterilization

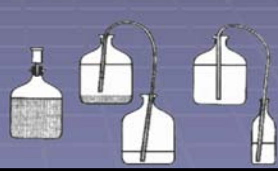
Cold Stabilization

- Chill wines at 25 to 27 °F for 5 days to 2 weeks to precipitate tartrate crystals

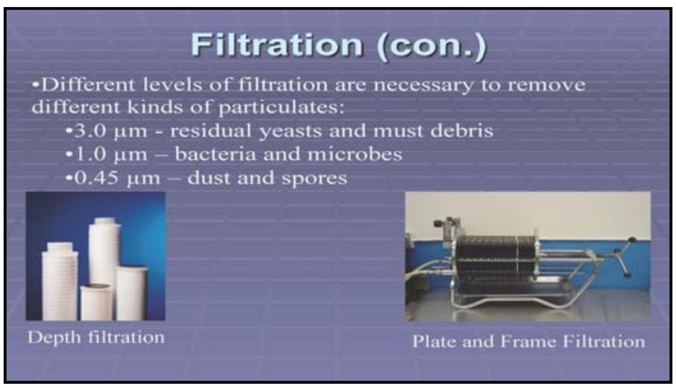
Racking

- Process of allowing debris, yeast particulates, and other precipitates to settle to the bottom of your fermentation vat, and then transferring the cleared wine to a separate container via siphon or pump action
- If filtration is not used, several rackings may be necessary over the course of several months to reach desired clarity.






Filtration
Most widely used methods of filtration are plate and frame or depth filtration
In conjunction with pressure kegs, nitrogen pressure forces wine through filtration apparatus
Faster than racking, however, more expensive.
Reduces risk of spoilage during racking
Removes finer particulates than racking alone


Filtration (con.)
•Different levels of filtration are necessary to remove different kinds of particulates:
•3.0 µm - residual yeasts and must debris
•1.0 µm – bacteria and microbes
•0.45 µm – dust and spores
Depth filtration
Plate and Frame Filtration


Blending and Bottling
Blend different lots or different varieties
Adjust SO_2 to 40 ppm
Bottle wine with N_2 gas if possible
Winemaker -Steve Pannell
Complexity required...
Unique character

Bottling

- Several styles to choose from
- Traditional white and red styles
- Bottles can be manually filled using siphon or pump action, or with a counter-pressure filler in conjunction with nitrogen pressure

Don't forget to design a personalized label!

Closures

•Closures are a very important consideration if wine is to be aged long term
•Closure types require corresponding bottle type
•Natural Cork: Can lead to off aromas from contaminated cork (TCA). Porous material allows slow oxidation for ageing or leak for overoxidation.
•Synthetic closures are the opposite: no oxidation, no contamination. Synthetic corks have had oxidation problems.

Storage and Aging

- Wines age best in cool, dark, relatively humid locations (natural cork)
- Optimum temperature is between 60-65 degrees Fahrenheit, and never over 70. Constant temps important.
- Excessively high temperatures can actually promote formation of a carcinogen in certain wines, and will always spoil flavors and aromas
- Excessively cool temperatures can prevent or slow ageing process.
- Specialized equipment is available to maintain constant temperature and humidity in storage areas

Wine Analysis

Wine Analysis Methodology

- Quantitative measures of wine quality
  - Objective tests
  - Independent of individual perceptions
  - Important to measure wine quality
  - Correct addition of additives to prevent spoilage

Standard Commercial Analysis

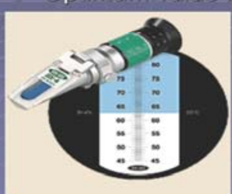
- Brix- Measures total soluble solids (primarily sugars)
- Titratable Acidity- measures total acid (tartness)
- pH- further acid test, pH can effect the amount of free SO_2 present in finished wine
- Alcohol %- Related to initial Brix; legal maximum of 14% for table wines. Dessert wines are designated for >14% but < 24%
- Free and Total SO_2- Used to prevent oxidation and bacterial spoilage

