Building a better starter

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All yeasts are not created equal

- Taste/Flavor
- Bouquet/aroma
- Color
- Mouthfeel

Why do a starter?

- To ensure complete and clean fermentation.
- Improves fermentation performance and consistency.
- Allows for fine-tuning of beers to achieve the desired flavor profile.
- Reproducibility.
- Versatility -not limited to commercial strains.

What is a starter?

- Mini-fermentation?
- Bioreactor
- Means of increasing yeast cell counts, mass, overall health of yeast.

How Much Yeast Do I Need???

- Pitching rate
  - 200 billions cells for 5 gallons
- Yeast sources
- Starter Methods & Composition

Pitching Rate

- the amount of yeast added to the fermenter
  - expressed as the amount of yeast in 1 ml of wort after pitching
- Ale pitching rates =
  - 6 - 10 million cells/ml x (1 - O.G)/0.048
- Lager pitching rates =
  - 10 - 15 million cells/ml x (1- O.G)/0.048

The evils of underpitching

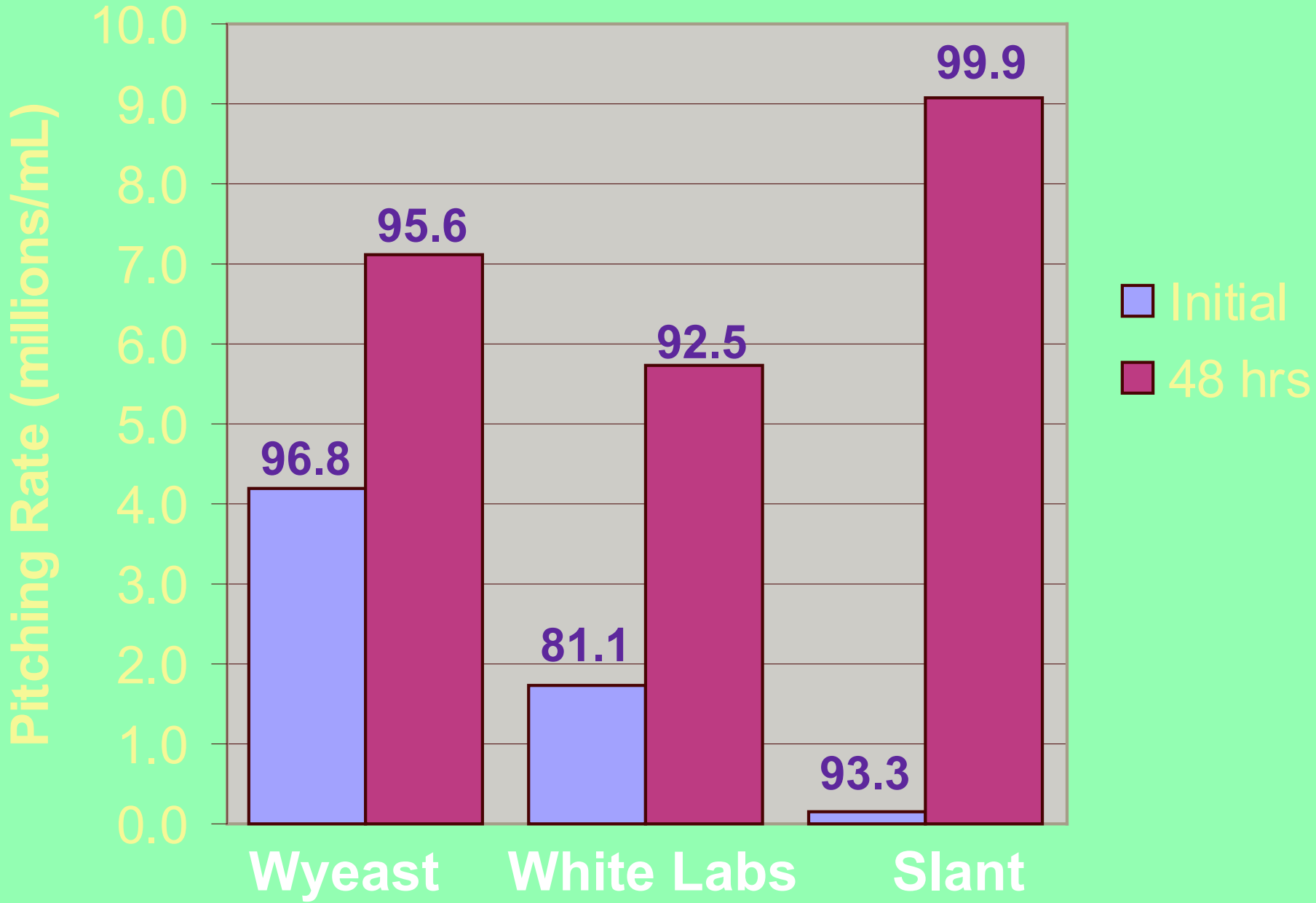
- Increased yeast cell growth
  - Excess ester formation
  - fusel alcohol generation
- Incomplete fermentation
  - Unreduced diacetyl hydrogen sulfide, acetaldehyde
  - Stuck Fermentations
- Susceptible to infection

Yeast Sources (circa. 1995)

