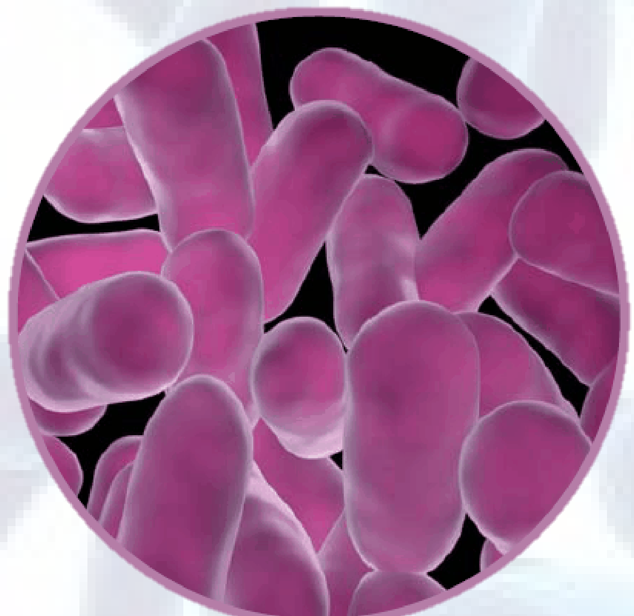
Getting To Know Your Lacto



Josh Armagost and Dan Ramos
The Brewing Science Institute

Overview

- What Is Lacto?
- Uses in the food industry
- Metabolism
- pH and Total Acidity (TA)
- Uses in brewing
  - Kettle souring
  - Mixed fermentations
- Summary

Sour Beers: A Growing Trend

- A dying style saved by American Craft Brewers
- Recent history has shown an explosion in sour styles!
  - 2002 GABF (First Sour Category): 15 entries
  - 2010 GABF: 149 entries
  - 2015 GABF: 497 entries
  - 2018 GABF: 820 entries

Historical Sour Beers

- Pre-Pasteur and hops – All beers were sour

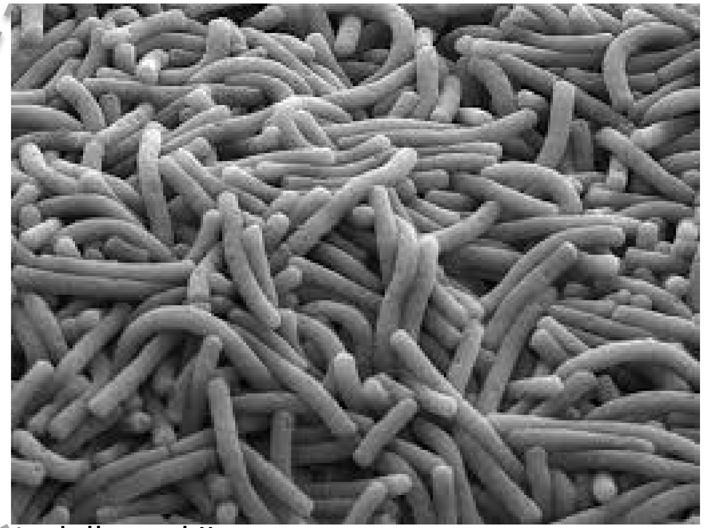
- Post-Pasteur Sour Beer Styles:
  - Lambics (spontaneous fermentation)
  - Berliner Weisse (*Lactobacillus*)
  - Gose (*Lactobacillus*)
  - Flemish Red (mixed culture)
  - Flemish Oud Bruin (mixed culture)

Sources of Acid In Sour Beer

- Lactic Acid - Lactic Acid Bacteria (LAB) - *Lactobacillus* and *Pediococcus*
- Acetic Acid – *Acetobacter* and *Brettanomyces*
- Citric Acid – *Saccharomyces* and fruit
- Malic Acid - *Saccharomyces* and fruit

What Is Lacto?

- Lactic Acid Bacteria (LAB) (genera)
  - Lactococcus
  - Enterococcus
  - Oenococcus
  - Pediococcus
  - Streptococcus
  - Leuconostoc
  - Lactobacillus



L. delbrueckii

Lactic Acid Bacteria

- LAB produce lactic acid as a product of fermentation.
- Over 100 species and subspecies of LAB
- Genus *Lactobacillus* represents largest group within LAB.
- All LAB are gram-positive

Lactic Acid Bacteria

- Used extensively in the food industry for:
  - Food preservation
  - Starters for dairy products (cheese and yogurt)
  - Fermented vegetables and meats (sauerkraut)
  - Probiotics (*L. casei* and *L. paracasei*)
  - Inoculant for silage/cattle feed (*L. acidophilus*)

Lactic Acid Bacteria

- Generally considered a contaminant when present in food processes not requiring fermentation

- Conversely, LAB are essential in the process of many fermented foods and bio-products

- Using LAB in the food process can be thought of as a “controlled spoilage” to produce desired results under carefully monitored parameters.

Lactobacillus

- Aerotolerant- does not require oxygen but will still operate under aerobic conditions
- Highly productive in temperatures between 100°F and 120°F (38-49°C). Goes dormant below 55°F (13°C)
- Inhibited by as few as 8 IBUs (some strains are more hop tolerant than others)
- Fairly alcohol intolerant (again, depending on strain)

Metabolism

- LAB produce lactic acid using one of two metabolic pathways:

- **Homofermentative** LAB use glucose to primarily produce lactic acid as a by-product of fermentation

- **Heterofermentative** LAB use glucose to produce lactic acid, as well as acetic acid, CO_2, and ethanol as by-products of fermentation

