SOCIETY OF NORTHEAST OHIO BREWERS

August 4, 2014

- SNOB Business
- Upcoming Events
- Yeast by Zech Laughbaum
- Yeast Starters
- Health break and Raffle

SNOB Business

- **Berea Oktoberfest** is on Labor Day weekend. Rich has offered the SNOBs a table/booth in the Bierhall on Friday, August 29th as well as a spot for a demo brew and time for a presentation on Sunday, August 31st. Anyone up to doing a brew demo and/or a home brew tech talk at the Berea Fairgrounds?
- **The September meeting** has been moved to August 25 due to Labor Day
- **Showing of the Beer Hunter Video**
  - Committee to discuss logistics
    - Who to invite, how much to charge
    - Where to hold, up on second floor
    - Robin's big screen, Scott's speakers?
- **Cleveland Edible** magazine is doing bus tour on Friday Oct 3, looking for 3-4 home brewers who will let them come by and watch and ask questions for about an hour. Starts at Platform for lunch then goes to homes afterwards.
- **Election of 2015 officers** takes place in November. Start thinking of who you would like to see in these positions and place some nominations or nominate yourself.

Upcoming Events

- **SNOB Night Out-July**
  - To be determined, Wednesday, August 27th at 6PM
- **Son of Brewzilla**
  - September 27 and registration is now open. Get your brew on! Details to follow.

YEAST 101

YEAST HAVE THE MOST IMPORTANT JOB IN BREWING!

ZECH LAUGHBAUM

YEAST A BRIEF HISTORY

-1680 **Anton van Leeuwenhoek** was first to observe yeast under a microscope.

-1789 **Antoine-Laurent Lavoisier** describes a chemical nature of fermentation.

-1879 **Louis Pasteur** officially “affirms” yeast is alive and changes the world forever.

-1883 **Emil Christian Hansen** isolated first lager strain.

BREWING YEAST

Historically:
Saccharomyces cerevisiae - ale yeast
Saccharomyces uvarum (carlsbergensis) -lager yeast
Now :
Ale: *Saccharomyces cerevisiae*
Lager: *Saccharomyces pastorianus*

Saccharomyces - "sugar mold"

Acid tolerant and will ferment sugars unless the sugar is present in very low levels < 1%

WHY IS YEAST SO IMPORTANT ?

Yeast will metabolize roughly 50%-80% of Wort extract

46.3% converts to carbon dioxide

48.4% converts to ethanol

5.3% converts to new yeast biomass

What about all the other hundreds of compounds that are produced ? Even though they add up to less than 1% they contribute enormously to flavor and essence of the beer.

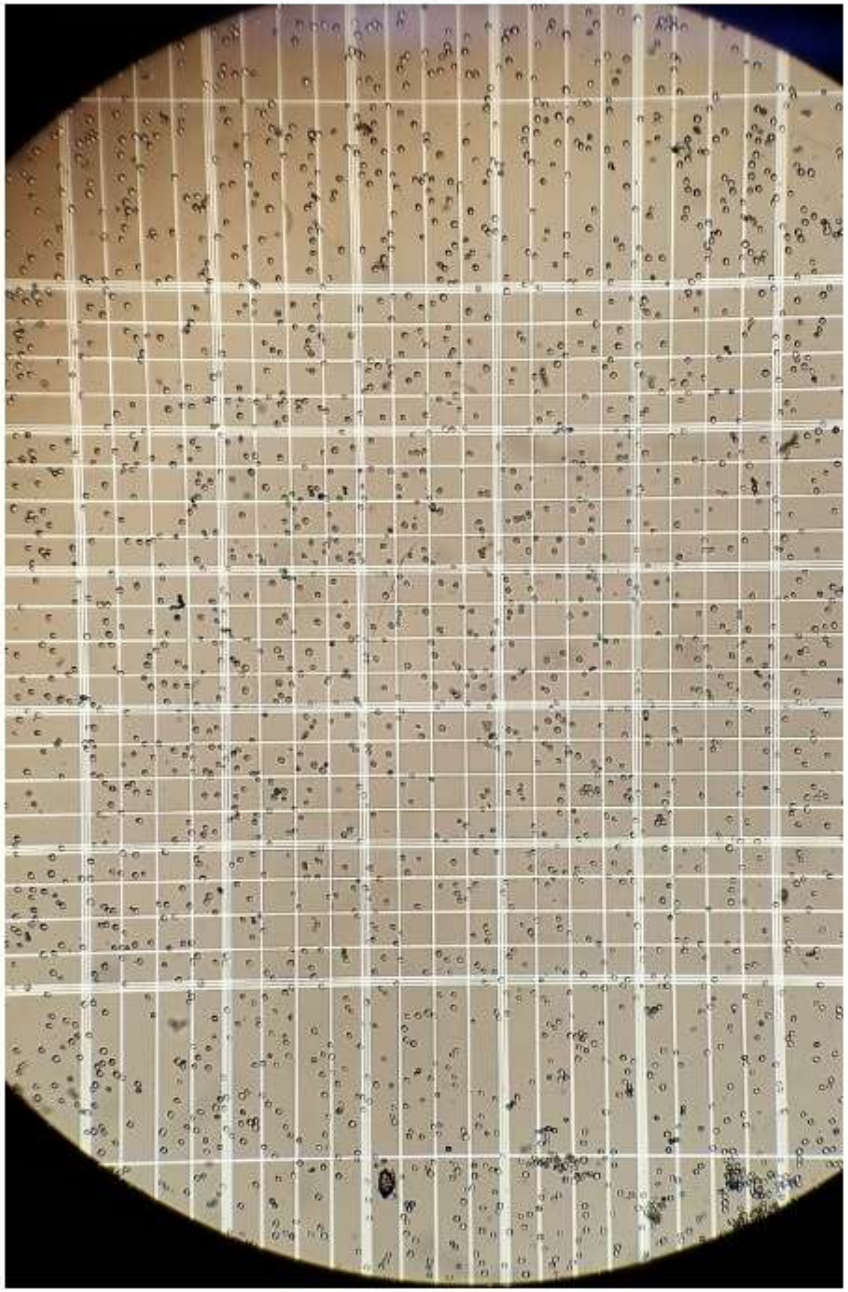
The types and amounts of flavor compounds produced by yeast during fermentation are by no means constant. The flavor will vary enormously depending on many factors such as yeast health, growth rate, sanitation, fermentation environment, and other factors to be discussed.

TOPICS TO BE DISCUSSED

- Cell counts, Viability, and Vitality
- Pitching Rates
- Liquid vs. Dry
- Yeast Starters
- Growth, Handling, and Storage
- And much more !

Cell Counting

CELL COUNTS, VIABILITY, AND VITALITY




Nikon
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WHY SHOULD YOU KNOW YOUR CELL COUNTS ?

