Crisp Malt Webinar Series - Fermentation

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Scope

- Fermentation overview
- The stages of fermentation
- Wort composition
- Sugar spectrum
- Nitrogen degradation and molecular spectrum
- Wort cooling and oxygenation
- Yeast pitching
- Monitoring fermentation
- Troubleshooting guide

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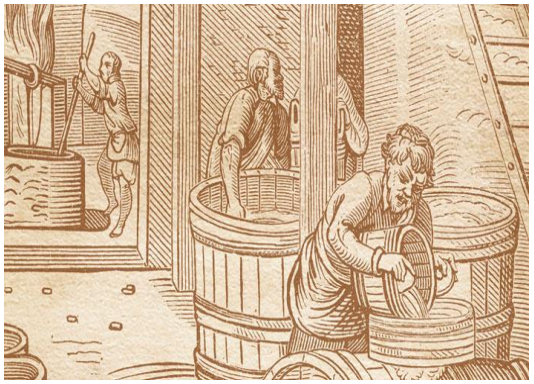
Fermentation

- Definition

  The process by which brewing yeast metabolises simple sugars and other nutrients from wort into ethanol, carbon dioxide, flavours and aromas to make beer

- Comprised of three stages

  - primary fermentation
  - secondary fermentation
  - conditioning or maturation (covered in next webinar)



- The word fermentation is derived from the latin “fervere” meaning to boil
- Before the role of yeast was understood back in the middle ages it was called “Godisgood”
- Louis Pasteur and Emil Hanson discovered the action of yeast in the 19th century
- Brewing yeast is predominantly Saccharomyces Cerevisiae, it was the first Eukaryote to be genome sequenced in 1996 which paved the way for the sequencing of the human genome some 10 years later

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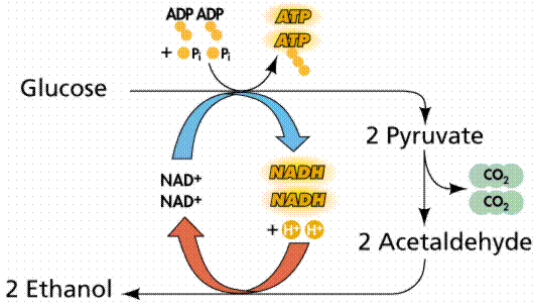
Primary Fermentation

- depletion of dissolved oxygen to produce sterols for growth followed by anaerobic phase
- acidification and reduction in pH
- yeast growth/culture expansion, rapid uptake of nitrogenous compounds.
- ethanol and CO2 production
- production of flavor compounds such as esters, diacetyl etc.
- consumption of most wort sugars
- Ales – 17 -24 °C
- Lagers – 8-14°C (can be started warmer then cooled when yeast kicks in)
- Wheat and Belgian styles – 17 - 29°C



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Secondary Fermentation

- Decreased rate of ethanol and CO_2 production
- Diacetyl conversion incorporating a slight increase in temperature (diacetyl rest) for 24 to 48hrs if necessary
- Reduction of some flavor compounds by yeast metabolism or CO_2 scrubbing
- Terminal gravity reached, cooling applied to vessel
- Yeast flocculation and settling begins due to increase in alcohol and depletion of nutrients

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Factors Affecting Fermentation

- Wort composition:
  - sugar spectrum
  - FAN levels
  - ionic co-factors e.g. copper and zinc
- Yeast strain and pitching rate
- Collection and core fermentation temperature
- Vessel geometry – Top fermenting strains prefer flat bottomed open vessels, bottom fermenting strains are better in cylindro-conical vessels (70° cone angle is optimal)
- Oxygenation/Aeration

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Wort compostion

Sugar spectrum

- 50% maltose
- 13% maltotriose
- 10% glucose
- 25% dextrins – non-fermentable for most yeasts, but saison and Brettanomyces strains are diastatic so ensure secondary fermentation is complete
- Mono-saccharides taken up first along with any sucrose which the yeast can break down to glucose outside the cell using its invertase enzyme
- Maltose is taken up next followed by the slow uptake of maltotriose
- Yeast strain dependant

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Wort composition

Nitrogen digestion

- The nitrogen in wort comes from the malt, the higher the total nitrogen content of the barley used to make it the higher the levels of soluble nitrogen nutrients and enzymes in the wort
- Endoprotease enzymes produce peptides and polypeptides during the germination phase of malting, 90% survive kilning but they decompose quickly during mashing at 65°C. Their activity can be utilized in a stepped temperature mash, with optimal activity at 42°C
- Carboxypeptidase enzymes produce amino acids during the germination phase of malting, they survive kilning and some can be moderately active up to 70°C

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Wort composition

Nitrogen spectrum

- Proteins

  soluble proteins from the malt, much of which is compromised of enzymes

- Polypeptides

  long chain sequences of amino acids, hydrophobic ones contribute to beer foam and acidic ones complex with polyphenols to create colloidal hazes

- Peptides

  sequences of 3 to 10 amino acids, smaller ones can be assimilated by yeast cells and larger ones are thought to contribute to mouthfeel