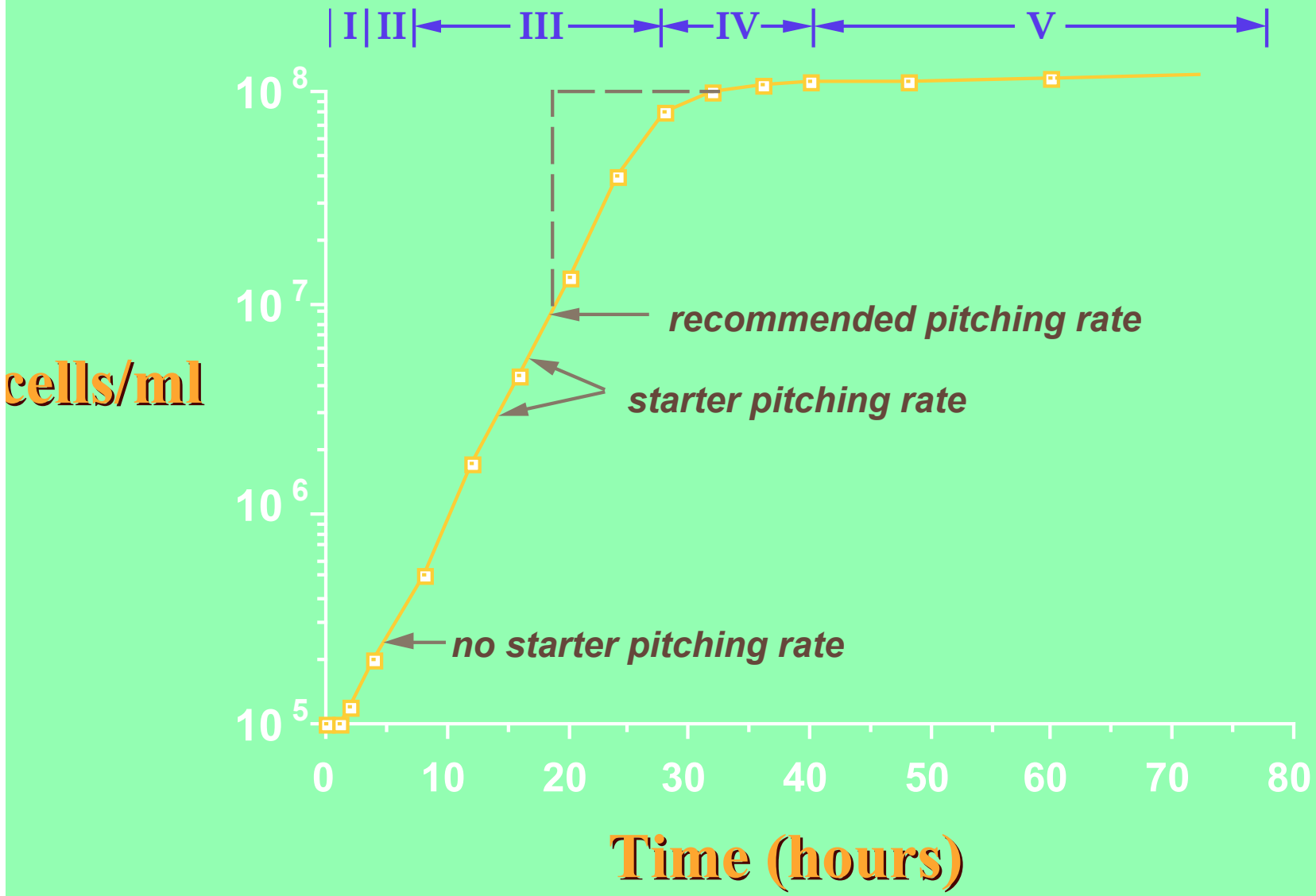
Yeast Forms	Yeast concentration (millions/ml)	pitching rate (millions.ml)	viability (budding)
Dried (5 g)	620 (200 ml)	6.2	70%(0%)†
Liquid #1	71 (50 ml)	0.18	25% (0%)
Liquid #2	58 (50 ml)	0.145	20% (5%)
Starter (shake)	60 (500 ml)	1.5	95% (100%)
Starter (stirred)	92 (500 ml)	2.3	98% (100%)
Starter (aerated)	180 (500 ml)	4.5	100% (100%)

† rehydrated yeast may exhibit increased methylene blue uptake.

2001 Yeast Sources



Extent of Yeast Growth during fermentation



Yeast Growth Vs. Fermentation

- Facultative anaerobe.
  - Survives in the presence or absence of oxygen.
- Yeast growth - aerobic conditions.
- Fermentation - anaerobic conditions.

Growth ≠ Fermentation

- Yeast propagation
  - increase yeast mass; favor yeast growth.
- Beer production
  - minimal yeast growth, optimal fermentation performance.

Factors Influencing Yeast Growth

- Oxygen/aeration
- Temperature
- Wort Composition
- pH

Optimal Fermentation Performance

- Production of a balanced sensory profile with no off-flavors or inappropriate esters.
- Rate of fermentation - length of time it takes to comp fermentation (3-5 days).
- Extent of fermentation = attenuation (apparent).
  - Percent reduction in gravity (70-80%).
  - For example, for 1.040 o.G. wort finishes at 1.010.
  - (1.040 - 1.010) / (1.040 - 1.000) = 30/40 = 75%.

Factors influencing yeast growth

- Oxygen/aeration
- Temperature
- Wort Composition
- pH

Oxygen

- Essential for yeast growth and fermentation.
- Absorbed rapidly.
- Used to synthesize unsaturated fatty acids and sterols.
  - oxygen storage
  - increasing cell mass
  - nutrient uptake
  - alcohol tolerance
- Stimulates synthesis of enzymes and proteins necessary for fermentation of maltose.