Counting Cells is a technique to determine cell concentration in a liquid.

Imagine you have a 5 gal batch of beer with an OG of 1.048, How much yeast do you need for a healthy fermentation ?? Do you have a high enough concentration of cells for a healthy fermentation ? Do you need a yeast starter ? Can you harvest yeast from your previous batch and pitch a yeast cake ?

The question now arises, how can you be certain you have the exact number of yeast cells after a starter or how much of the yeast cake do you need to harvest ?

This question can be answered with a cell count.

Knowing your cell counts gives you the ability to know how many cells you are pitching into your wort to ensure a succesfull fermentation.

WHAT DO YOU NEED TO COUNT CELLS ?

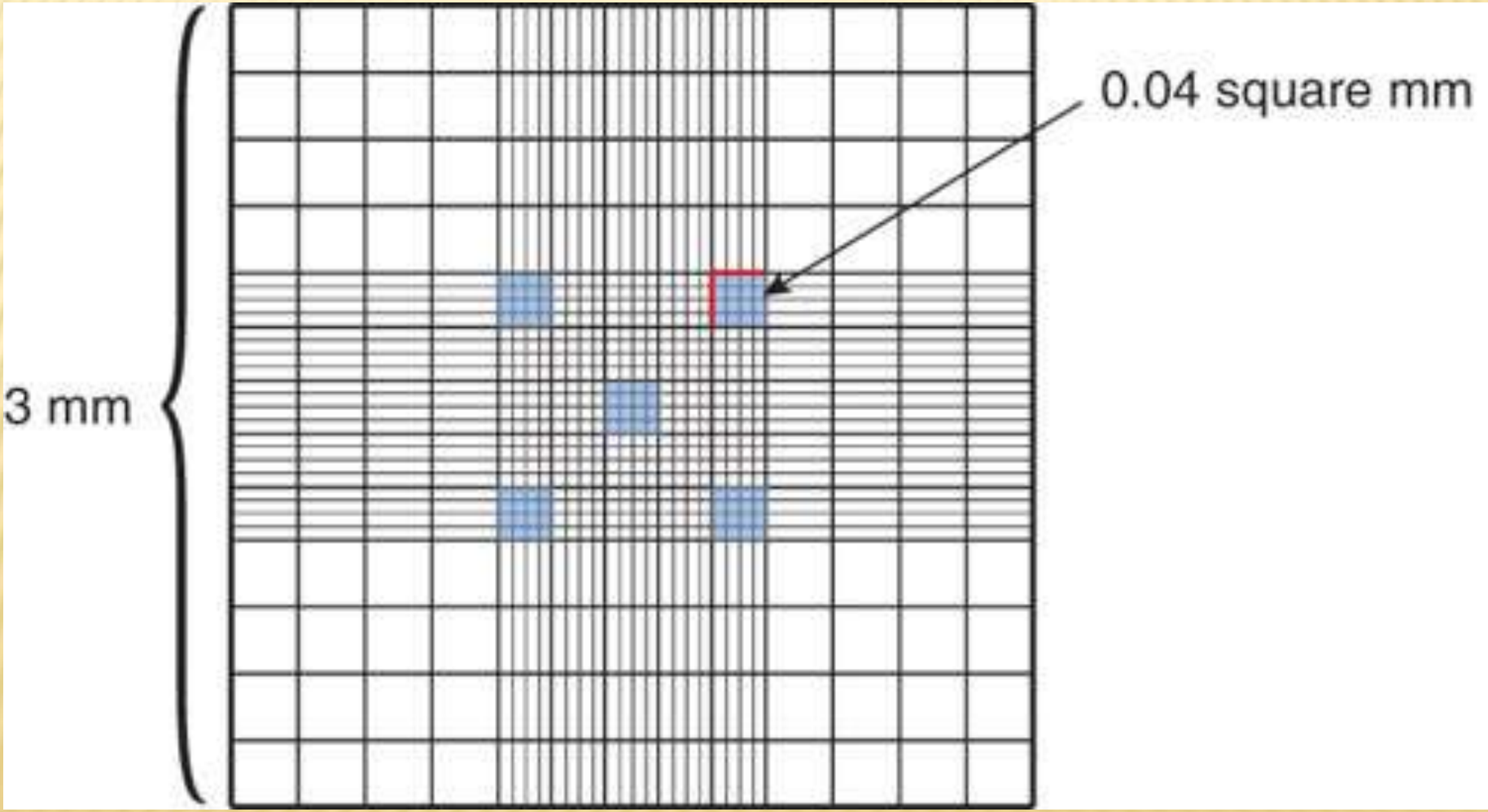
First of all, you need a counting chamber. A counting chamber is a special glass slide with engraved squares located in the middle of the slide for accurate counting. Holding a precise volume of 1 mm^2 allowing you to accurately determine the cell count of your yeast sample.