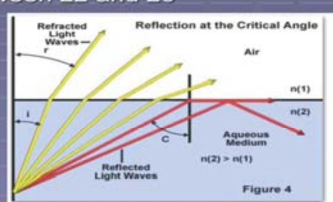
Analytical Tools

- Brix- Refractometer
- Titratable Acidity- Titration endpoint apparatus
- pH- pH meter or pH strips
- Alcohol %- Hydrometer
- Free SO_2- Titration endpoint apparatus in conjunction with an indicator solution

Brix

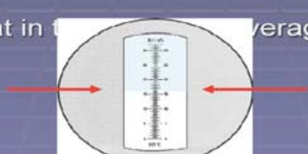
- Measured via Refractometry
- Amount of solute in juice affects index of refraction, which corresponds to reading on Brix scale
- Optimum value between 22 and 26



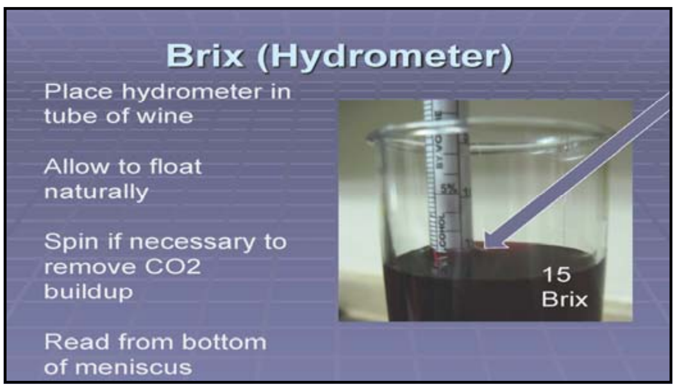


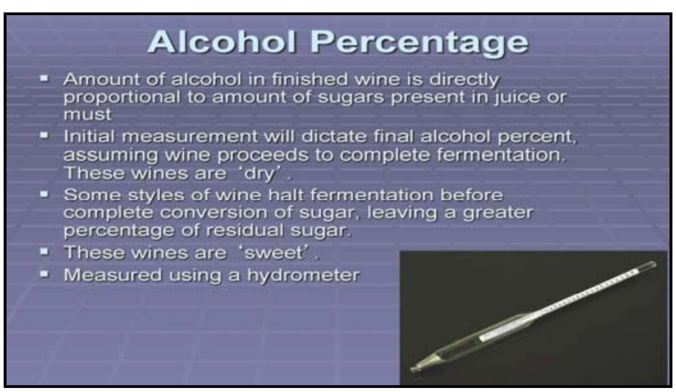
Brix (con.)

- Makes sure lens is clean of debris and thoroughly rinsed between tests
- Apply a droplet of juice to lens plate
- Point refractometer toward light source
- Read value at level of line against scale
- Repeat in t … verage values



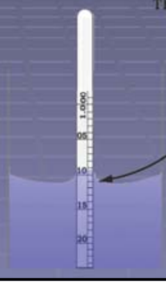

Brix via Hydrometer
▪ Alcohol changes refraction index making a refractometer measurement invalid
▪ Use Hydrometer during and after fermentation


Brix (Hydrometer)
Place hydrometer in tube of wine
Allow to float naturally
Spin if necessary to remove CO2 buildup
Read from bottom of meniscus
15 Brix


Alcohol Percentage
▪ Amount of alcohol in finished wine is directly proportional to amount of sugars present in juice or must
▪ Initial measurement will dictate final alcohol percent, assuming wine proceeds to complete fermentation. These wines are 'dry'.
▪ Some styles of wine halt fermentation before complete conversion of sugar, leaving a greater percentage of residual sugar.
▪ These wines are 'sweet'.
▪ Measured using a hydrometer

Alcohol Percentage (con.)