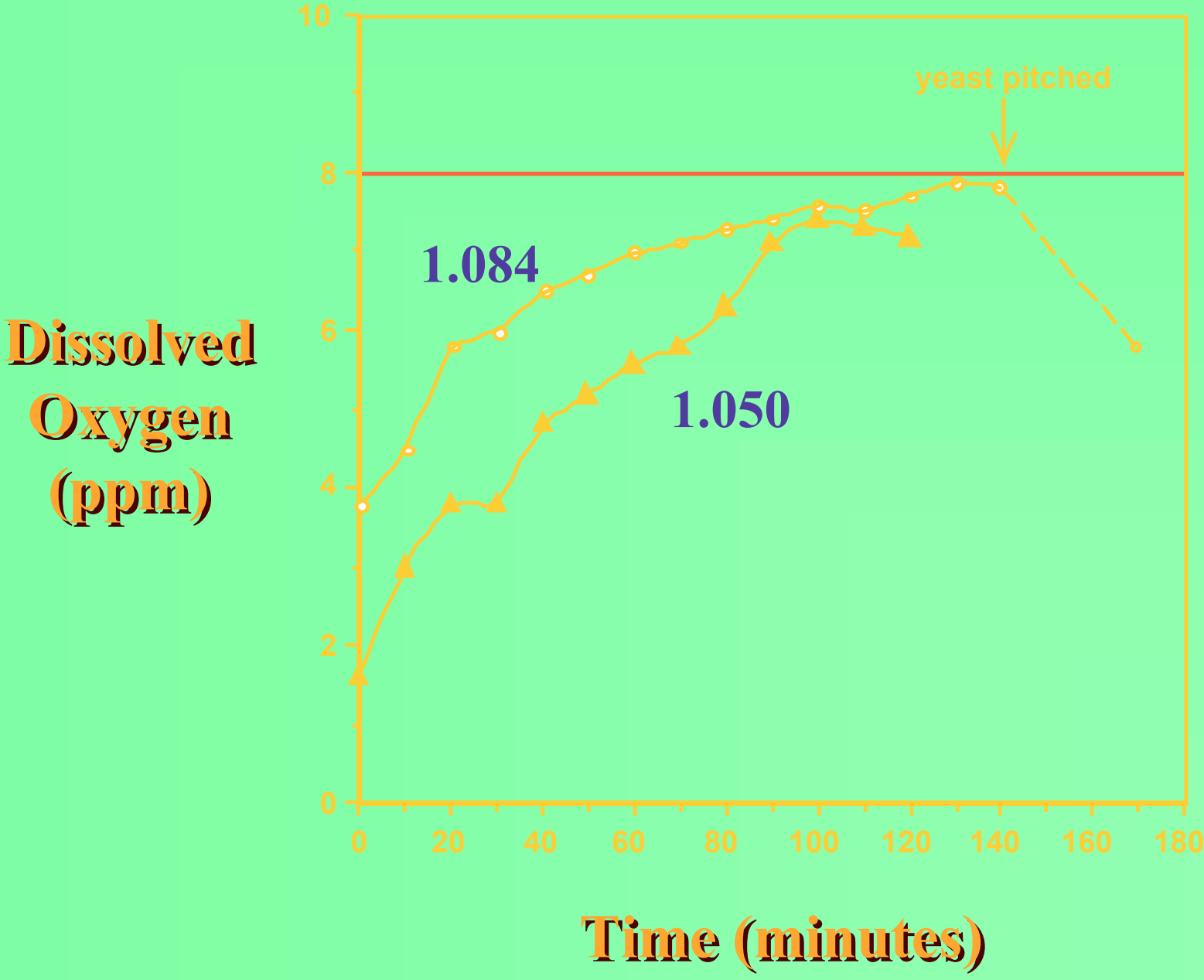
Oxygen and Fermentation

- Only important in early stages of fermentation.
  - First 6-24 hours.
  - Aeration after first 24 hours can lead to beer oxidation and the generation of off-flavors.
- Achieving sufficient oxygen levels in wort.
  - Yeasts vary in their oxygen requirements.
  - Difficult to achieve wort saturation (8 ppm) let alone higher levels.
- Insufficient aeration
  - excessive ester formation.
  - stuck fermentations.
  - yeast performance (repitching).