Secondly, you need a microscope with magnification greater than 400x

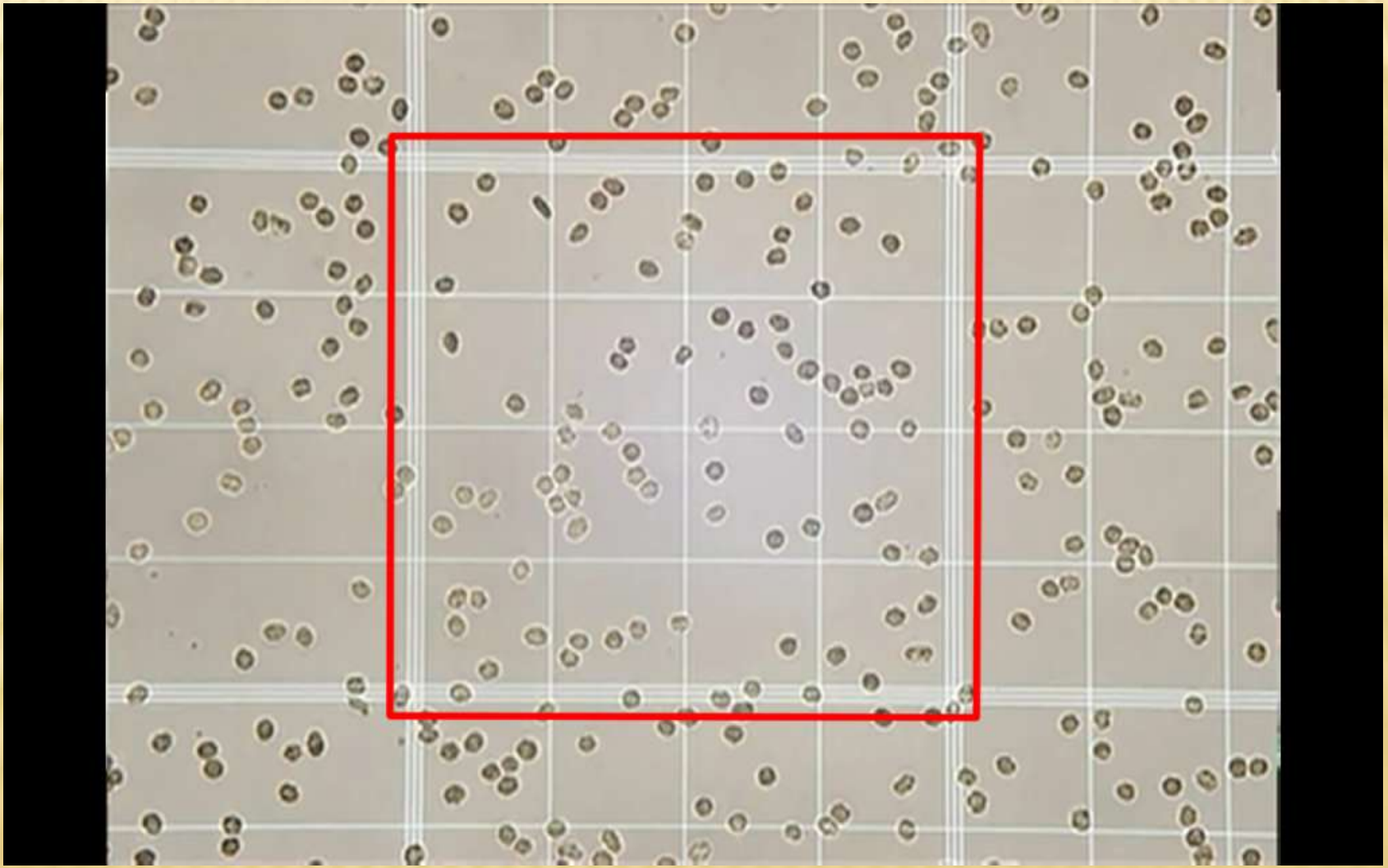
And finally basic equipment to dilute the yeast sample such as pipettes and a graduated cylinder.

NEUBAUER IMPROVED COUNTING CHAMBER

HAEMOCYTOMETER GRID



EXAMPLE



COUNTING METHOD

Count the yeast cells within the 5 numbered squares.

There are 25 of these small grids, to estimate the total number of cells in the entire grid multiply the 5 grids counted by 5.

The entire chamber holds a precise amount of liquid, 1/10,000 milliliter. To calculate how many cells would be in a milliliter, multiply the total cells in the grid by 10^4 (or 10,000).

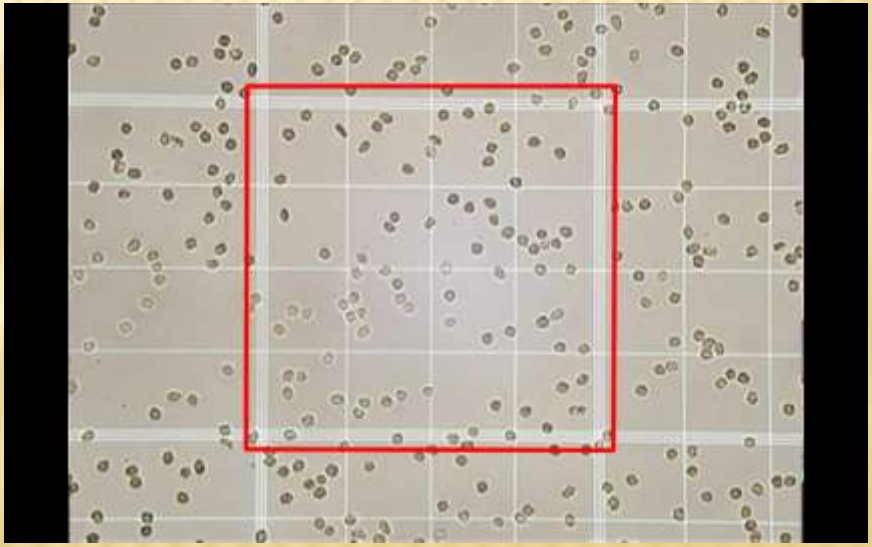
The resulting formula is:

Yeast cells / milliliter = counted cells x 5 x dilution factor x 10^4

EXAMPLE

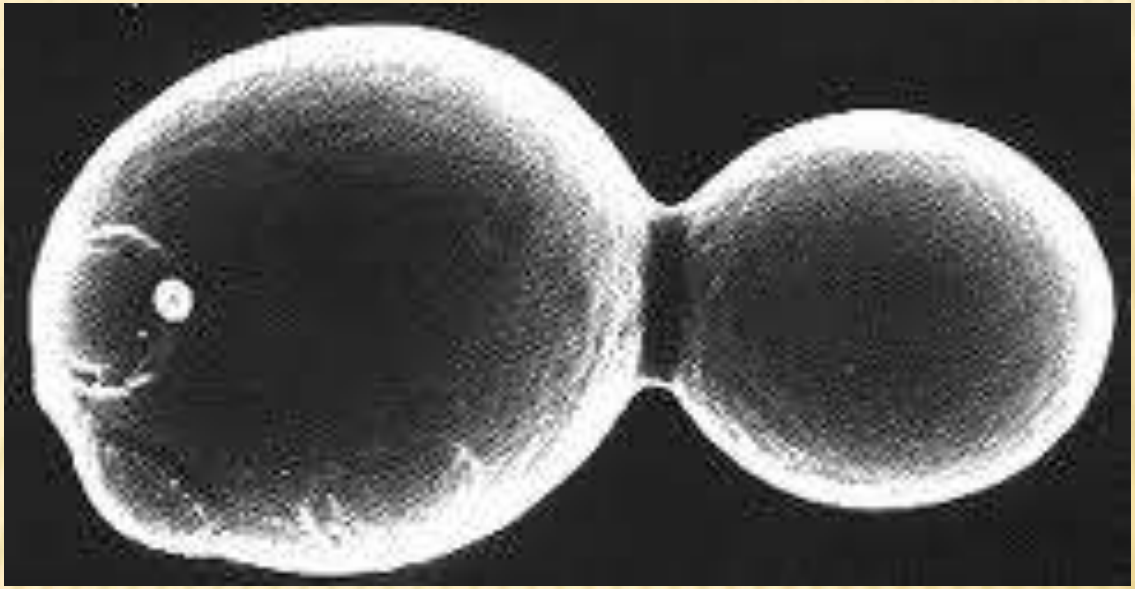
For example, if you diluted the yeast by a factor or 200 and counted 220 cells within the 5 numbered squares, you would calculate:

Yeast cells/milliliter = 220 x 5 x 200 x 10,000 = 2,,200,000,000
Or 2.2 Billion cells / milliliter