- Can be used to take initial brix (balling), potential alcohol, and specific gravity
- Potential alcohol is the approximate alcohol percentage assuming complete fermentation
- Fermentation can be monitored by taking intermittent readings
- As fermentation progresses, brix will fall
- If brix ceases to fall, the fermentation is 'stuck'



Calculated Potential Alcohol

°Brix	Sugar (g/L)	Ethanol (% volume)
18	180	10.0 -10.9
19	190	10.6 -11.5
20	200	11.1 -12.1
21	210	11.7 -12.7
22	220	12.2 – 13.3
23	230	12.8 -13.9
24	240	13.3 – 14.5
25	250	13.9 – 15.2
26	260	14.4 – 15.8

- Potential Alcohol = Initial Brix x 0.55

pH

- Measure of a solution's alkalinity or acidity
- Optimally, musts and wines fall between 3.0-3.5
- Keep pH low to prevent spoilage
- Approximated using test strips, or accurately measured using pH meter
- Affects quantity of sulfur dioxide to be added to fermenting wines

Titratable Acidity

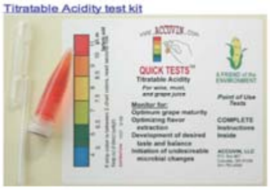
- The titratable acidity of a solution is an approximation of the solution's total acidity (mostly tartrate). Optimal values are between 6 and 8 g/L
- Takes into account the buffering capacity of the must/wine
- Measured via a titration endpoint apparatus, illustrated on the right

Titratable Acidity (con.)

- Materials needed: Titration burette, pH meter, standardized 0.1N NaOH
- Fill burette with NaOH
- Fill flask with 75 mLs deionized water
- Add 3 mLs must sample to flask
- Place pH meter electrode into flask
- Using burette, titrate sample to a pH of 8.2, stirring constantly
- Record amount of NaOH needed to titrate back to 8.2 and calculate the TA (we will do this in the lab today).

Titratable Acidity Strips

Titratable Acidity test kit



pH test kit

www.accuvin.com

Hanna Titratable Acidity Meter

HI 84432

Titratable Acidity Mini Titrator and pH Meter for Fruit Juice

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Free and Total SO_2

- Sulfur provides protection against oxidation and bacterial spoilage, but can cause off odors and flavors if used in excess
- Measured using specialized still, illustrated below
- Based on a controlled oxidation-reduction reaction between volatile H_2S gas, and hydrogen peroxide

Free and Total SO_2 (con.)

- Free SO_2 is a measure of unbound SO_2 which can contribute to protection against oxidation and spoilage. Sample is kept on ice.
- Total SO_2 is a measure of all sulfur forms present in sample. Bound SO_2 does not contribute to protection of wine. Sample is heated via a flame source.

Aeration – Oxidation Method

- Materials: .01% H_2O_2, 25% Phosphoric Acid, .01N NaOH, Titration burette, sulfur analysis still, vacuum source
- Can also be approximated using sulfur testing ampoules
- Equipment for exact sulfur measurement is expensive, and may not be necessary for personal use

Ripper Method

- A tritration method using iodine and a starch indicator
- Need a titration setup with a titration burette
- Indicator turns blue at the end point
- Doesn't work well with red wines

SO_2 strips

www.accuvin.com

Hanna SO_2 titration meter

HI 84100

Sulfur Dioxide Mini Titrator for Wine Analysis

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Wine Faults

- Wine can develop many faults (taints) during production
- Most taints are detectable by sensory analysis

Common Wine Faults

- Oxidation
- Brettanomyces
- Sulfurous Compounds
- Lactic Acid Bacteria
- Wild Yeast
- Environmental
- Volatile Acidity
- Stuck Fermentation
- Cork Taint (TCA)

Oxidation

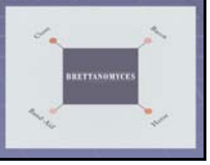
Caused by wine exposure to oxygen

Wine turns brown and has old smell

Cured by SO_2 and keeping oxygen exposure down

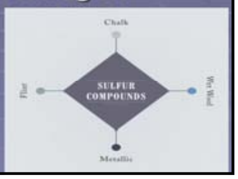
Brettanomyces

- Commonly found in European wines
- Wild yeast that gives off aromas
- Common in wheat beer fermentations
- Sensory analysis for Brettanomyces
  - Barnyard aroma
  - Wet hay or sweaty socks smell
- No Cure! Just clean really well and hope for the best next time