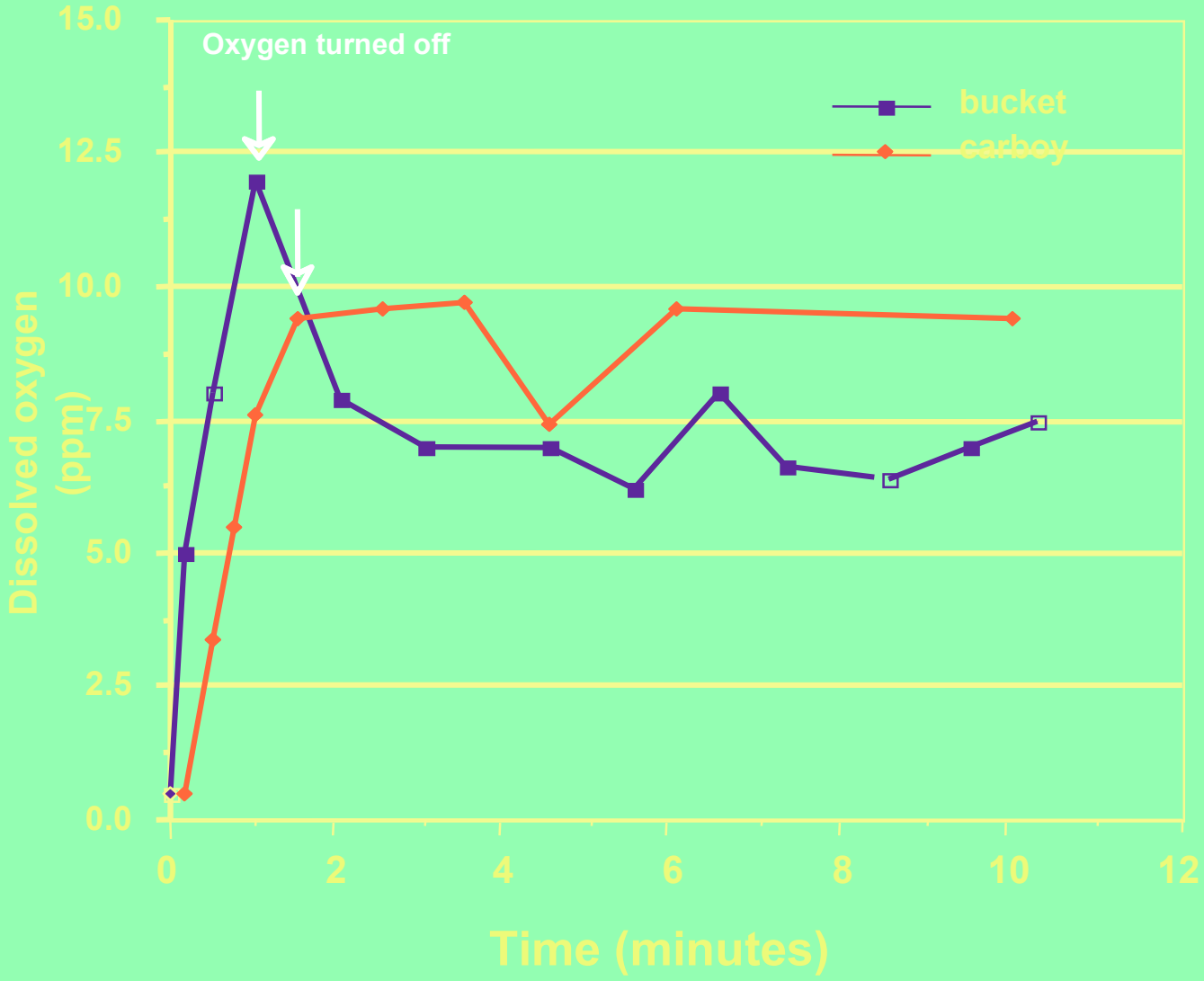
Aeration and Yeast Propagation

- Oxygen is essential to good yeast growth.
- Can affect fermentation performance of the yeast
- The more aeration and agitation the better.
  - helps to increase overall number of yeast cells.
- Methods of introducing air into starters
  - direct injection
  - intermittant shaking
  - continuous shaking
    - rotator
    - shaker
    - stir plate