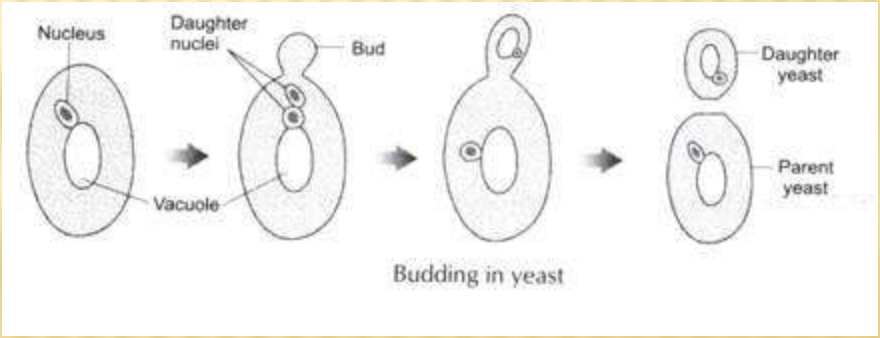


Yeast vegetative reproduction by budding

Mother Cell Bud



Sequence of cell



0 min 25 min 95 min

VIABILITY AND VITALITY

How do you know the quality of your yeast ?

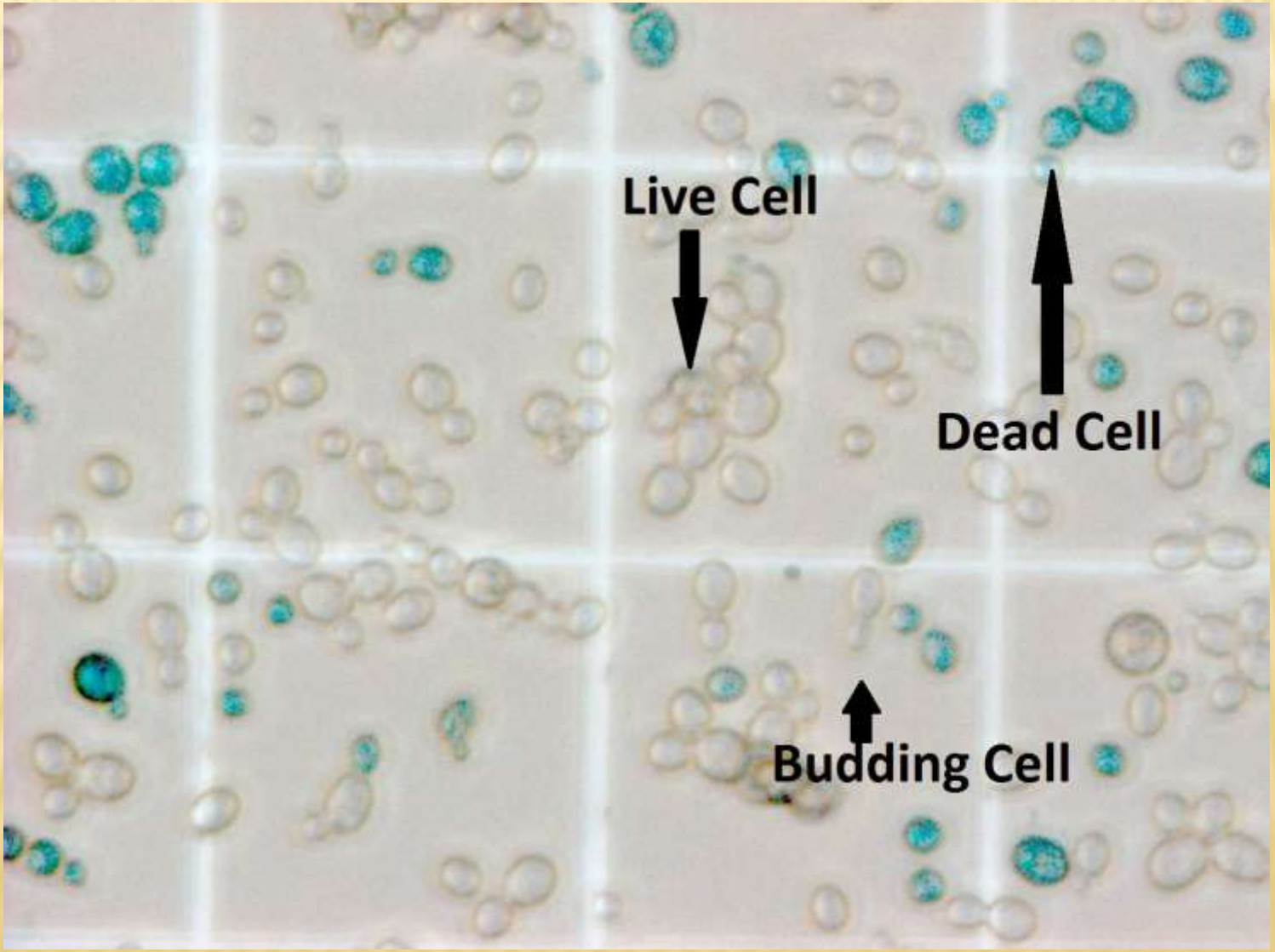
Viability is used to describe if the yeast is alive or dead

For example if every cell in a yeast culture is alive, we call that 100% viable. If half of the yeast in a culture is alive, the culture is only 50% viable.

Vitality is used to tell us the condition and health of the yeast

Measurement of metabolic activity of the yeast. If yeast culture is very healthy, strong, and ready for fermentation, we call that high vitality. If the cells are old, tired, starved, and not capable of good fermentation, we call that low vitality.

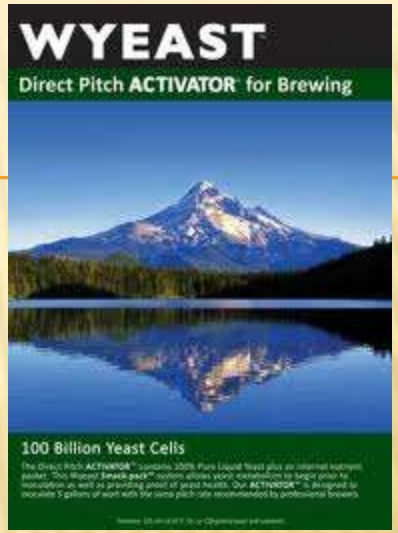
VIABILITY OF YEAST



VITALITY OF YEAST

The industries most popular method to test yeast vitality is to perform an acid power test. The idea is that active yeast will drive the pH of the medium down (acidify it), so the faster the yeast acidifies the medium, the healthier and greater their vitality.