Homofermentative LAB

Glucose

↓

Pyruvate

↓

Lactate

1 Mole Glucose → 2 Moles Lactate

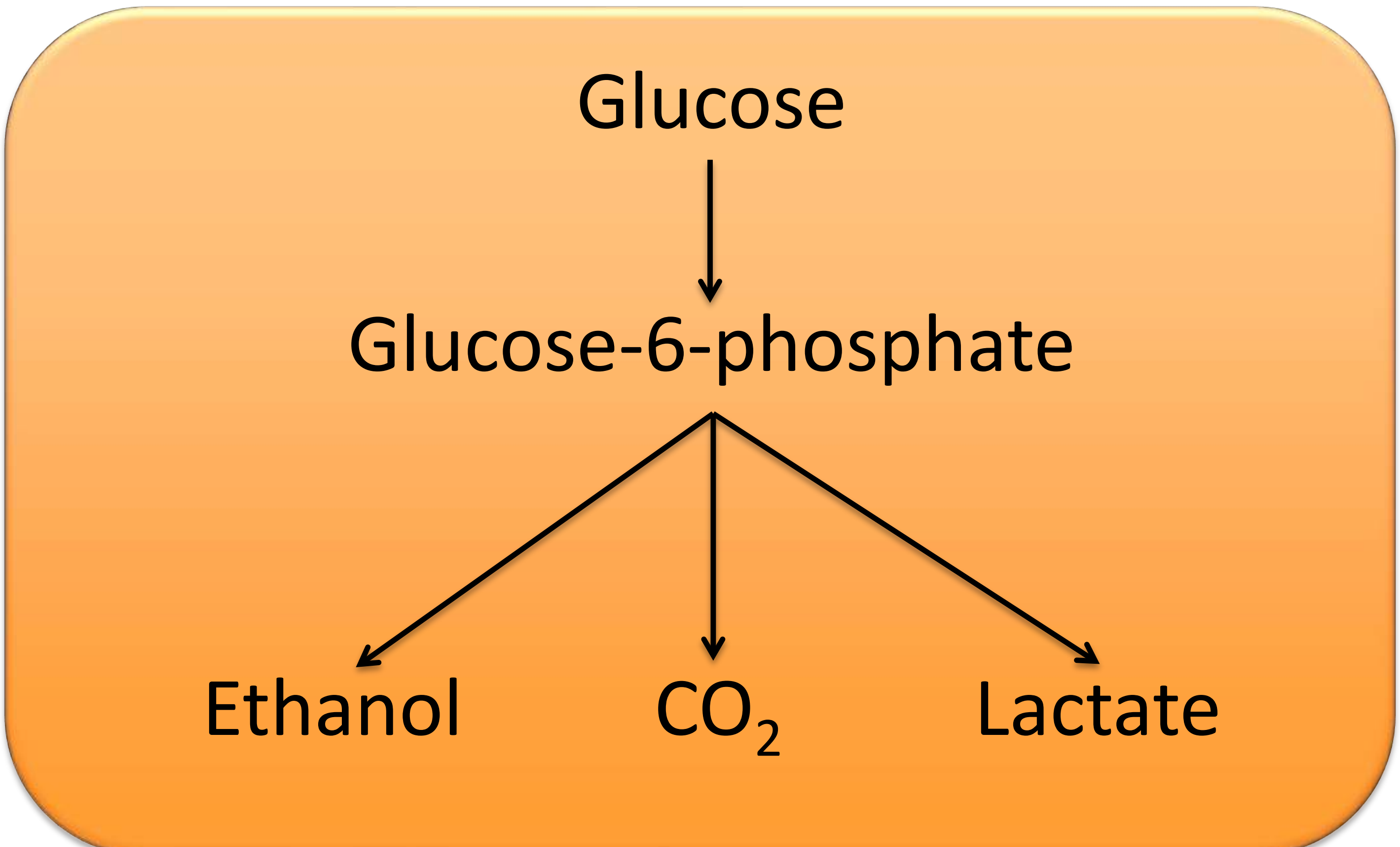
Homofermentative LAB

- *Lactobacillus, Lactococcus, Enterococcus, Streptococcus, and Pediococcus*

- Common brewing strains: *L. delbrueckii* and *Pediococcus damnosus*

- Produces a “clean” lactic flavor

Heterofermentative LAB



1 Mole Glucose → 1 Mole Lactate, 1 Mole Ethanol

Heterofermentative LAB

- *Lactobacillus, Leuconostoc, Oenococcus, Weissella*

- Common brewing strains: *L. brevis* and *L. buchneri*

- Produces the same lactic acid present in homolactic fermentation, but is said to be a harsher sourness. This possibly due to the sub-threshold levels of acetic acid also present as a by-product of heterolactic fermentation

Facultatively Heterofermentative LAB

- Try saying that 5 times fast ^^^
- Will perform homolactic fermentation in conditions with an abundance of nutrients.
- In nutrient poor conditions, will perform heterolactic fermentation to produce CO_2 and ethanol as additional by-products.
- Common brewing strains: *L. casei* and *L. paracasei*

Considerations When Choosing Lacto

- **Starting Gravity** – all species are different and variable.
  - *e.g. L. delbrueckii* 10 Plato or less but with time it has soured a 13 Plato wort.

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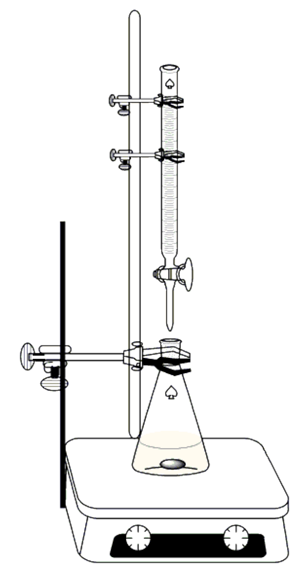
- **Adaptability** – it has been shown that through repeated incremental culturing you can increase the tolerance of some *Lactobacillus spp.*

Managing Lacto in the Brewery

- Cell counting bacteria is difficult and expensive to obtain reliably. Pitch by volume instead.
- Commercial pitch or 4-12% volume of harvested sour wort.
- Bacterial health is important for it’s effectiveness.
- To maintain health, feed un-hopped, low gravity wort.

Measuring Acidity

- Sensory – can be misleading
- pH strips – inaccurate (place them in the garbage)
- pH meter – accurate, but not the whole story
- Titratable Acidity – best method for measuring perceived acidity



WARNING!

A FLASHBACK

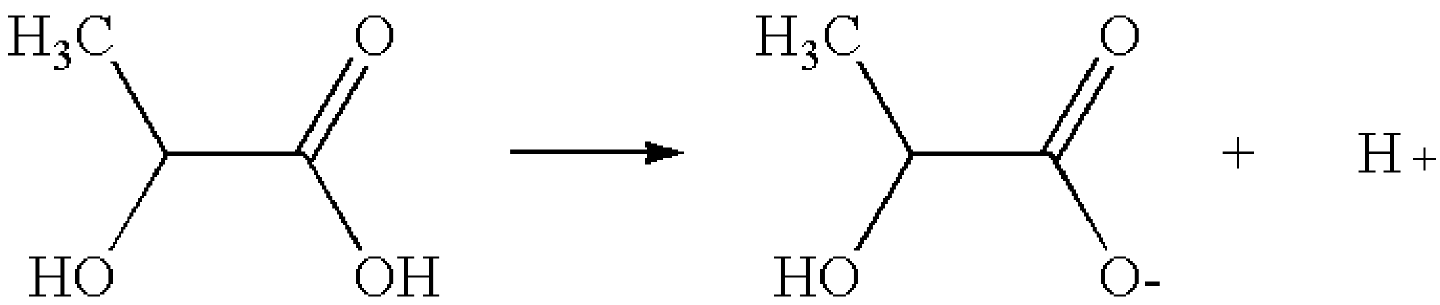
TO

CHEMISTRY

CLASS!!!

What is an Acid?

- An acid is any compound that disassociates in an aqueous solution increasing the concentration of Hydrogen ions.