- Free Amino Nitrogen (FAN)

  crucial for yeast cell multiplication, play an important role in creating beer flavour

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Summary

Malt makes wort a nutritious medium for yeast growth

In the Brewery
Wort Cooling and Oxygenation

- Wort must be cooled prior to yeast pitching
- Before casting from the kettle to the fermentation vessel ensure that all mains and the FV itself are clean and sterile
- Achieve the desired wort temperature as soon as possible and monitor it throughout the cast, adjusting cooling water or wort flow appropriately. Aim to collect 2°C lower than core fermentation temperature to encourage yeast growth
- Oxygenate or aerate the wort, to the desired level (not necessary with dried yeasts), if injecting post chiller, ensure it is sterile and clean the stone and filter regularly
- Oxygenation/Aeration is critical for healthy yeast growth at the beginning of fermentation

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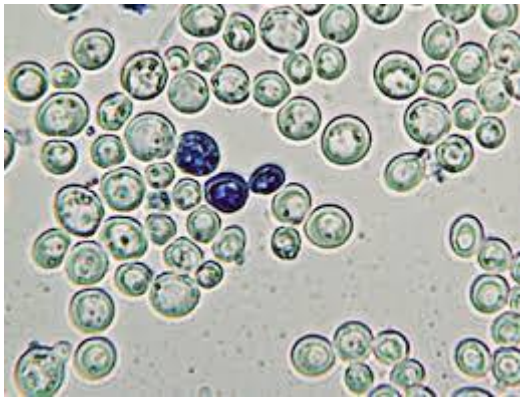
In the Brewery
Yeast Pitching



- Use an appropriate yeast for the style of beer being produced, they have a fundamental effect of flavour and aroma
- Pitch the recommended amount of dried yeast, hydrating in sterile conditions if required, this can be cropped and re-pitched up to 4 times
- If pitching wet yeast, establish the viability and solids content of the slurry and always pitch the same amount of live yeast for a given beer and volume of wort (6Mcells/ml for ales, 10M cells/ml for lagers), this can be cropped and re-pitched up to 10 times (yeast in a few breweries has never been replaced!)
- Higher OG/ABV beers need more yeast pitched at the start of fermentation
- Wear clean clothes when pitching into vessels, keeping a clean overcoat away from the main brewing area is the easiest way to do this

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In the Brewery
Effects of Yeast Pitching Rate

- Too low:
  - excess levels of diacteyl
  - increased higher/fusel alcohol production
  - increased ester formation
  - increased volatile Sulphur compounds
  - high terminal gravities
  - stuck fermentations
  - increased risk of infection

- Too high:
  - very low ester production
  - very fast fermentations
  - thin beers that lack body/mouthfeel
  - autolysis leading to off flavours

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In the Brewery
Monitoring Fermentation

- The temperature should be controlled throughout, preferably automatically with thermometers, controllers and actuated valves on a glycol cooling system. These can be set up at a very reasonable price.
- Record the exact time that the brew was collected, it's temperature and gravity
- Check the gravity at appropriate time intervals no longer than 24hrs apart
- Check pH in the first 48hrs
- Record all the data and ideally draw a graph of the readings and compare this to a perfect fermentation profile

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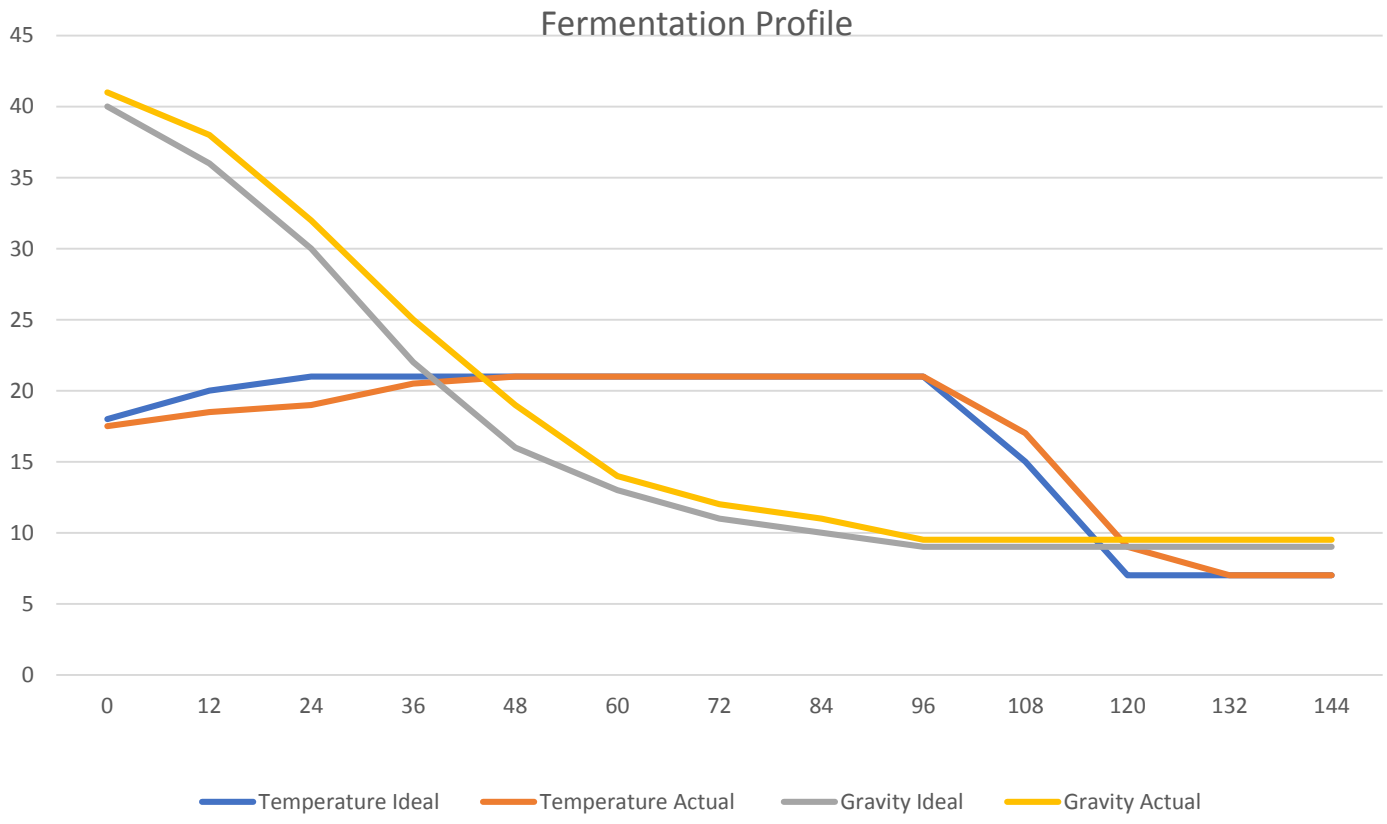
In the Brewery
Fermentation Graph