Sulfurous Compounds

- Metallic or Sulfurous aromas
- Caused by lack or nutrients in fermenting wine. Yeast breakdown amino acids containing sulfur in search of nitrogen releasing sulfur aromas
- Cure: Add DAP or other nutrient source



Bad Lactic Bacteria

- Often caused by poor sanitation, fruit fly's, exposure to oxygen, or high pH
- Sensory analysis
  - Nail polish remover
  - Acetone
- Cure
  - Remove oxygen from wine (cover and add dry ice
  - Lower pH by adding Tartaric Acid
  - Add Lactase

Wild Yeast

- Grapes are covered in wild strains of yeast from the vineyard
- These yeasts typically cannot ferment in high alcohol wine leading to a stuck fermentation or off aromas
- Cure: Inoculate with a certified wine strain and add SO_2 when grapes arrive

Environmental

- Wine can take on any flavor it comes in contact with
- Smoke taint is the most common instance of this
- Sensory analysis
  - Smoky aroma
  - Eucalyptus aroma
  - Garlic

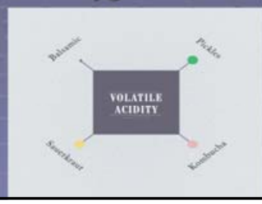
Cure: Keep wine and grapes away from strong negative odors

Store in a clean dry environment

Volatile Acidity (VA)

- VA can be caused by yeast, lactic acid bacteria, and acetic acid bacteria
- Caused by wine exposure to oxygen
- Sensory Analysis
  - Vinegar

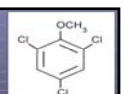
Cure: keep wine away from oxygen
Keep SO_2 levels in proper ranges
Keep winery clean



Stuck Fermentation

- Wine fails to ferment to dryness
- Leaves residual sugar which can lead wine to spoil over time
- Caused by nutrient deficiencies and MANY other possible factors
- Add nutrients early on in fermentation
- Blend stuck wine into healthy fermenting must slowly to complete fermentation

Cork Taint



TCA

- Affects 1 in 10 bottles of wine
- Caused by fungus that grows on corks that is VERY difficult to control
- Sensory Analysis
  - Musty old sock aroma
  - Smell of old bag of baby carrots
  - Dead fruitless wine aroma with dull flavor
- Cure: Don't use corks!
  - Or test your wine before you drink it. Don't be afraid to send it back

Important Factors for Quality

- Keep fermentation temperature at proper levels
  - 60°F for whites
  - 80 °F for reds
- Give yeast proper amount of nutrients
- Re-hydrate yeast properly
- Keep oxygen exposure down

Important Factors for Quality

- Keep SO_2 at proper level
- Keep pH below 3.6
- Inoculate with commercial yeast strain
- Harvest fruit at proper time
- Don't allow fruit to sit out or become warm for extended periods of time
- Remove diseased fruit and other material other than grapes

Key to making good wine

- Sanitation
- High Quality Fruit
- Patience

Beer Fermentation

What this lecture covers

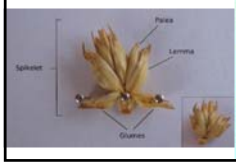
- Definition of a beer
- Components of a beer
- Process and terms of beer making
- History of beer
- Beer chemistry

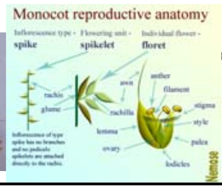
Beer definition

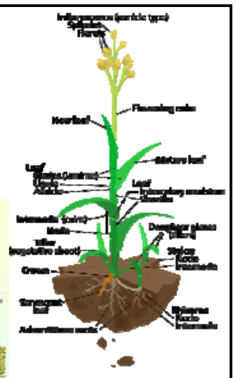
- An alcoholic beverage made from cereals (grasses). Hops are often added as well.
- Usually made from malted barley but also can be made from wheat, corn (maize) and rice.
- One of the oldest beverages known to man.
- Archeological evidence doesn't go back as far as wine but could have been made before wine, nobody really knows.