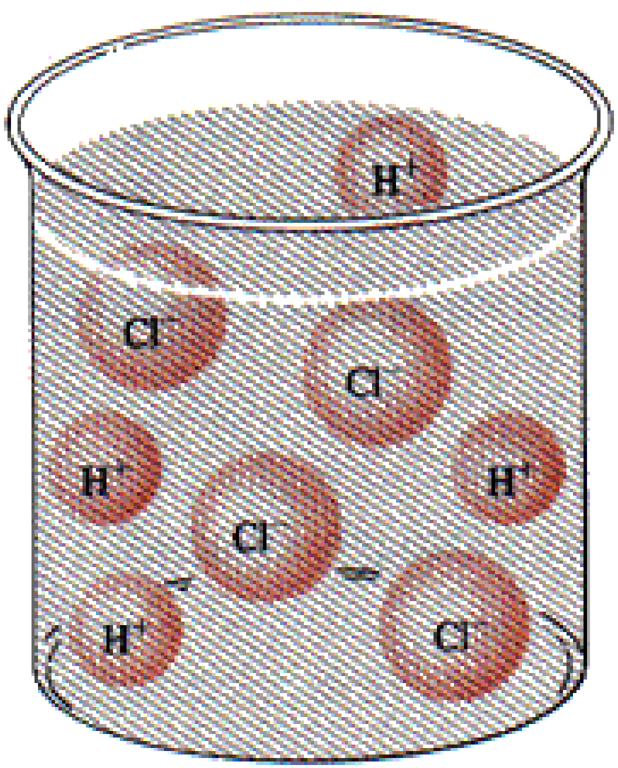


Lactic acid

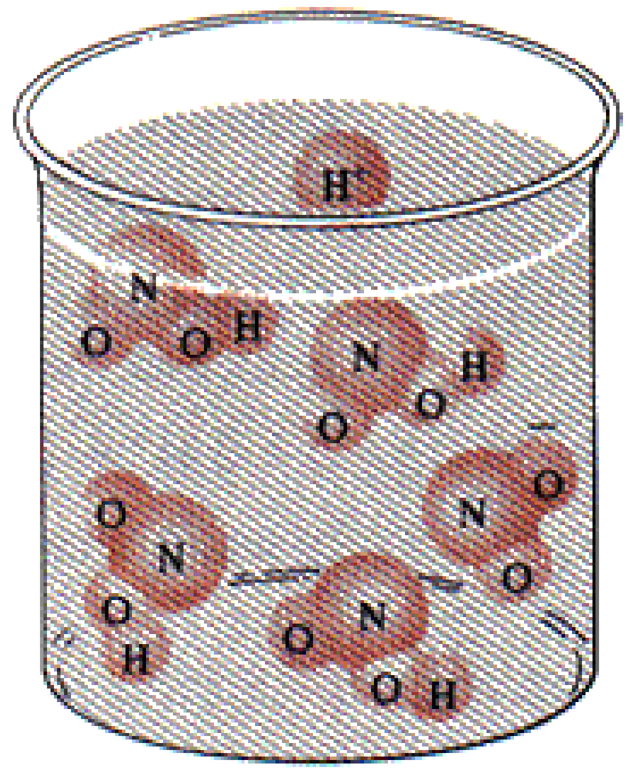
Lactate anion

H+ Ion

Organic Acids in Beer are Weak Acids



Strong Acid



Weak Acid

Titratable Acidity vs pH

- pH only measures the free Hydrogen ions.
- Titratable Acidity (TA) measures all Hydrogen ions associated and dissociated.
- What's the difference? We taste all the acid!

Titratable Acidity vs. pH: An Experiment

TA vs. pH Experiment

- Five popular sour beers selected
- Measured variables (ASBC methods):
  - pH
  - TA
  - F.G.
- Tasting panel to rate “sourness” on a scale of 1 to 10 (Eight willing participants)

THE **SOUR** BEERS

Results:

Russian River Supplication
FG: 1.002
TA: 11.39 g/l
pH: 3.27
Avg. Sourness Rating: 6.75

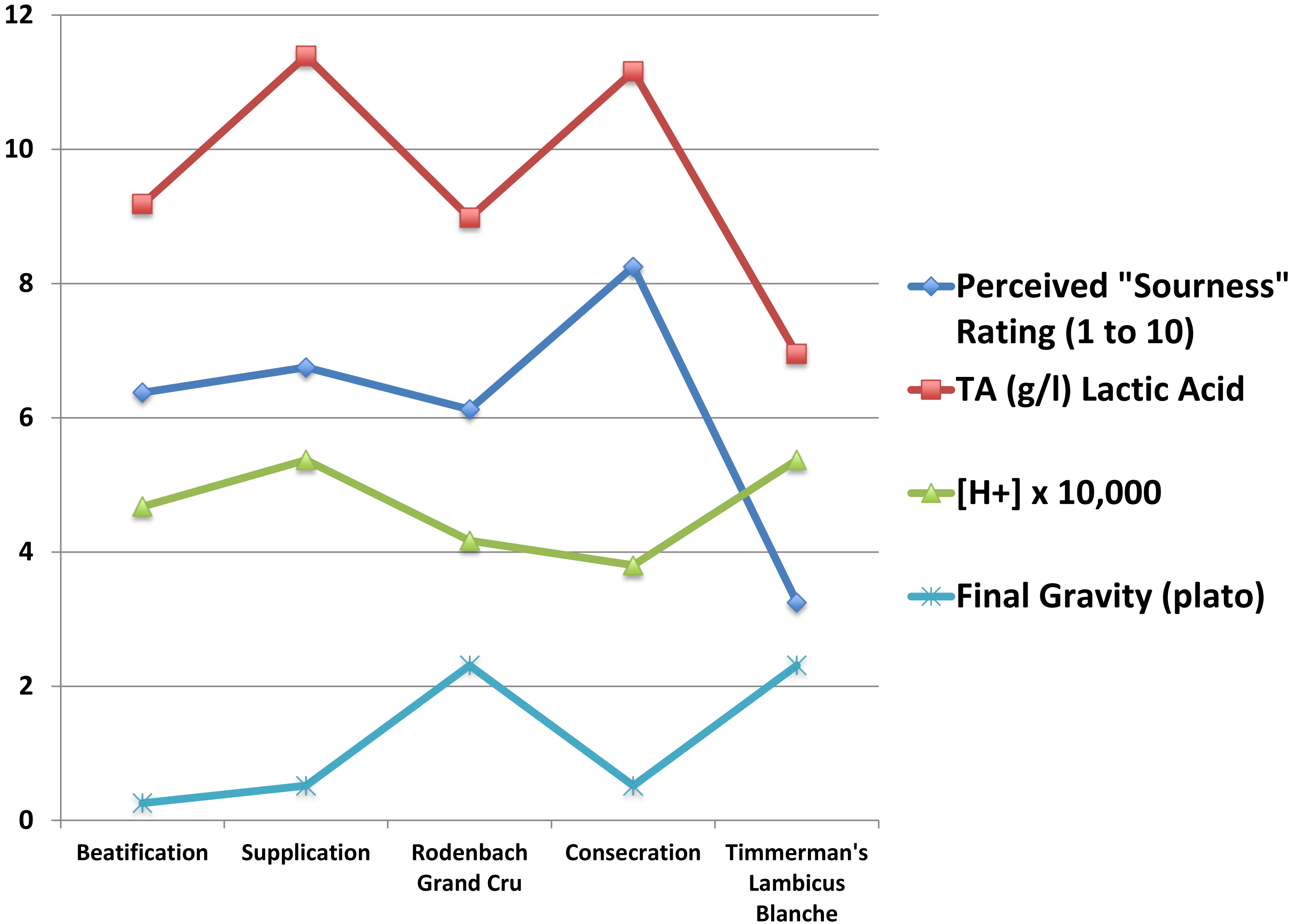
Russian River Consecration
FG: 1.002
TA: 11.16 g/l
pH: 3.42
Avg. Sourness Rating: 8.25

Russian River Beatification
FG: 1.001
TA: 9.18 g/l
pH: 3.33
Avg. Sourness Rating: 6.38

Rodenbach Grand Cru
FG: 1.009
TA: 8.98 g/l
pH: 3.38
Avg. Sourness Rating: 6.13

Timmerman's Lambicus Blanche
FG: 1.009
TA: 6.95 g/l
pH: 3.27
Avg. Sourness Rating: 3.25

Note: "Avg. Sourness Rating" is a subjective measure of perceived acidity by tasting panel on a scale of 1 to 10.