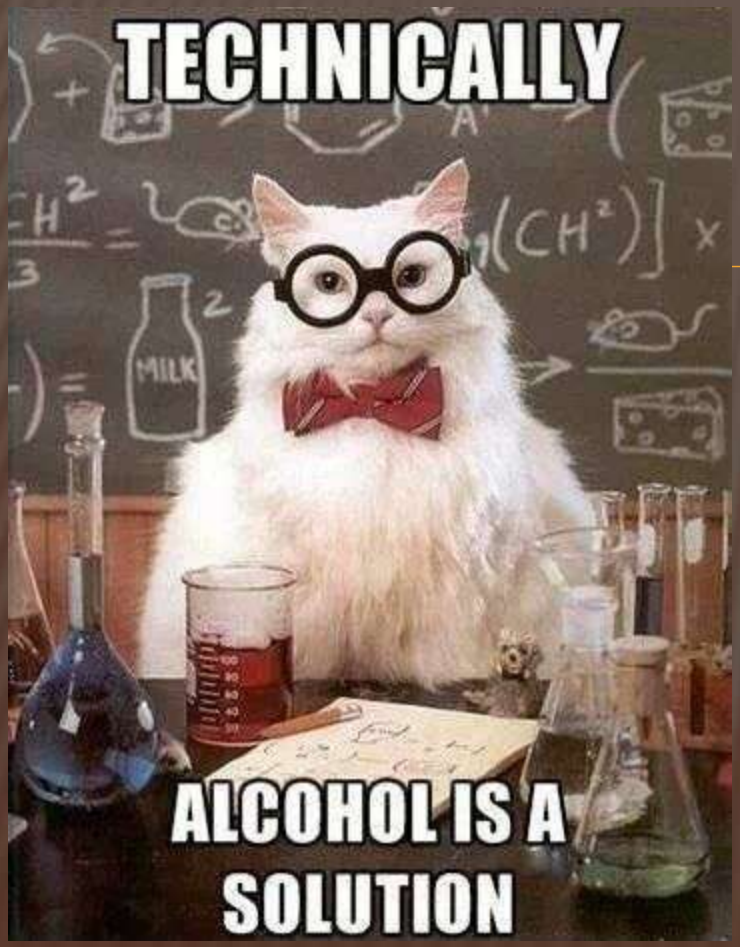
FYI



The date on a Wyeast package is the *production date*.

The date on a White Labs vial of yeast is the *"best by" date* and the production date for calculating viability is 4 months prior the "best by" date on the vial (6 months for bacteria and brett).

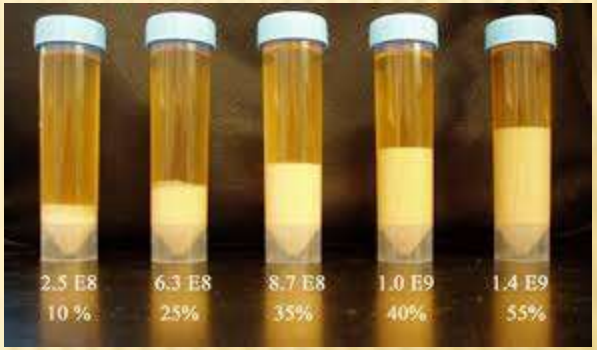
PITCHING RATES



PITCHING RATES

It takes precise measurements to achieve consistent, high-quality beer. One of the most important measurements is the pitching rate. Without consistent pitching rates, flavor can change significantly from batch to batch. Can you over pitch or under pitch ?

Underpitching affects flavor more, while overpitching negatively affects yeast health more over generations. However, both can result in less than ideal fermentation with high levels of diacetyl, acetaldehyde, and low attenuation.



Over pitching

- Low or unexpected esters
- Yeast autolysis flavors
- Poor head retention

Under pitching

- Slower fermentation with long lag times
- higher levels diacetyl
- low attenuation
- Allows competing bacteria more time establish itself

An often quoted pitching rate is 1 million cells per milliliter of wort per degree Plato. This is more of a guideline than a hard and fast rule.

Typically
0.75 million cells per degree Plato for ales

1.5 million cells per defee Plate for lagers

EXAMPLE

Calculate the pitching rate for a 12 °P ale wort in a 5.3 gallon batch of homebrew.

Since this is an ale wort we will use a rate of 0.75 pitching rate. Multiply your pitching rate (0.75) by the specific gravity of the wort in Plato (12) to determine how many million cells you want per milliliter of wort. In this example you want 9 million cells per milliliter. You then multiply that number (9 million cells/ml) by the volume of wort in milliliters, to determine the total number of cells to pitch.

(pitching rate)x(milliliters of wort)x(degree Plato) = Cells Needed

(750,000)x(20,000)x(12) = 180,000,000,000

Or enter your information into Mr. Malty's Pitching Rate Cal.
http://www.mrmalty.com/calc/calc.html

WHY USE A YEAST STARTER ?

“Most home brewers buy liquid yeast in the so-called pitchable tubes or smack packs. Yeast in this form generally does not contain enough viable cells to achieve the pitching rates required for successful fermentations. As a consequence, most home brewers chronically under pitch, perhaps by a factor of 20!”

For a standard 5-gallon batch, this means you should be pitching in the neighborhood of 200 billion cells into your cooled wort. Higher gravity worts and lagers require even higher cell counts. A starter becomes necessary for a number of reasons.

YEAST STARTERS

Primary focus of a starter is to create enough **clean** and **healthy** yeast to ferment your wort under optimal conditions.

Always think yeast HEALTH first and cell growth second.

Sanitation is key !

“Homebrew propagation is somewhat easier, because you do not need as much yeast as a commercial brewery; it is essentially all lab scale.”

BREAKING DOWN STARTERS BY THE NUMBERS

Brewers should not believe the myth that yeast become acclimated to high-gravity fermentation from a high-gravity starter! In general when dealing with reasonably healthy yeast, you want the gravity of the starter between 1.030 and 1.040 (7 - 10 °P)

If you are trying to revive a stressed yeast use a lower-gravity starter wort, about 1.020 (5 °P).

Lower-gravity starters are easier on the yeast but result in less growth.

High-gravity starters result in more growth but are more stressful for the yeast.

WHAT IS THE BEST STARTER SIZE ?

The most important thing to know about starter size is that the inoculation rate affects the rate of growth. The “Pitching Rate” of your starter has a big effect on the amount of new yeast cells you will see from any propagation.

It is not the volume of the starter that is important, but how many cells you add in relation to that volume!

To high inoculation rate, and you get very little growth.

To low inoculation rate, then you are not really making a starter, you are fermenting beer.

MAKING A STARTER

A Starter is easy to make.

You will need a clean, sanitized container able to hold the starter plus some headspace, aluminum foil, light dried malt extract (DME), yeast nutrients, and water.