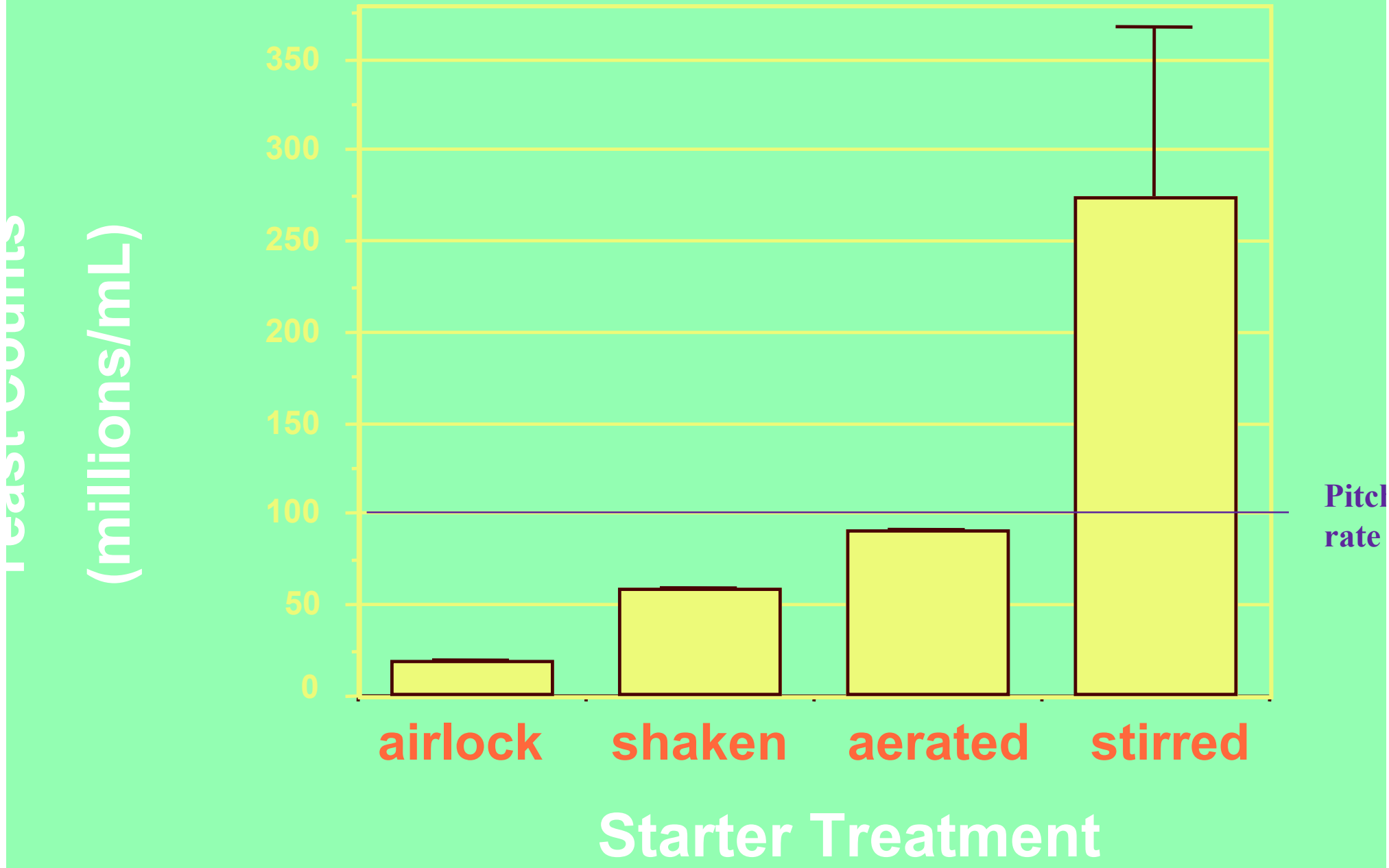
Aquarium pump aeration



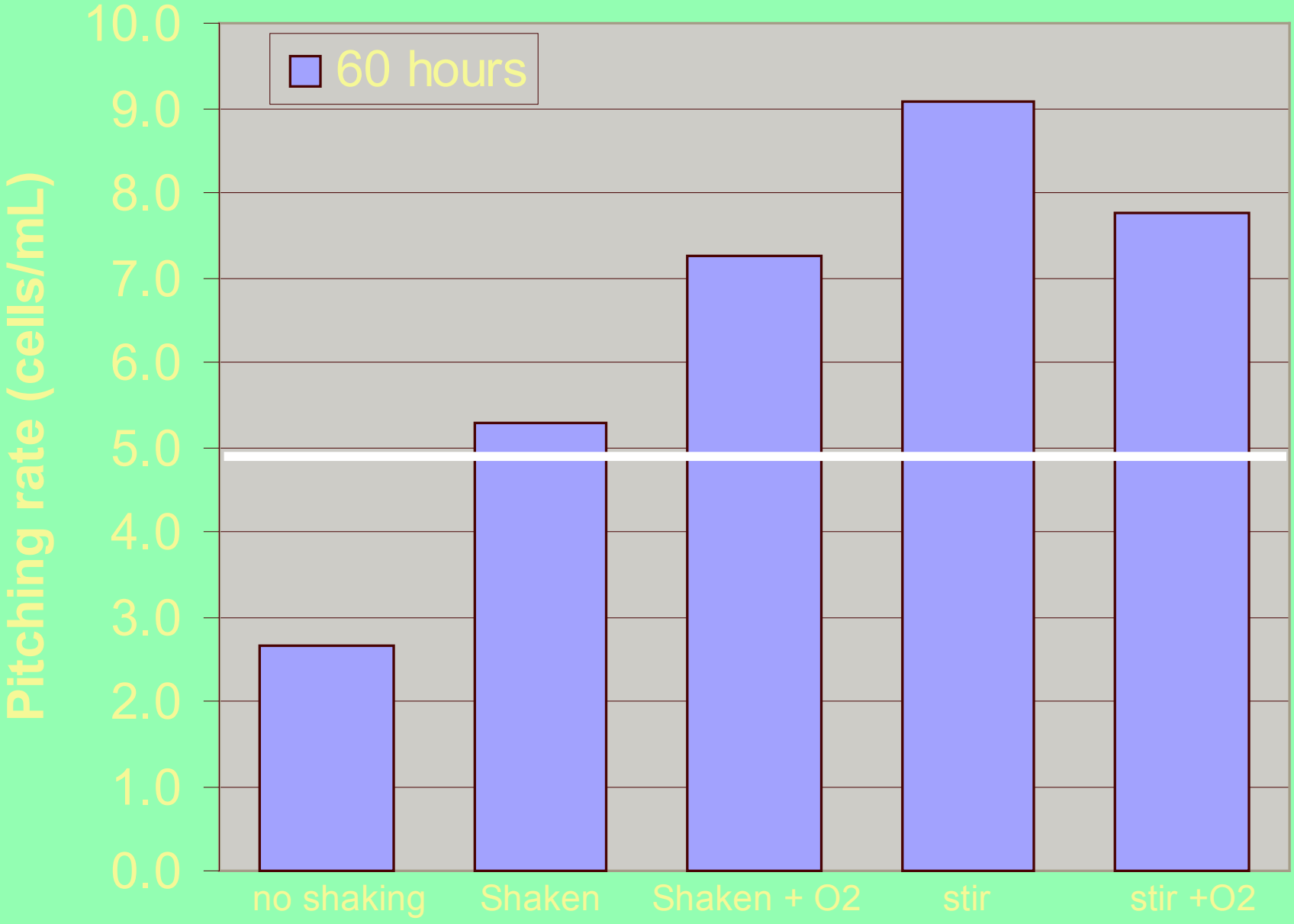
Oxygenation



Effect of Starter Method on Yeast Counts



Effect of Starter Method on Yeast Counts II



Starter method comparisons – other factors besides cell counts

	cell counts	pitching rate	Krausen	Contamination
initial	2.84	0.2		--
no shaking	50	2.6	ND	ND
Shaken	100	5.3	>60 hrs	++
Shaken + O2	137	7.2	60 hrs	+
stir	172	9.1	36hrs	-
stir +O2	147	7.8	24 hrs.	-
stir (no nutrient)	95.5	5.0	48 hrs	-

Factors influencing yeast growth

- Oxygen/aeration
- Temperature
- Wort Composition
- pH

Temperature and Fermentation

- Influences yeast growth and metabolism.
- Optimal fermentation temperatures vary among yeast strains.
  - Lager strains: 35 - 55 °f.
  - Ale strains: 55 - 70 °f.
- Profound effect on fermentation performance.
  - Higher temperatures - excessive esters. And fusel alcohols.
  - Lower temperatures - incomplete ferment, high levels of diacetyl hydrogen sulfide, acetaldehyde.
  - Trade-off between flavor profile (ester production) and rate and extent of fermentation.