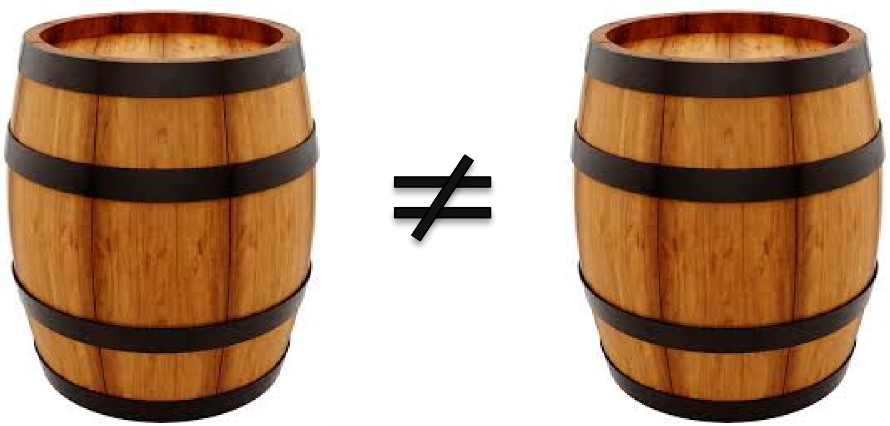

12
10
8
6
4
2
0
Beatification
Supplication
Rodenbach Grand Cru
Consecration
Timmerman's Lambicus Blanche
Perceived "Sourness" Rating (1 to 10)
TA (g/l) Lactic Acid
[H+] x 10,000
Final Gravity (plato)

Considerations

- There are many factors that can influence perceived acidity:
  - ABV
  - Residual Sweetness
  - Non-acidic flavor compounds (esters, phenols, etc.)
  - Subjective bias, not all palates are created equal
  - Types of acids present

Blending Considerations

- Blending by pH is difficult because it is a logarithmic scale. E.g. a 50/50 blend of wort at 5.3pH and 3.1pH results in a wort of 3.5pH.
- TA serves as a better indicator for blending to a target acidity.