Definition of a grass

- Gramineae (Poaceae) family
- Monocot with round, jointed stems with slender, sheathing leaves in two rows; flowers born on a spikelet of bracts







Cereals used in beer

Barley

Wheat

Rice

Maize

Botanical drawings of the grasses used in beer

Barley (*Hordeum vulgare*)

Wheat (*Triticum aestivum*)

Rice (*Oryza sativa*)

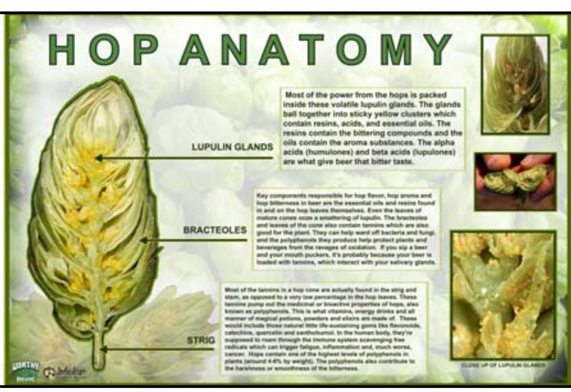
Maize (*Zea mays*)

Two row vs six row barley

- Spikelets arranged in triplet
- Two row, only one is fertile
  - Used in English ales
  - Malting barley with more uniform germination and shorter steeping
- Six row, all are fertile
  - Common for American lagers
  - Higher protein content

Hops (*Humulus lupulus*)

- Vigorous climbing perennial dicot
- Flower of the plant used in flavoring beers
- Add bitterness and citric flavors



There are five varieties of this *H. lupulus*

- *H. lupulus* var. *lupulus* – Europe, western Asia
- *H. lupulus* var. *cordifolius* – eastern Asia
- *H. lupulus* var. *lupuloides* (syn. *H. americanus*) – eastern North America
- *H. lupulus* var. *neomexicanus* - western North American.
- *H. lupulus* var. *pubescens* – midwestern and eastern North America

Regional styles of hops

- Gruit (herb mixture) used before hops in beer making
- Hops use started in Europe
- Americans have active hops breeding programs particularly at Oregon State University
- European style different from American style

Common USA hops used in beer making

- Bittering hops
  - Chinook
  - Nugget
  - Simcoe
- Dual Purpose
  - Amarillo
  - Centennial
- Aromatic hops
  - Cascade
  - Citra
  - Willamette

The basic process of making beer is simple

- Malt extract beer
  - Make wort
    - Boil water
    - Add malt extract
    - Add hops
    - Cool wort
  - Start fermentation with yeast
  - Rack off of yeast
  - Bottle or keg beer

- All grain beer
  - Instead of malt extract you make a mash that hydrates the malt, gelatinizes the starches and releases the enzymes to convert starch to fermentable sugars

History of beer

- Chemical evidence goes back to 5000 BC in Iran
- Likely that it was discovered from spontaneous fermentation in the grains
- Oldest beer recipe comes from a Sumerian poem about Ninkasi, the goddess of brewing
  - Recipe utilized fermented bread made from barley
- Beer dates back to Europe about 3000 BC
- English beers largely made of grain, yeast and water started about 2000 years ago when the Romans occupied the region
  - Additions to beer didn't start until the middle ages

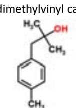
Beer Styles

- Affected by ingredients and climate effects on the ingredients
- There are hundreds of styles of beers including:
  - Ales
    - English
    - Belgian
    - Indian Pale Ale
    - Brown
    - Porter
    - Stout
  - Lagers
    - American Light
    - Bavarian Dark
    - Bock
    - Classic Pilsener
  - Wheat beers
  - Sour beers
  - Altbiers

The history of hops
(a relatively recent addition to beer)

- Used by Romans as a bitter vegetable and others as medicinal, calming agent. People made a pillows from hops to cure sleeplessness. Contains dimethylvinyl carbinol.
- First known additions to beer were in the 9th century in France
- Germans didn't start using it until the 12th century
- During the mid 19th century it became popular as a bittering agent and preservative in Ales

dimethylvinyl carbinol



Hops culture has potential in Nevada

- Hops are dioecious (male and female plants) vines (bines). Male plants needed only for producing seeds.
- Hops like sunlight and good drainage with medium levels of irrigation
- Fast growing with low maintenance
- Can tolerate USDA Plant Hardiness zones 3 – 8 (Reno is zone 7a)
- Can grow up to 25 ft in height
- Experimental plot of 10 hops varieties at Main Station Farm