Temperature and Propagation

- Brewing yeast (except some lager strains) will gro at temperatures up to 98 °f .
  - Affects viability and stability of the yeast.
- Laboratory yeast typically propagated at 86 °f.
- Brewing yeast can be propagated at room temperature (~ 77 °f).
  - Rapid growth and fermentation without affecting fermentation performance.
  - Typical temperature of wort at pitching.
    - Acclimation of yeast to cooler temperature may be necessary if pitched into cold wort.
- Fermenter temperature > outside temperature.

Factors influencing yeast growth

- Oxygen/aeration
- Temperature
- Wort Composition
- pH

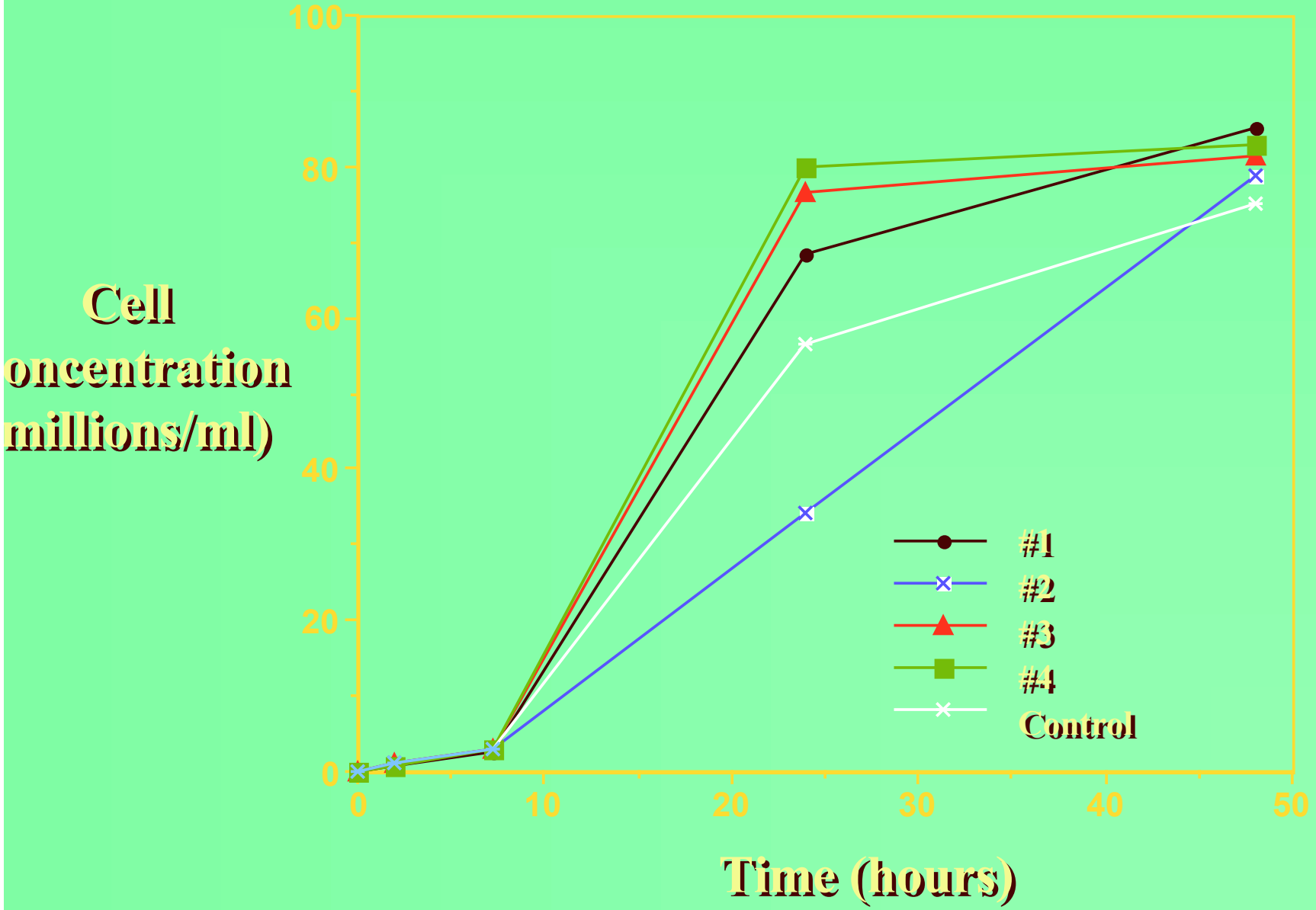
Wort (Media) Composition

- Determines yeast growth and fermentation performance.
- Important in maintaining and storing viable, stab yeast.
- Standard brewing wort contains most of the ingredients necessary for fermentation.
  - Nitrogen composition is the most common problem.
    - poor quality malt extracts.
    - large amounts of adjuncts.