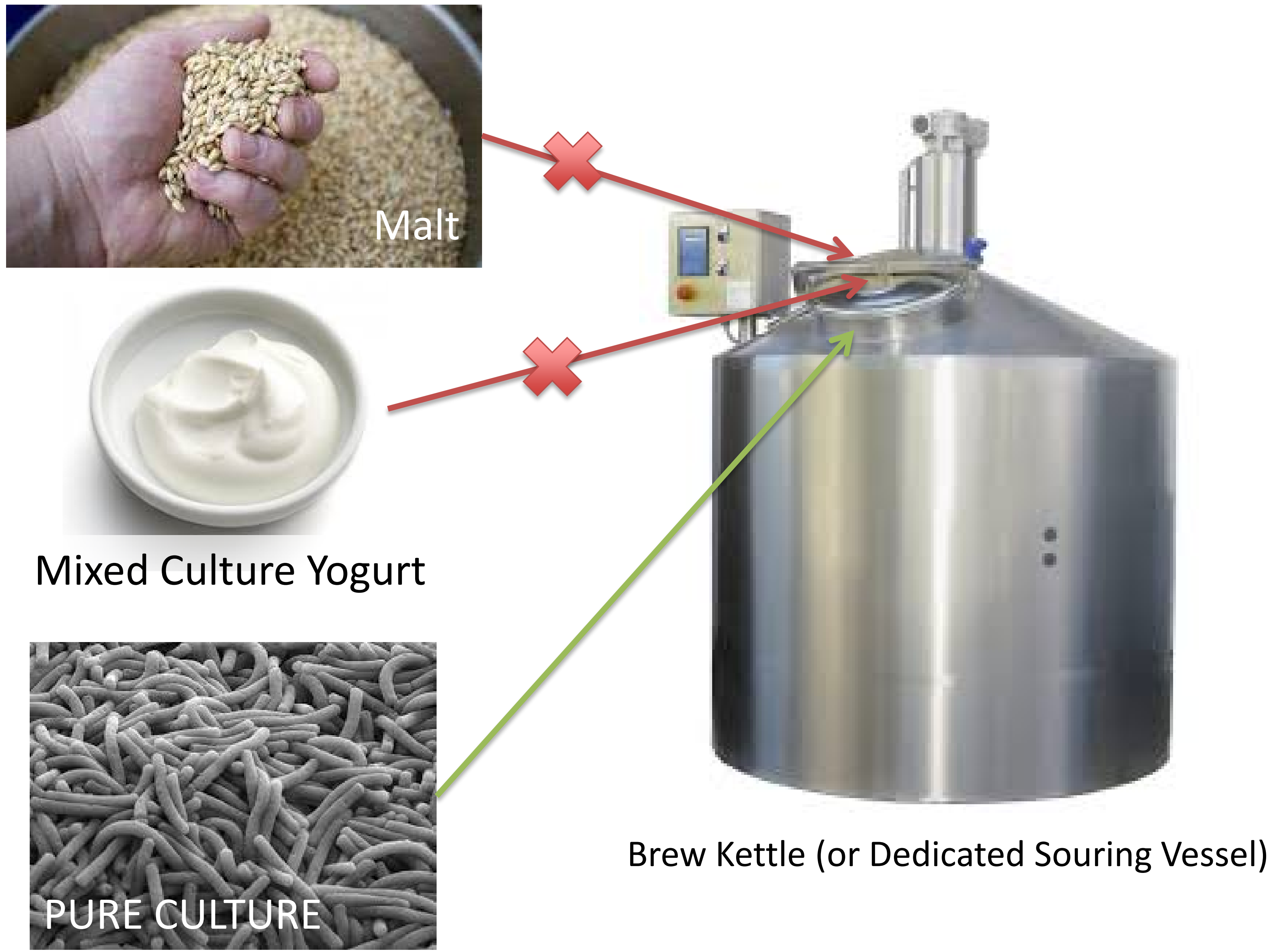
Sour Beer Production Methods

- Pre-boil wort souring
  - Sour mash (use with caution)
  - Kettle Souring

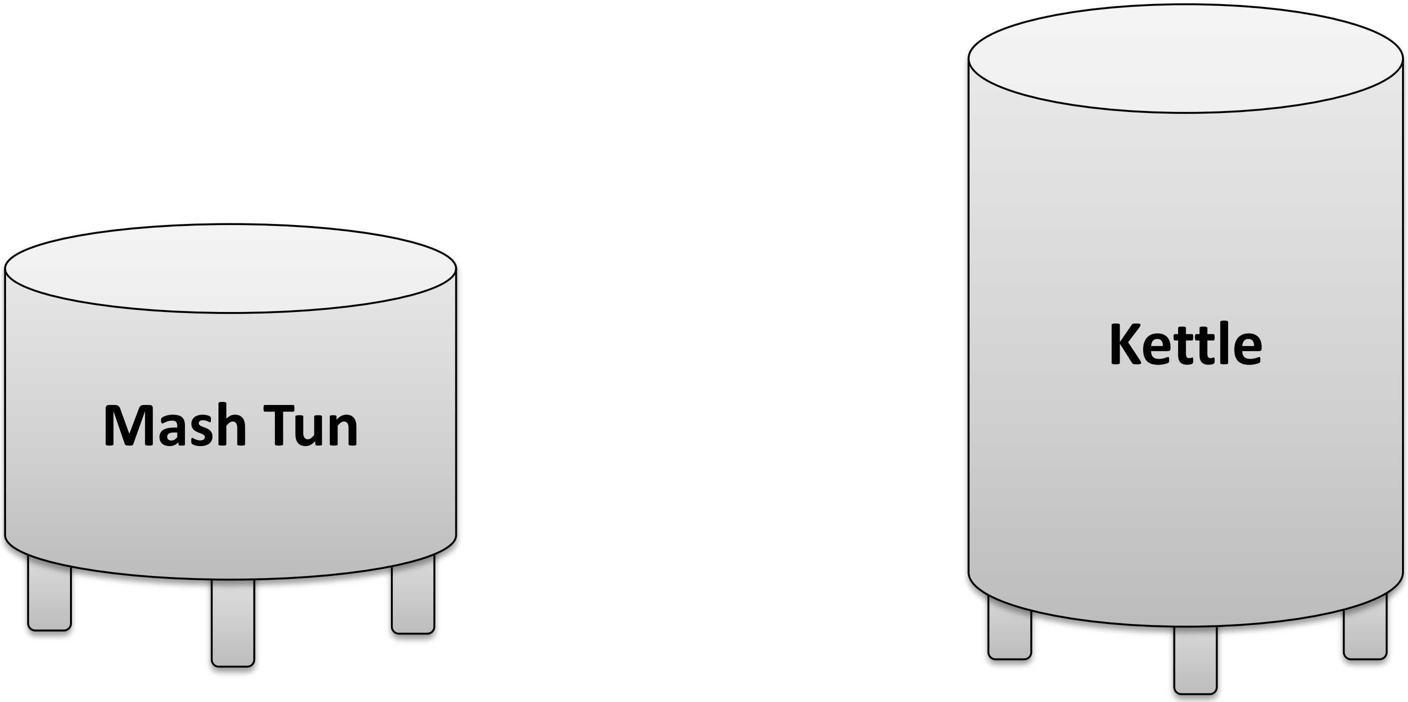
- Post-boil souring
  - Primary mixed fermentation inoculation
  - Primary yeast fermentation - Secondary bacteria inoculation
  - Spontaneous Fermentation

Pre-Boil Wort Souring

- Aka **Kettle Souring**
- Lactobacillus is added to wort prior to boiling.
- Souring takes place within the first 12-96 hours
- pH of 3.2-3.4 can be achieved within first 24 hours under optimal conditions

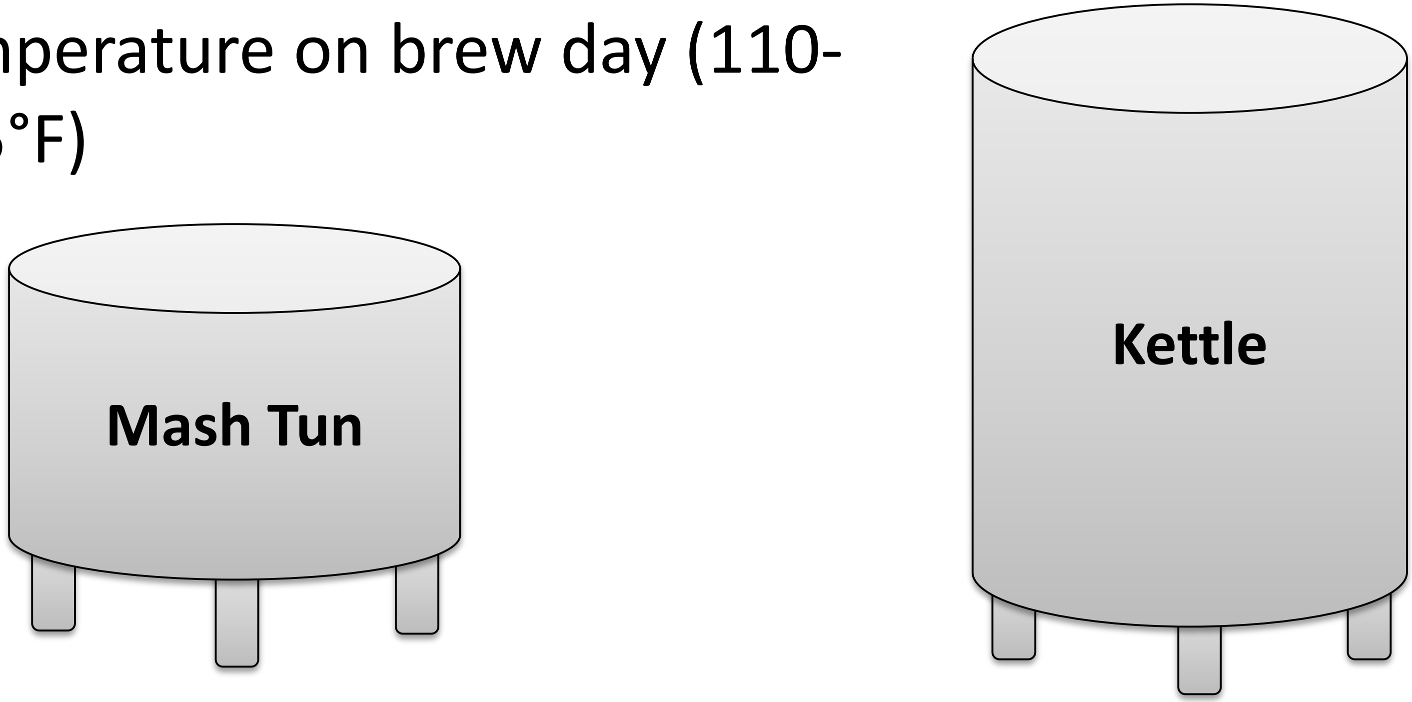

Malt
Mixed Culture Yogurt
PURE CULTURE
Brew Kettle (or Dedicated Souring Vessel)