Using metric measurements you can use a 10 to 1 ratio. Add 1 gram DME for every 10 milliliters of final wort volume. Example: to make 2 litters of starter wort, add water to 200 grams of DME until you have 2 liters total volume. Add 1/8 teaspoon of yeast nutrient, boil 15 minutes, cool to room temperature, transfer to sanitary vessel, and add yeast.

Following this basic process results in growth as shown in the following slide however, it is fairly simple to increase the amount of yeast growth through the addition of oxygen and agitation.

Starter Volume (liters)	Inoculation Rate (millions/ml)	New Cells Created (billions)	Total Cells at Finish (billions)	Number of Doublings	Yield Factor
0.5	200	12	112	0.1	3.4
0.8	125	38	138	0.4	6.9
1	100	52	152	0.5	7.4
1.5	67	81	181	0.8	7.7
2.0	50	105	205	1.1	7.6
4.0	25	176	276	1.8	6.3
8.0	13	300	400	3.0	5.3

Figure 5.5: Effect of inoculation rate on yield factor for typical propagation rates, starting with 100 billion cells.

Reference: Yeast The Practical Guide to Beer Fermentation; Chris White with Jamil Zainasheff pg.140

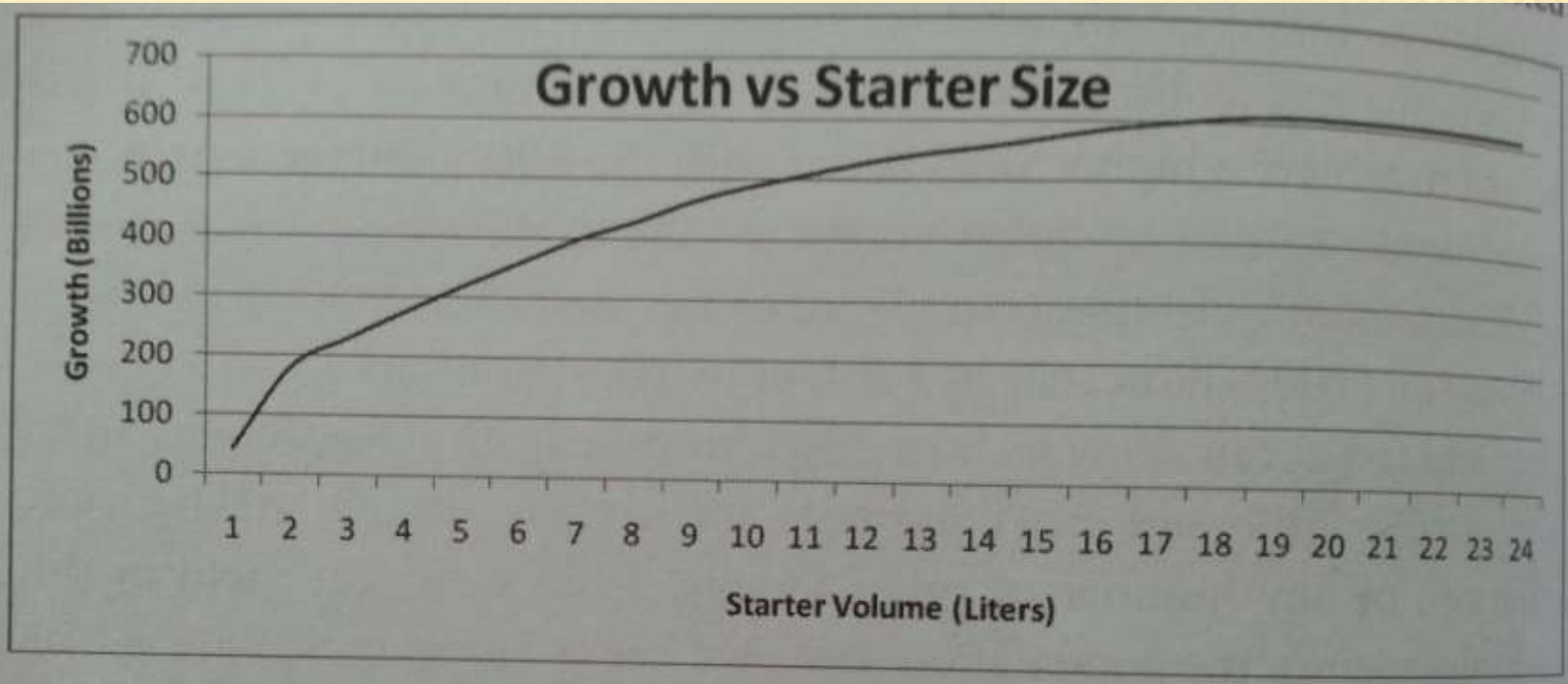


Figure 5.8: A similar experiment utilizing the same yeast strain, pitching rate, starter gravity, and temperature as in Figures 5.5 and 5.7. This shows the results of 100 billion cells into starters of increasing size, up to typical homebrew batch size. A curve shows how the possible number of doublings and growth becomes limited as the inoculation rate falls.

Reference: Yeast The Practical Guide to Beer Fermentation; Chris White with Jamil Zainasheff pg.142