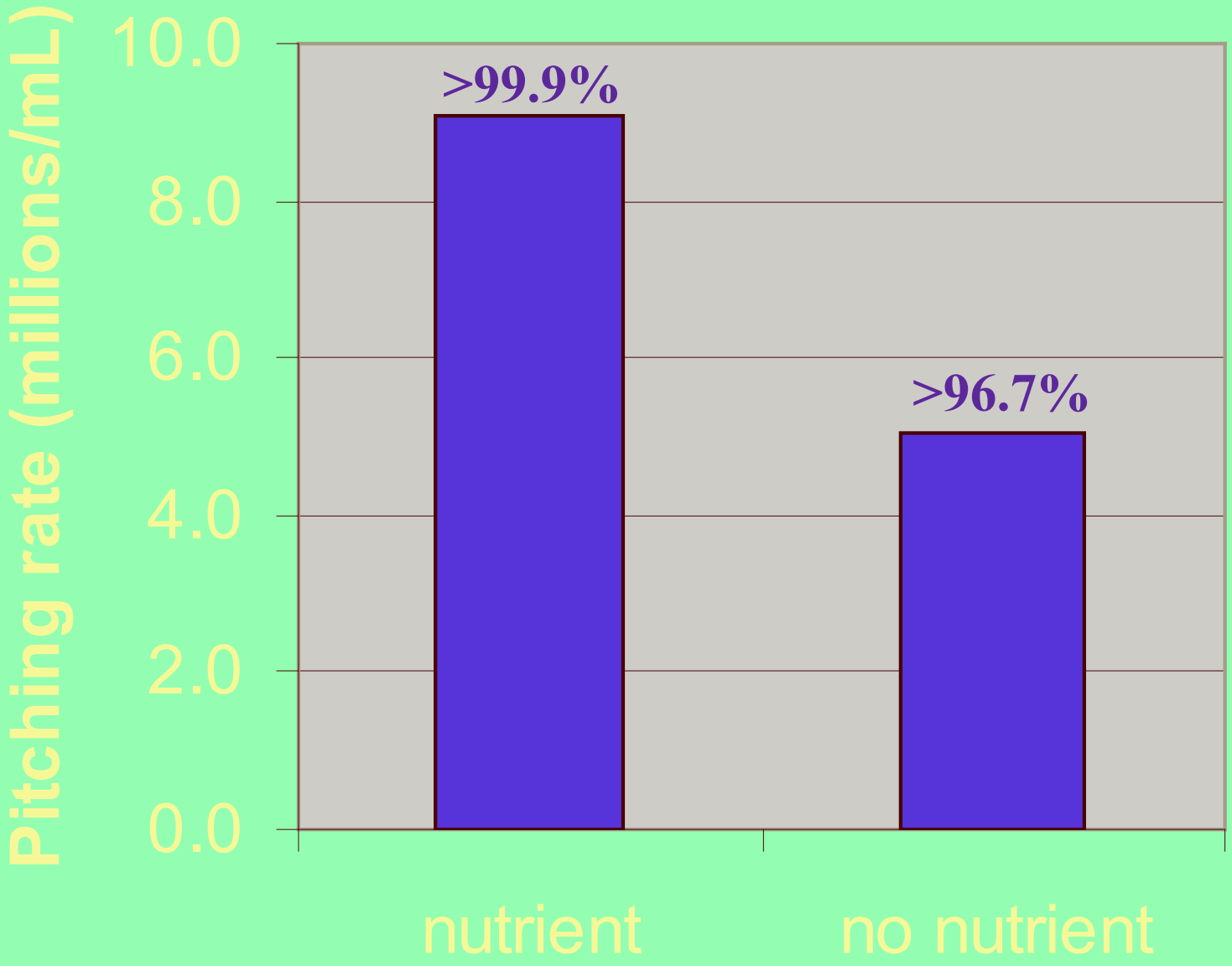
Wort composition for Propagation

- Gravity
  - Closer to the wort to be fermented, the better.
    - less acclimation.
    - osmotic shock.
  - 1.020 yields higher yeast mass but does not perform well in ferments. Frequently get stuck fermentations.
  - 1.040 works well in most worts.
  - 1.065 for high gravity fermentation.
- Nitrogen supplements
  - ammonium phosphate
  - amino acid/peptide/vitamin mix.
  - Fermentation vs. propagation?

east Nutrients Increase the Rate of Yeast Growth



Yeast nutrients increase starter yields



Additional wort components

- **Zinc**
  - recommended for improving yeast growth.
  - 0.5 ppm improves fermentation.
  - present in amino acid/peptone/vitamin based nutrient.
- **Sugar composition**
  - simple sugars more readily metabolized and are sufficient for growth but may affect fermentation performance.
  - use only in early propagation or for maintenance of stocks.

Recommended Starter Composition

Starter Wort	Amount for 1 Liter (qt)
Dry Malt Extract or	
~1.040 O.G. wort	1 cup or 0.25 lbs DME
1% vitamin based yeast nutrient	1/2 tsp or 10 g
Hops (optional)	1 pellet or a few drops of iso-alpha extract.