Kettle Souring Methods



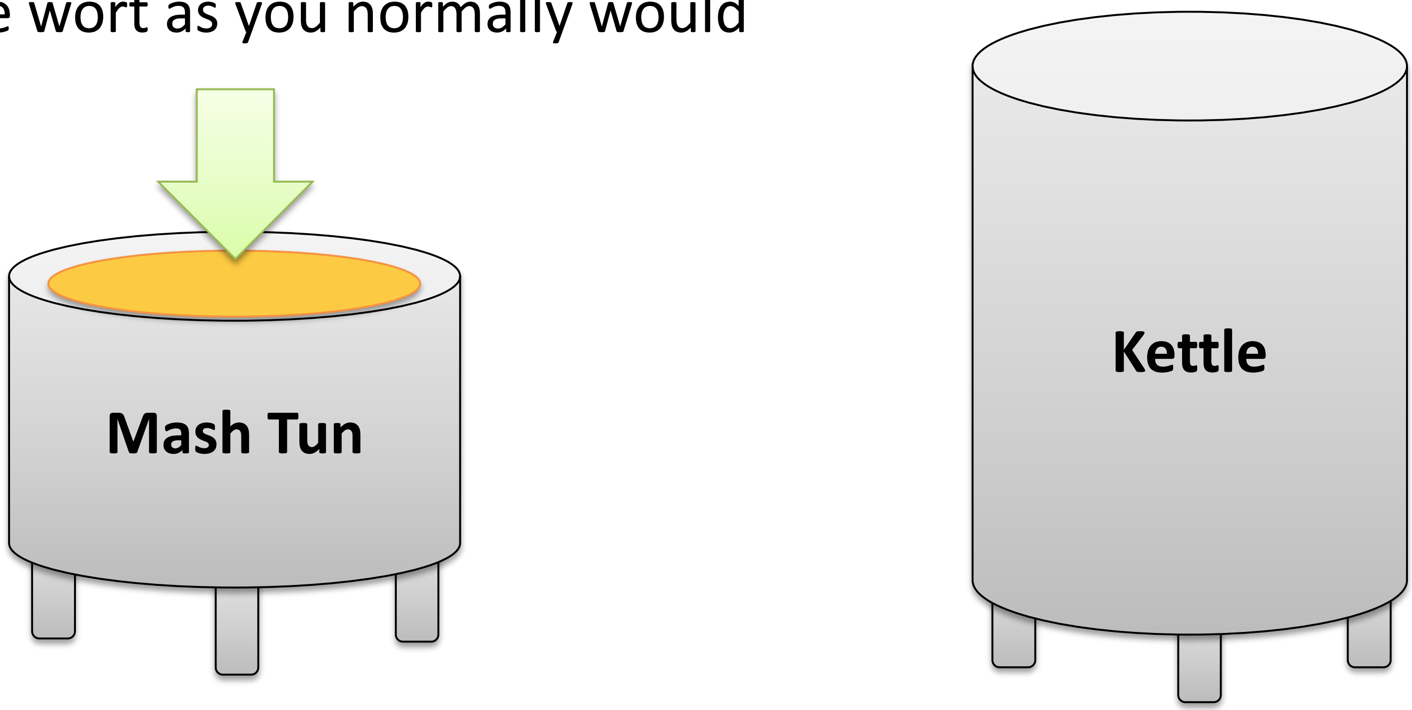
Kettle Souring Methods

- Attemperate Lacto to pitching temperature on brew day (110-115°F)



Kettle Souring Methods

Produce wort as you normally would



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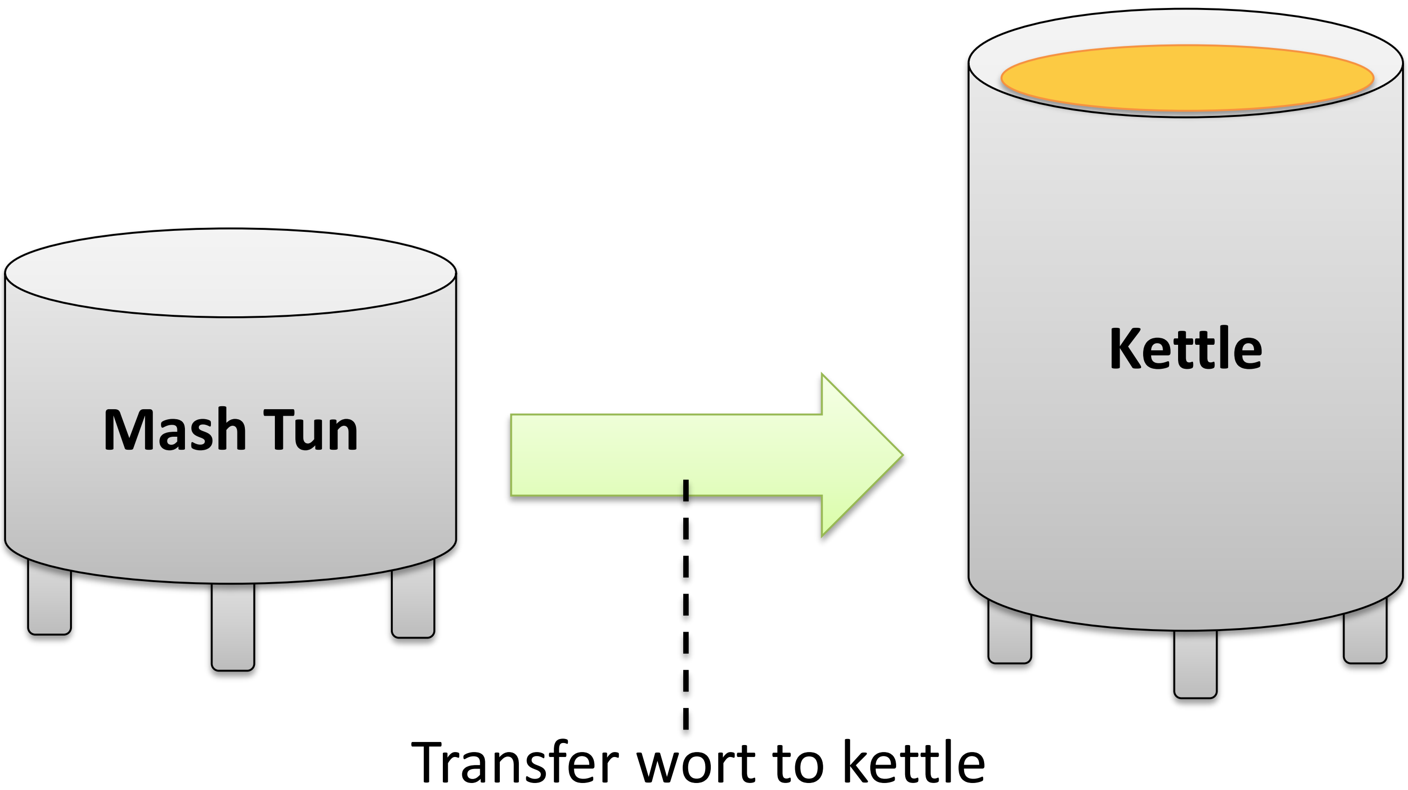
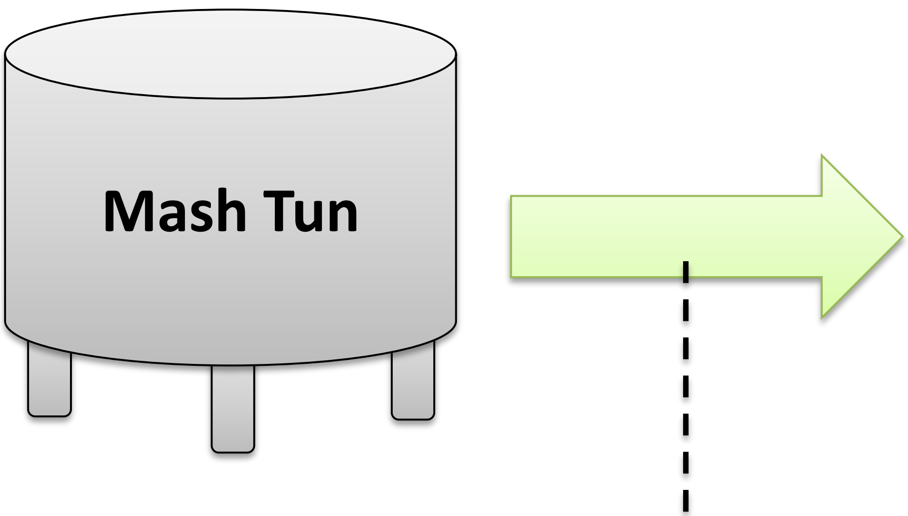