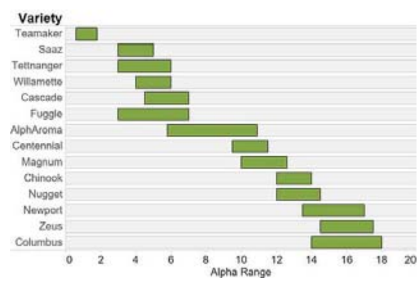
How to grow and process hops

- Plant rhizomes 6 to 12 inches deep about 3 ft apart in the spring (March or April)
- Build a trellis (twine) system to allow the hops to grow up vertically
- Harvest the cones (strobiles) around late August or early September
- Use the fresh cones immediately or dry them in a food dehydrator or oven until brittle or papery feeling.
- Dried hops can be vacuum sealed to preserve them
- Vine dies back to the ground in the winter and grows back in the Spring

Important components of hops

- Alpha acid humulone and resins (bittering hops are high in alpha acids) are desirable
  - Used for bittering (usually 5 to 9% in bittering hops; 8 to 19% in American hops))
  - Volatile loss during the boil
- Beta acid lupulone not desirable; lupulone oxidation affects taste
- Terpenes (linalool, myrcene, limonene, geraniol, terpeneol)
  - Fresh hops aromas from dry hopping
- Aldehydes
- Timing of addition during and after the boil affects the flavor profile of the beer

Alpha acid variation in different hop varieties

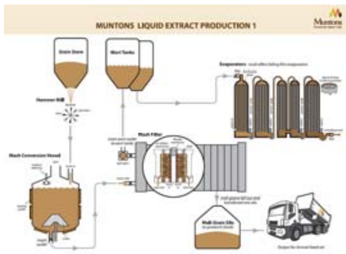


Measurements of hops in a beer

- Hops must be boiled to get the hops resins (oils) to isomerize and dissolve into the beer.
  - Up to 30% can be isomerized in a homebrew.
  - Longer boils produce more isomerization and bitterness
- Alpha Acid Units (AAUs): take the weight of the hops x the % alpha acids
- Utilization is the efficiency of the isomerization. It is a function of the boil time and gravity of the beer. It is usually calculated from a table (see http://realbeer.com/hops/research.html).
  - (Specific) gravity of the beer is a function of how much malt (sugar) is in the wort
- International Bitterness Units (IBUs):
  - IBUs = AAUs x Utilization x 75/Volume
  - 75 is a conversion factor to convert ounces/gallon to mg/liter
  - IBUs determine how many AAUs have isomerized and dissolved into the beer.
  - In contrast to AAUs, IBUs are a measure independent of the gravity of the beer

How to make beer (in more detail)

- Wort
  - Made from malt extract
    - Malt extract is premade in liquid (LME) or dry (DME) form
  - Mash is heated for enzymatic action
  - Filtered
  - Then evaporated to consistency of molasses



What is malt?

- Partially germinated barley
- Allows enzymes from the barley aleurone layer to be released and be prepped for protein and carbohydrate catabolism
- Prepares the starches for conversion to sugars
- Principal source of sugars (maltose)
- 2 kinds
  - Those that need to be mashed
  - Those that don't need to be mashed

How is malt made?

- Highest grade barley is steeped in water until it absorbs 50% of its initial weight in water
- Imbibed barley is drained and partially germinated in a growing room
- At this stage you have green malt
- Dried in a kiln to about 4% moisture with temperatures between 122 and 158°F (base or lager malt)
- Roots (radicles) are knocked off by tumbling
- Many enzymes are denatured but not the important malting enzymes
- ”diastatic power” refers to the potential for starch conversion

What kinds of malt are there?