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In the Brewery
Harvesting Yeast

- Yeast mass should treble during fermentation so if it can be re-used within 96 hours it's a lot more cost effective than using new yeast every time
- Top fermenting yeast strains will be available for harvesting (cropping) around day 3 to 4.
- Harvest with a sterilized scoop or yeast pump
- Bottom fermenting yeast strains will be available at the end of fermentation and are concentrated as the beer cools down
- Harvest slowly from the bottom of the vessel as soon as possible and discard the first part which will contain too many dead cells
- Yeast cells will die and rupture if left in beer after fermentation is complete so yeast should be removed as quickly as practically possible to avoid off flavours

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Fermentation Troubleshooting Guide

Fermentation fails to start

Cause	Root Cause	Solution	Remedy
No yeast pitched	Check records and yeast stock		Pitch more yeast
Vessel has chilled	Check temperature and actuator valve	Warm wort back up by circulating hot water around jackets	Pitch more yeast
Wort pH incorrect	Caustic left in vessel	Destroy beer	None
Yeast died	Collection temperature too high	Remove dead yeast if possible	Pitch more yeast

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Fermentation Troubleshooting Guide

Fermentation slow to start

Cause	Root Cause	Solution	Remedy
Insufficient yeast pitched	Poor viability/yeast solids		Pitch more yeast
Insufficient oxygen	No oxygen added		Oxygenate through bottom
	Supply emptied during cast	Check supply and replace if necessary	Oxygenate through bottom
	Supply pipework or filters blocked	Take apart, clean and sterilize	Oxygenate through bottom
Collection temperature low	Cooling water pressure/flow variation during casting	Check pumps and regulating valves	Warm wort back up by circulating hot water around jackets
Insufficient wort nutrients	Mashing issues	Check records for mash temperatures and times	If mash parameters a long way out, split the wort and top up
	Raw material deficiencies	Check COA's on malt, yeast food, brewing salts	Add yeast food

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Fermentation Troubleshooting Guide

Fermentation too fast

Cause	Root Cause	Solution	Remedy
Yeast over-pitched	Viability and solids not checked		Reduce temperature of fermentation
Possible infection	Poor hygiene	Check under microscope or send for testing	If confirmed, destroy beer and double clean
Trub carryover	Trub/hop filters damaged/un-seated	Check and repair	Seal vessel as well as possible
Collection temperature high	Cooling water pressure/flow variation during casting	Check pumps and regulating valves	Reduce temperature of fermentation
Wort too nutritious	Raw material changes	Check malt and yeast food COA's	Reduce temperature of fermentation

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Fermentation Troubleshooting Guide

Fermentation slow or fails to finish

Cause	Root Cause	Solution	Remedy
Yeast under-pitched	Poor viability and/or solids	Don't add more yeast or oxygenate if more than 3 days in	Increase fermentation temperature and rouse with CO2
Poor yeast growth	Lack of oxygen aeration in wort	Increase oxygen/aeration	Rouse vessel if no more than 3 days in
	Lack of nutrients	Add yeast food	Rouse vessel if no more than 3 days in
	Temperature too low		Heat vessel by circulating hot water through cooling panels
Too many complex sugars	Mashing problems		Split and top up with wort from a 62° mash

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Thanks for Listening any Questions Please?