Kettle Souring Methods

- Lower pH of wort to below 4.5 to inhibit enterobacter growth (acid malt or food grade acid)



Transfer wort to kettle

Kettle Souring Methods

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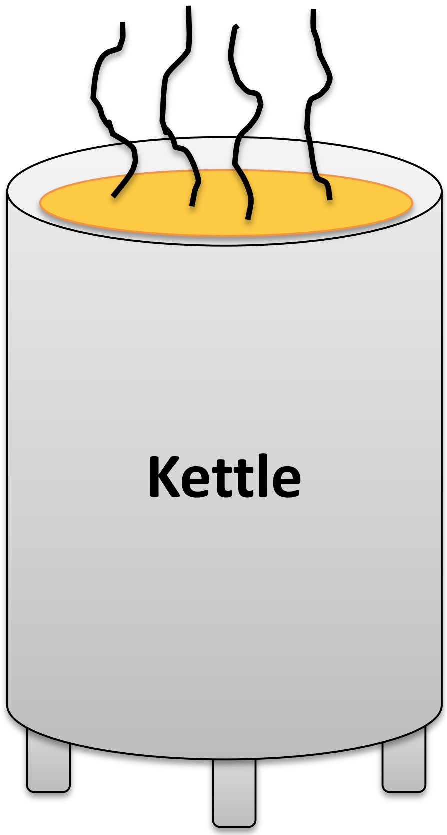
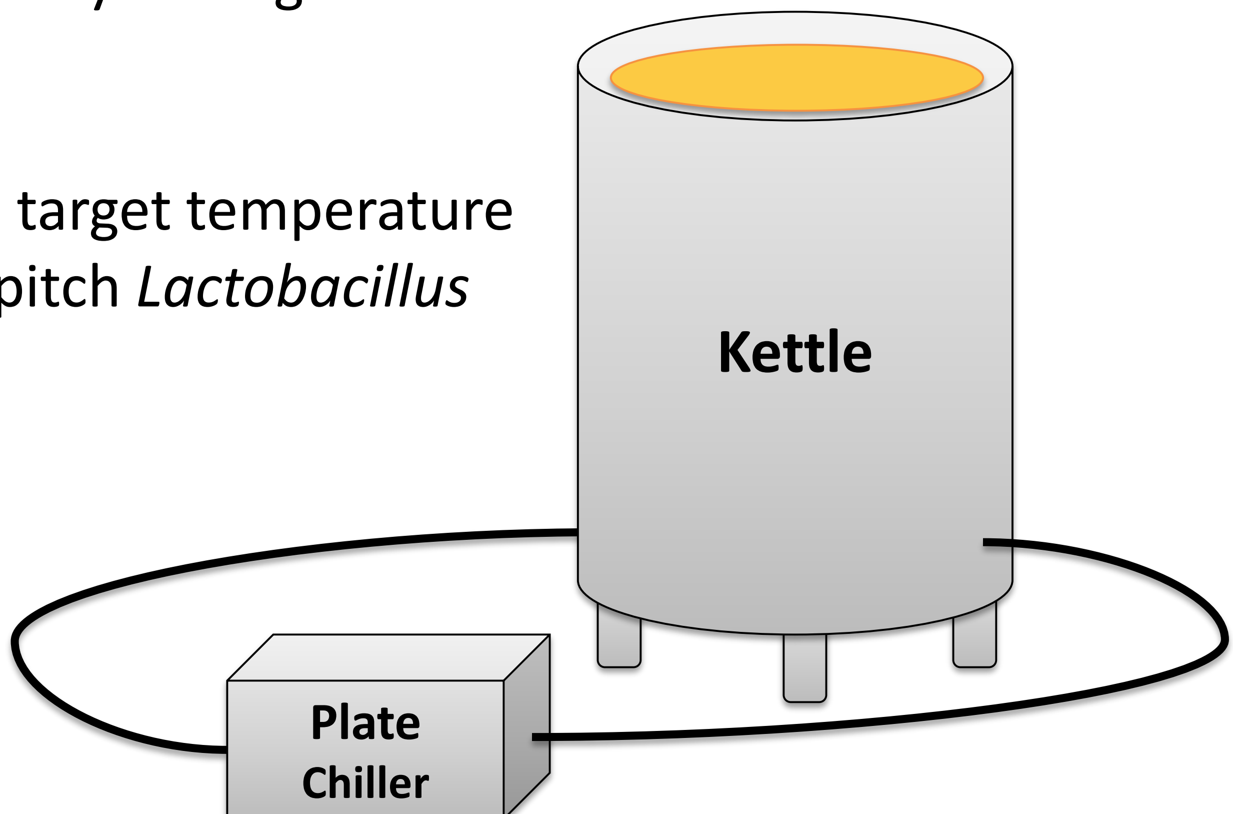
- Pasteurize wort by boiling for 5 minutes



Kettle Souring Methods

- Pasteurize wort by boiling for 5 minutes
- Cool wort to a target temperature of 110-115°F, pitch *Lactobacillus*



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- Maintain temperatures between 110°F and 115°F during souring
- If possible, blanket wort with CO_2 to inhibit aerobic bacteria