- Light-colored malts need to be mashed and provide the enzymes needed for starch conversion
  - Pale ale malt
  - Pilsner malt
  - Malted wheat
  - Toasted malts like Vienna, Munich, biscuit, brown, etc. have less diastatic power
- Specialty malts don't need mashing and are used for flavoring
  - Have no diastatic power
  - Caramel and crystal malts (different sweetness and color)
  - Different roast (color) levels (eg. chocolate malt) created by temperature

Malt adjuncts

- Refined sugar
- Corn
- Rice
- Oatmeal
- Unmalted rye, wheat and barley

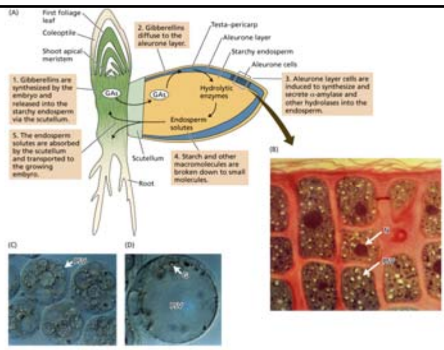
All grain extract

- Wort
  - Made from all grain extract
    - A more complicated process but worth it in terms of flavor and complexity
  - Making mash
    - pH is important
    - Temperature is important
    - Infusion or decoction
  - Lautering
    - Mash out
    - Recirculating
    - Sparging

Mash Chemistry

- Starch must be gelatinized and liquified for efficient conversion to sugar
  - Barley starch gelatinizes between 60 (140°F) and 65 (149°F) °C making it more accessible to enzyme catabolism
- Mash pH ideally between 4.5 and 6
- Catabolic enzymes convert starch into fermentable sugars
  - Malting enzymes (beta-glucanase, beta and alpha amylases, limit dextrinase proteases and peptidases)
  - Alpha amylase works best at 60 to 70 °C (150 to 158°F)
  - Beta amylase is denatured at 65°C, best between 55 and 65°C, so during mashing this enzyme activity can diminish
  - Lower temperature of a mash makes a lighter bodied, drier, more attenuated beer (more conversion to sugars)

Structure of a barley grain and the functions of various tissues during germination

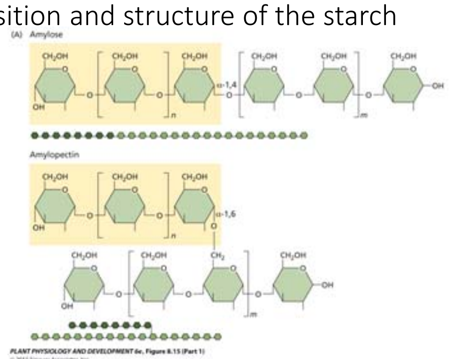


PLANT PHYSIOLOGY AND DEVELOPMENT 6e, Figure 18.9

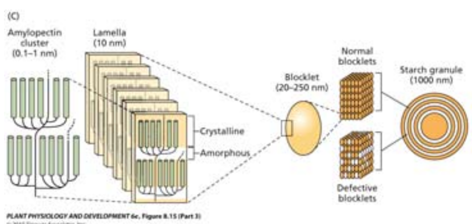
Image of starch granules

PLANT PHYSIOLOGY AND DEVELOPMENT 6e, Figure 8.15 (Part 2)

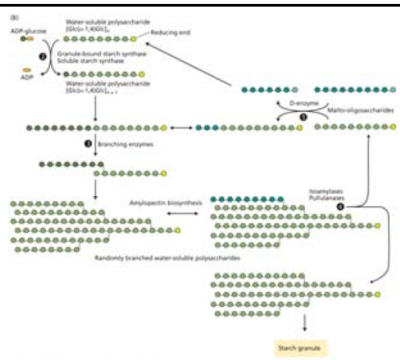
Composition and structure of the starch granule



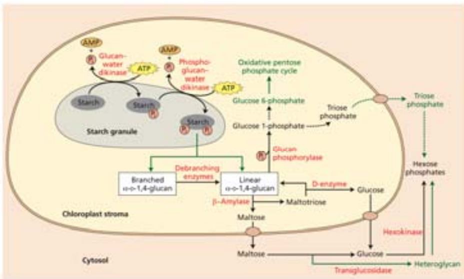
Composition and structure of the starch granule