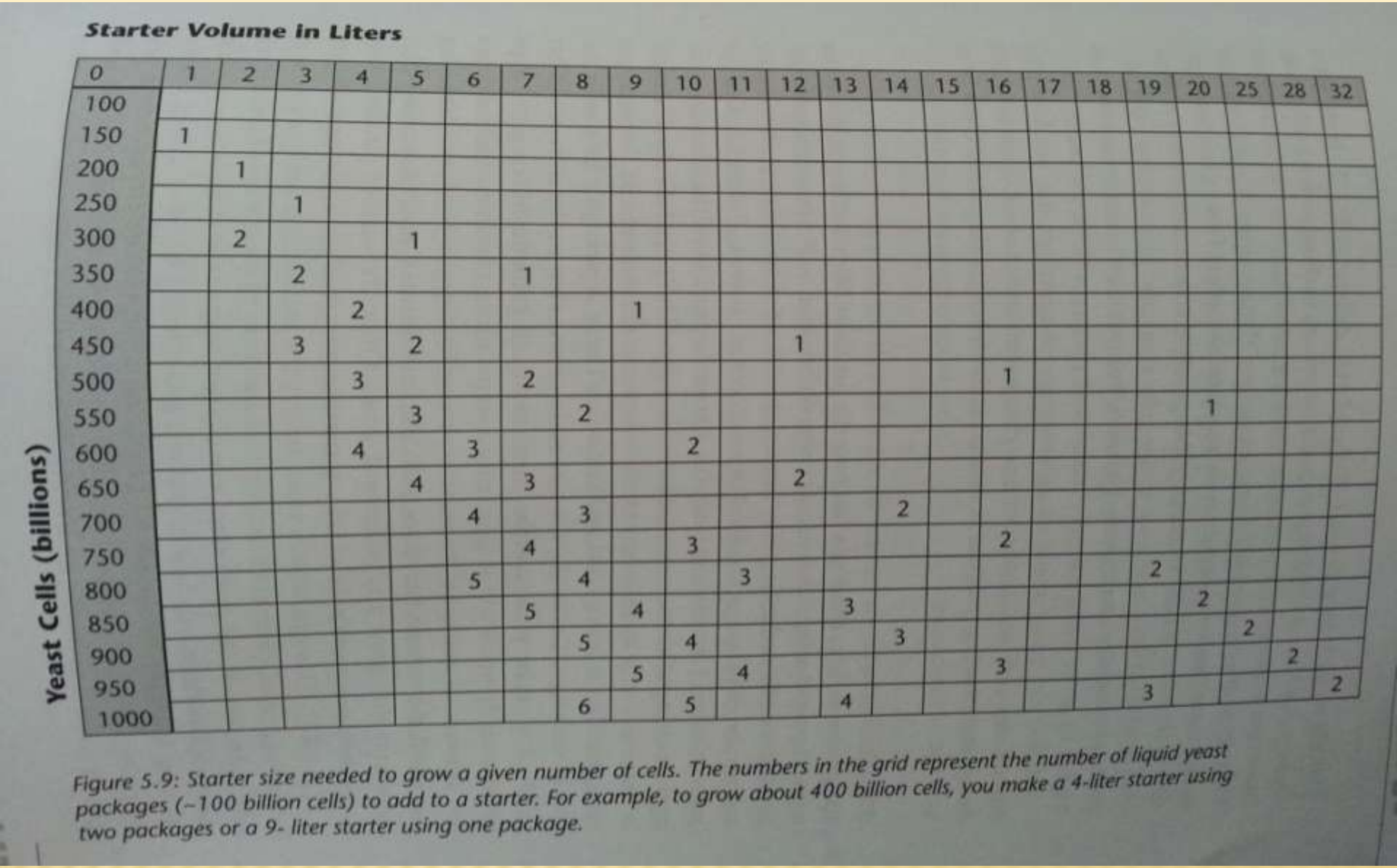


Figure 5.9: Starter size needed to grow a given number of cells. The numbers in the grid represent the number of liquid yeast packages (~100 billion cells) to add to a starter. For example, to grow about 400 billion cells, you make a 4-liter starter using two packages or a 9- liter starter using one package.

Reference: Yeast The Practical Guide to Beer Fermentation; Chris White with Jamil Zainasheff pg.143

If you have pure oxygen handy, you can add a dose of oxygen to your starter at the beginning. You will get much healthier yeast and far more yeast growth if you provide a small, continuous source of oxygen throughout the process.

Oxygen is critical to yeast growth. Yeast use oxygen to synthesize unsaturated fatty acids and sterols, which are critical to creating a healthy cell membrane and good cell growth.

There are several ways to add oxygen:
Intermittent shaking, continuous shaking, a stir plate, pure oxygen, or an air pump with a sterile filter.

A stir plate is the most effective method allowing gas exchange, keeping yeast in suspension, and drives off carbon dioxide. The use of a stir plate increases yeast growth around 2 – 3 times as much yeast as a non-stirred starter !

4 KEY FACTORS IN YEAST HEALTH AND GROWTH

Nutrients

- Most key nutrients are provided in the yeast nutrient including zinc, amino acids, and nitrogen. Don't forget Oxygen as it is critical to the survival and growth of yeast and tends to be the limiting factor for most starters.

Temperature

- Keep your starter between 65 – 75 °F
  Warmer starters (up to 98 °F) equal rapid growth but there are practical limits to how high you can go. High temps negatively affect the viability and vitality, and result in weak cell membranes.

Sugars

- Use all-malt wort for starters. The sugar in the starter needs to be maltose, not just simple sugars.

pH

- pH of the starter needs to be around 5, but no need to worry as the typical wort ranges between 4-6 pH so use a decent quality DME.

LIQUID VS. DRY

DRY YEAST STARTERS

Reference:Dr. Clayton Cone, the Yeast Guru from Lallemand

- Contains 220-230 billion cells in average 11 gr package
- Every strain of yeast has its own optimum rehydration temperature. Most of them range between 95F to 105F, most of them closer to 105F but some are in the 80's. The dried yeast cell wall is fragile and it is the first few minutes (possibly seconds) of rehydration in the warm temperature is critical while it is reconstituting its cell wall structure.
- If you drop the initial temperature of the water from 95 to 85 or 75 or 65F, the yeast leached out more and more of its insides damaging the each cell. The yeast viability also drops proportionally. At 95 -105F, there is 100% recovery of the viable dry yeast. At 60F, there can be as much as 60% dead cells.
- The water should be tap water with the normal amount of hardness present. The hardness is essential for good recovery. 250 -500 ppm hardness is ideal. This means that deionized or distilled water should not be used.
- For the initial few minutes (perhaps seconds) of rehydration, the yeast cell wall cannot differentiate what passes through the wall. Toxic materials like sprays, hops, SO2 and sugars in high levels, that the yeast normally can selectively keep from passing through its cell wall rush right in and seriously damage the cells. The moment that the cell wall is properly reconstituted, the yeast can then regulate what goes in and out of the cell. That is why we hesitate to recommend rehydration in wort or must. Very dilute wort seems to be OK.

DRY YEAST

- We recommend that the rehydrated yeast be added to the wort within 30 minutes. We have built into each cell a large amount of glycogen and trehalose that give the yeast a burst of energy to kick off the growth cycle when it is in the wort. It is quickly used up if the yeast is rehydrated for more than 30 minutes. There is no damage done here if it is not immediately add to the wort. You just do not get the added benefit of that sudden burst of energy. We also recommend that you attemperate the rehydrated yeast to with in 15F of the wort before pitching. Warm yeast into a cold wort will cause many of the yeast to produce petite mutants that will never grow or ferment properly and will cause them to produce H2S. The attemperation can take place over a very brief period by adding, in increments, a small amount of the cooler wort to the rehydrated yeast.
- One very important factor that the distributor and beer maker should keep in mind is that Active Dry Yeast is dormant or inactive and not inert, so keep refrigerated at all times. Active Dry Yeast looses about 20% of its activity in a year when it is stored at 75 F and only 4% when refrigerated.

DRY YEAST-NET TAKEAWAY

- Typical 11gr package 220-230 billion cells
- Try to buy dry yeast that has been kept refrigerated. Active Dry Yeast looses about 20% of its activity in a year when it is stored at 75 F and only 4% when refrigerated
- Do not make a starter with dry yeast
- Rehydrate no more than 30 minutes before pitching
- Rehydrate following manufacturer instructions in warm tap water only, usually 95-105F. Do NOT use wort, deionized or distilled water
- Only pitch when the temperature differentiation between the yeast and wort is less than 15F
- There are many fewer styles of dry yeast as can be found in liquid so your options are limited.