Advantages of Kettle Souring

- Speed: *Lacto* is able to sour wort within days of inoculation rather than weeks as with other souring methods
- *Lactobacillus* is added before hop additions and thus growth is not inhibited by bitterness
- pH and Total Acidity (TA) are easy to monitor
- Souring can be halted by simply bringing the wort to a boil

Advantages of Kettle Souring

- Low risk of cross contamination as the souring is constrained to hot-side brewing operations

Disadvantages of Kettle Souring

- Can tie up brewing operations while souring is in progress
- Not able to produce same complexity as an aged sour beer (No kettle soured lambics)
- Not recommended to harvest and re-pitch yeast from kettle soured beers

Kettle Souring Recap

- Attemperate Lacto (No really, do it)
- Design recipe for Lacto (gravity thresholds)
- Lower wort pH to <4.5 to inhibit microbial growth (acidulated malt or food grade acid)
- Boil for 5 minutes to pasteurize wort
- Cool wort to 110° - 115°F and maintain during souring
- Purge kettle with CO_2 and cap the stack if possible

Mixed Fermentations

Goose Island Barrel Room

Traditional Long Fermenting Method

- Primary saccharomyces fermentation
- Secondary Brett/Bacteria Fermentation

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Traditional Long Fermenting Method

- Primary saccharomyces fermentation
- Secondary Brett/Bacteria Fermentation
- Pro - minimizes contamination risk
- Pro – minimizes time in FV
- Con- long aging process – 6 months - 3 years
- Con – less controllable

Primary Mixed Fermentation (Faster)

- Pitching Lacto with a Brett or Sacch strain.

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Primary Mixed Fermentation

- Pitching Lacto with a Brett or Sacch strain.
- If you're worried about contamination ferment in barrels. Trub build up is a problem.
- With good CIP practices, and having sour specific gaskets and hoses, FV is an option.
- Starting in the FV gives the flexibility of splitting finished beer into barrels with different adjunct additions.

Primary Mixed Fermentation

- With experimentation you can control acidity

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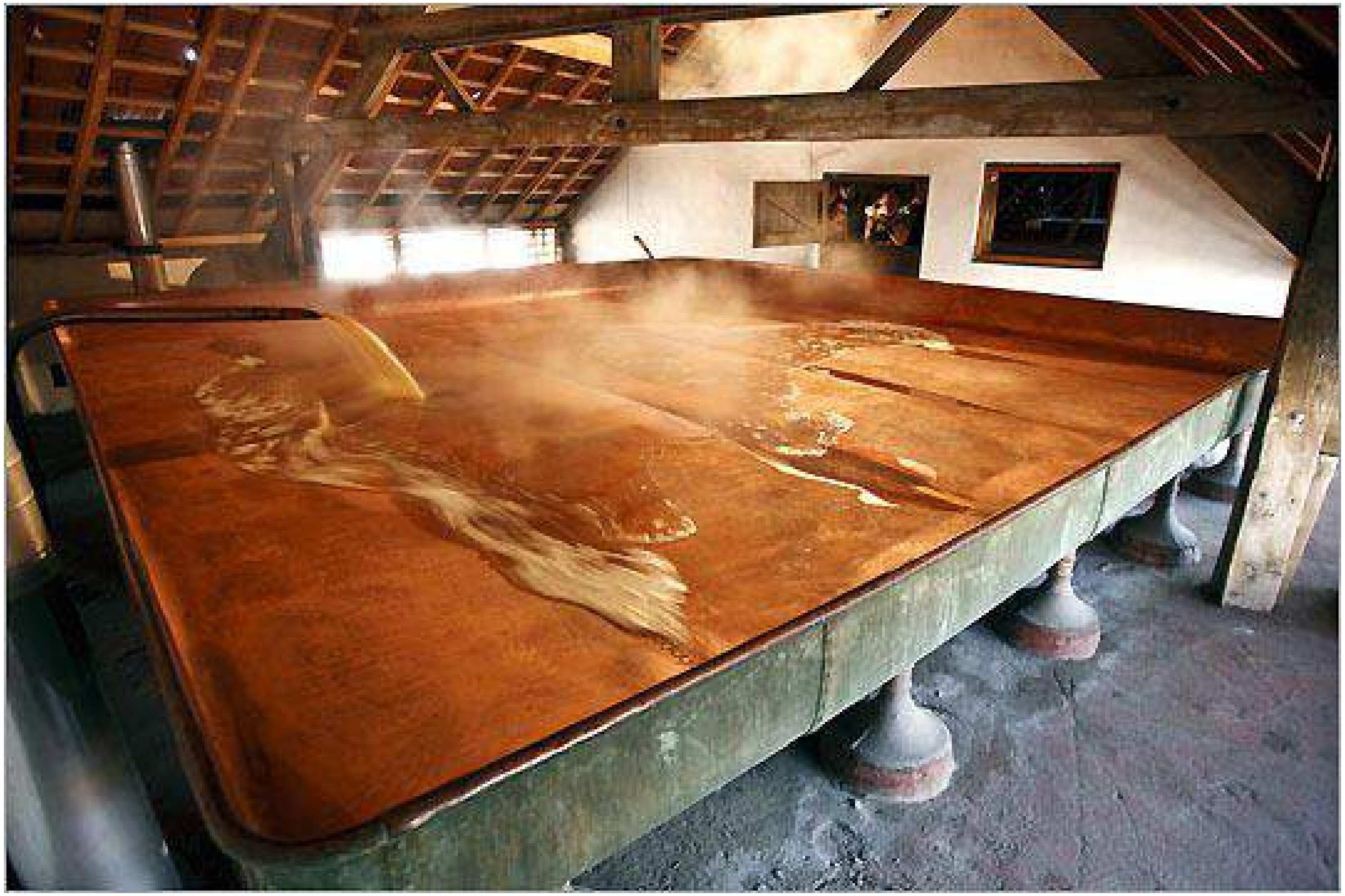
- Low acidity – pitch yeast and Lacto simultaneously at yeast fermentation temp.
  - Yeast will quickly out-compete Lacto for nutrients and food

Primary Mixed Fermentation

- With experimentation you can control acidity
- Low acidity – pitch yeast and Lacto simultaneously at yeast fermentation temp.
  - Yeast will quickly outcompete Lacto for nutrients and food
- Higher Acidity – Give the Lacto a head start. KO at 110-120F and pitch Lacto. After 24-72 hours cool wort to yeast temps and pitch yeast

Spontaneous Fermentation



GO WILD!!!

Recap:

- LAB have many practical uses in the production of sour beers
  - Souring beer is a method of "controlled spoilage"
  - Just like yeast, bacteria require specific parameters to perform optimally
  - Get to know your specific lacto strain!

Recap:

- Various brewing methods available to produce sour beers depending on your needs
  - What are your goals?
    - Speed? Sourness? Complexity? Tradition? Low contamination risk?
    - Let your goals determine the methods you use

Recap:

- Titratable Acidity is a better measure of perceived acidity than just pH alone
  - How you quantify your “sourness” matters
  - The lowest pH beer is not always the most sour tasting beer
  - We taste all of the acids!

Questions?

CHEERS!