Starter Preparation

- Vessel
- Boiling
- Tyndallization
- Sterilization

Factors influencing yeast growth

- Oxygen/aeration
- Temperature
- Wort Composition
- pH

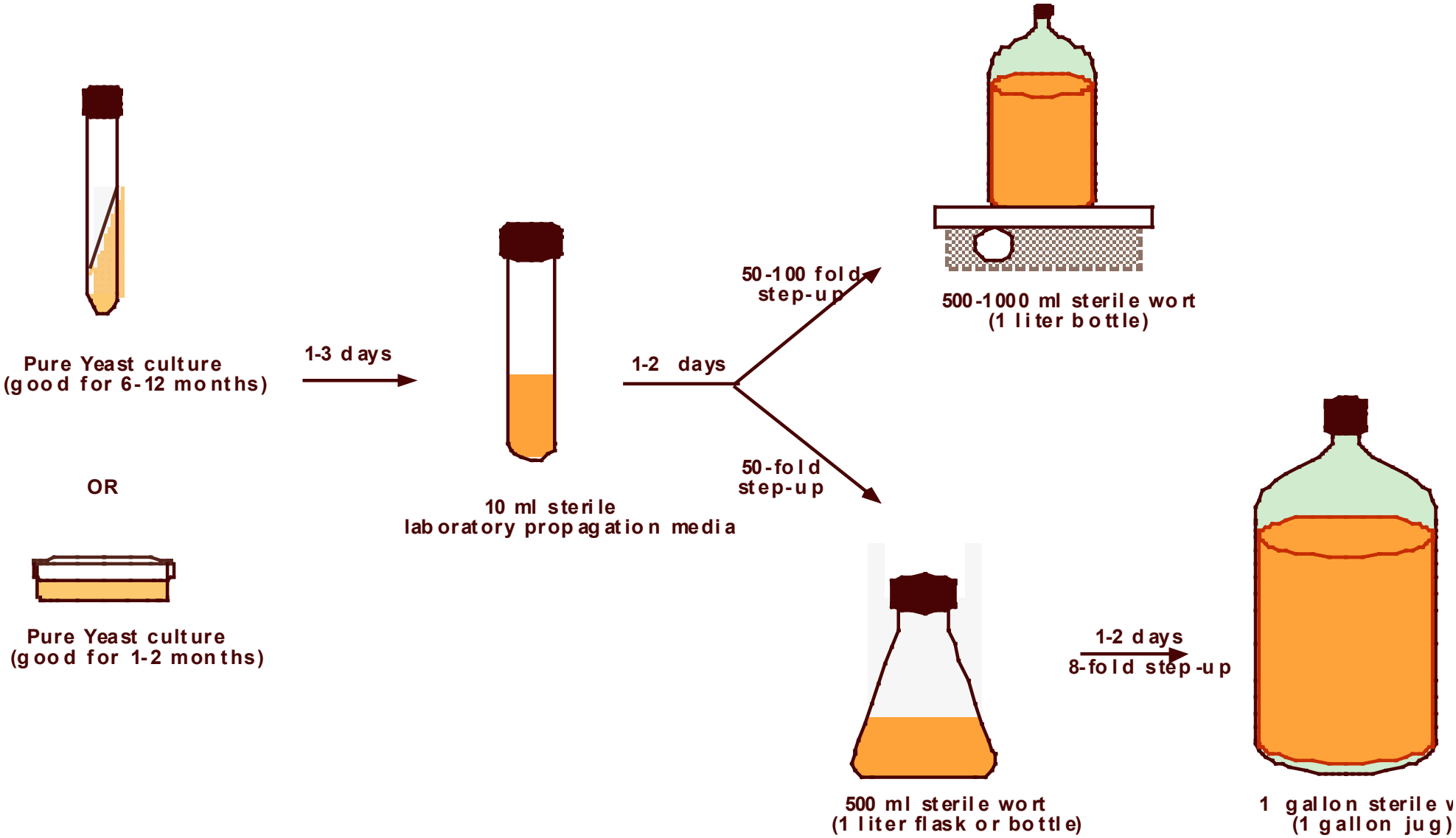
pH (acidity)

- Optimal yeast growth between pH 4.0 - 6.0.
- Wort pH = ~5.2; drops to 4.1 during fermentation
  - helps prevent bacterial infection
- Laboratory media pH = 7.0
- Yeast survive @ pH = 2.0
  - basis for acid washing.

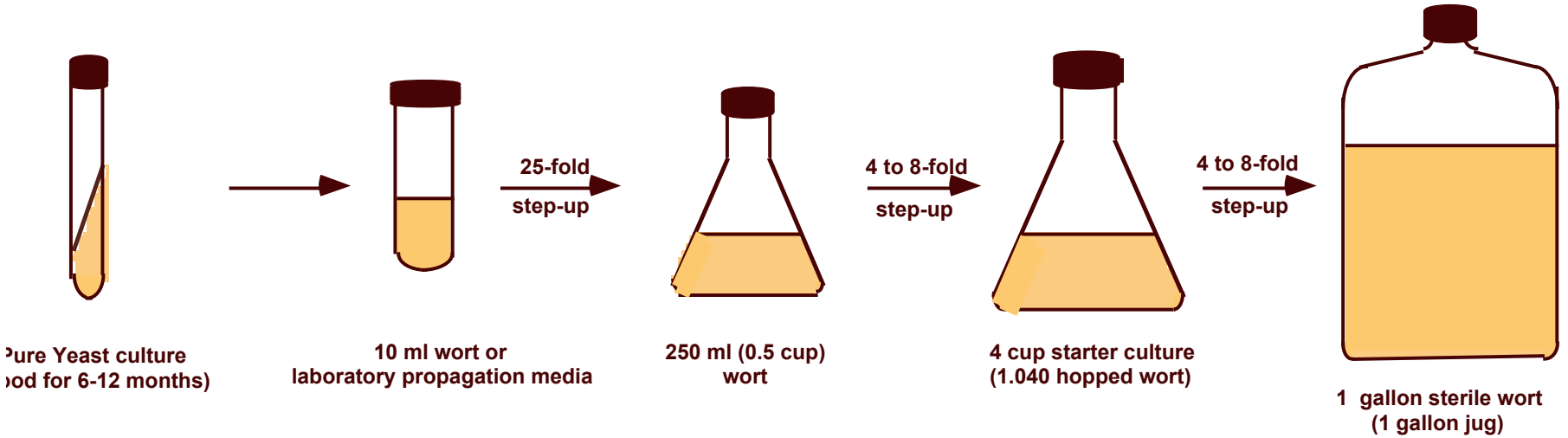
Applying the principles of yeast growth

- Media composition.
- Temperature.
- Oxygenation/Agitation.
- Volume
- Length of time between propagations
- Size and number of step-ups.

Propagation of pitching yeast



Brewery Propagation of Pitching Yeast



Starter Recommendations

- always make one
- 1 quart absolute minimum
- composition - 1.040 wort + nutrients + hops
- preparation - 15 - 30 minute boiling or tyndallization
- initiation - 10 ml sterile culture or liquid yeast.
- treatment - shake! shake! shake! or stirrrr
- temperature - room temperature (75 F)
- time - approx. 2 days per step
- storage - okay for a 1-2 weeks; feed before using

Tips for handling yeast

- Common misconceptions.
  - Need glove box
  - Bacteria have legs
- Work in draft-free clean area.
- Perform all manipulations near a flame source.
- Keep containers open for as little time as possible.
  - rehearse