Pathway of starch synthesis



Nocturnal starch degradation in Arabidopsis leaves



PLANT PHYSIOLOGY AND DEVELOPMENT 6e, Figure 8.17
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Key enzymes in the mash

- Alpha amylase
  - Makes maltose and dextrins (a glucose-glucose disaccharide) from starch
- Beta amylase
  - Makes maltose from starch
- Beta-glucanase
  - Makes glucose from maltose
- Limit dextrinase
  - Cleaves the amylopectin bond
- Proteases
  - Breaks up proteins into peptides
- Peptidases
  - Cleaves peptides into amino acids

Importance of <u>mash</u> pH

- In addition to temperature the optimum pH increases enzyme activities
- Can adjust pH or alkalinity of the water and with malts
- Most malts will bring the pH to the correct range but you may want to check the pH of the mash once started
- The darker the malt, the more acidic the mash
- Pilsen makes light beers because of the lower pH of their water
- Dublin makes dark beers because of the alkalinity of their water
- Mash pH can affect tannin extraction from grain husks and thus the astringency of the beer

Importance of Ca^{++} in water (hardness)

- Promotes clarity, flavor and stability of the beer
- Affects many of the enzyme reactions
- Interacts with bicarbonates in the water affecting water hardness and alkalinity

Methods of mashing

- Single temperature infusion (most common method)
  - One, compromized temperature (150 to 155°F or 65 to 68°C) to optimize <u>all</u> mash enzyme activities
  - Infusion temperature is usually 10 to 15°F higher before adding to the mash
  - Hold the mash temperature for an hour to allow enzymes to do their job
- Multi-rest mashing at different temperatures
- Decoction (expert brewers)
  - Combined method where a portion of the mash is heated at a high temperature on the stove and added back to the main mash to change mash temperature
  - Can add a little more malty character to your beer

Lautering (getting the wort out)

- Separating the malt sugars (sweet wort) from the grain
- Grain grind affects extractability and lautering
- Lautering performed in a large vessel (tun) with a false bottom
- The grain is sparged (rinsed) of its residual sugars
- Temperature of mash is usually raised to 170°F (mash-out) to stop enzyme activities before lautering
  - Also makes the grain bed and wort more fluid for lautering

Next steps

- Cool the sparged wort
  - Using a wort chiller is ideal
- Add yeast to start the fermentation
- Rack after fermentation
- Filter?
- Bottle or keg the beer
- Next? I don't know…Drink? Sell?

Beer faults

- Alcoholic
  - Fusel alcohols produced at higher temperatures
- Astringent
  - Excess tannin extraction
- Acetaldehyde
  - Product of ethanolic fermentation and dependent upon the type of yeast and your yeast pitch rate
- Cidery
  - Too much corn or cane sugar added

Beer faults continued

- Diacetyl (butter)
  - Yeast did not fully consume by end of fermentation; increase pitch rate
- Dimethyl sulfides (creamed corn)
  - Not venting boil or cooling too slowly; bacterial infection
- Estery/Fruity
  - Use cooler fermentation temperature
- Grassy
  - From poorly stored ingredients or from the hops
- Husky/Grainy
  - Poor crushing or sparging procedures

Beer faults continued

- Medicinal
  - Chlorophenols produced from reactions of chlorine-based sanitizers and phenols; wild yeasts
- Metallic
  - Unprotected metal exposure in the wort. Even stainless steel can deteriorate if it becomes pitted. Let a stable oxide layer build up to protect the metal. Don't overclean or scrub with iron brush or bleach. Bleach reacts with and destroys the oxide layer.
- Moldy
  - From the grain or making wort in a musty area
- Oxidized (wet cardboard or sherry-like flavors)
  - Don't expose to oxygen at 80°F or higher

Beer faults continued

- Soapy
  - Comes from breakdown of fatty acids; don't leave in primary fermentor for too long
- Solvent-like
  - Caused by high fermentation temperatures and oxidation
- Skunky
  - Caused by photochemical reactions with the isomerized hops compounds
- Sweaty/Goaty
  - Bacterial infection (from the tap?)
- Yeasty
  - Not waiting long enough for the yeast to drop out