LIQUID YEAST STARTERS

Reference: David Logsdon, Founder/Owner of Wyeast Laboratories, Inc., Greg Doss, Wyeast Laboratories Microbiologist, and Neva Parker, White Labs Inc. Lab Manager

- Vial/package contains about 100 billion cells
- In general, a two liter (2-quart) starter doubles the amount of yeast in a single vial or pack. The minimum starter size for significant yeast growth from a vial or pack of yeast is 1 liter. One vial or pack into 1 liter results in approximately a 50% increase in cell mass
- Mr. Malty states proper pitching rate for 5-gal is 180 billion cells so make a starter or use more yeast if making a bigger beer, not if making small beer like a 4.5% bitter as you might over pitch.
- You should never make a starter if you can't handle the steps in a sanitary way or you can't provide proper nutrition for the yeast
- When making starter wort, keep the starting gravity between 1.030 and 1.040 (7 - 10°P) by adding ½ cup DME to one quart of water or 1 cup to two quarts if you want a larger starter. Add ¼ teaspoon of yeast nutrient, boil 15 minutes Do NOT make a high gravity starter
- Use an Erlenmeyer flask made of borosilicate glass if possible, add DME and water in the flask, drop in any nutrients you desire and put the flask directly on the stove burner. Boil gently for fifteen minutes, and then let it cool, oxygenate, pitch your yeast and cover with foil

LIQUID YEAST STARTERS

- If you have oxygen handy, you should add oxygen to your starter or at the very least shake it every few hours to increase the amount of oxygen available to the yeast
- If you have a stir plate, that works even better. A stir plate provides good gas exchange, keeps the yeast in suspension and drives off CO2, all of which increases yeast growth (around 2 to 3 times as much yeast as a non-stirred starter). Keep the starter around room temperature (72°F, 22°C)
- Four main factors that affect yeast growth and health: nutrients, temperature, sugars, and pH.
  - Key nutrients include oxygen, zinc, amino acids, and nitrogen. Oxygen is one of the things many brewers ignore, yet it is critical to the survival and growth of yeast. You should do what you can to provide oxygen to the yeast, as it tends to be the most limiting factor for most starters
  - Keep starters between 65°F (18°C) and 75°F (24°C). A temperature around the low 70s (72°F, 22°C) strikes the best balance for the propagation of yeasts. My stir plate generates heat so I use nylon spacers under the flask to allow air space
  - Use an all malt wort for starters. The sugar in the starter needs to be maltose, not simple sugar. Yeast that have been eating a lot of simple sugars stop making the enzyme that enable it to break down maltose, which is the main sugar in wort. The yeast quickly learn to be lazy and the ability to fully attenuate a batch of beer suffers
  - The pH of a starter needs to be around 5 pH, but if you can't test it, don't worry. Typical wort ranges between 4 to 6 pH, so use a high quality DME and it will be OK

LIQUID YEAST STARTERS

- Most yeast experts say that when propagating yeast, pitching at high krausen is optimal. The time of high krauesen can range anywhere from a few hours to twenty-four or more. It depends on the amount of yeast added to the starter wort, yeast health, temperature, and several other factors
- Doss says a starter made from an XL pack of yeast into 2 liters of wort will reach its maximum cell density within 12-18 hours. If you're starting with a very small amount of yeast in a large starter, it can take 24 hours or more to reach maximum cell densities. For the average starter, let's just say that the bulk of the yeast growth is done by 12-18 hours

LIQUID YEAST STARTERS-NET TAKEAWAY

- Typical vial or package contains 100 billion cells
- There are MANY more styles of liquid yeast than with dry yeasts
- Only buy liquid yeast that has been kept refrigerated and has not expired
- Sanitation is very important, sanitize the vials/packages or scissors before opening as well as flask
- Do not make a starter in a sealed container, the co2 must be allowed to escape, cover with foil
- Use a stir plate if possible, yeast growth is around 2 to 3 times higher than a non-stirred starter
- Do make a starter for high gravity beers, not necessary for beers with about a 1.048 starting gravity
- Only pitch when the temperature differentiation between the yeast and wort is less than 15F, 5F if pitching the starter at high krauesen

Shelf life of Harvested Yeast

Everyone always asks how long can I store a yeast that I get from a brewery ?? The real answer is that there is no way of knowing the real condition of the yeast and its ability to ferment another beer without testing for viability, cell counts, and purity.

Here are some questions to consider first and then we can give a ball park estimate on how long of a shelf life your yeast has.

What was the condition of the yeast at the time of collection ?

What beer did it ferment previously ?

What Strain is it ?

What are the storage conditions ?

“A homebrewer can take more of a risk, as the loss of a batch of beer does not carry as high a price tag- although the emotional price tag may be high”

Yeast viability and health drop in storage, and the longer it is stored, the lower the viability and health of the pitch.

High levels of isomerized alpha acids negatively affect viability.

Yeast harvested from highly bitter beers will have lower viability

Alcohol also poses a problem for yeast.

Alcohol is toxic to yeast, high levels of alcohol are detrimental to yeast

Time between repitching and storage conditions have the highest priority

Store collected yeast cold in the range of 33-36°F

Ideally reuse collected yeast within one to three days.

“In practice, when starting with reasonably healthy yeast, one week of storage is acceptable for all yeast strains, and many strains are still viable enough for direct repitching after two weeks of proper storage.”

Generally speaking
Clean ale strains and lager strains do the best in storage
Fruity and highly flocculent strains are a little less stable
German weizen strains seem to hold up the worst in storage

After four weeks yeast viability is typically 50% or less

Ideally you do not want to pitch yeast that has dropped below 90% viability.

FERMENTATION

Phases of fermentation

- Lag Phase
- Exponential Growth
- Stationary Phase

LAG PHASE: ZERO – 15 HOURS AFTER PITCHING

After pitching yeast, it begins to acclimate to the enviroment

The cells begin the uptake of oxygen, minerals, and amino acids from the wort and build proteins from the amino acids.

Temperature directly affects yeast growth

You will not see any visible activity during the lag phase, but this phase is very important for building new healthy cells for fermentation.

Overpitching can decrease lag phase, but each individual cell will not be as healthy at the end of fermentation.
Although most brewers find it reassuring to see fermentation activity within one hour, it is not the optimal condition for the yeast.

EXPONENTIAL GROWTH: 4 HOURS – 4 DAYS

As yeast come out of the lag phase, they consume the sugars in solution and produce CO2, among other things.

During this phase the cell count increases rapidly, and the yeast produce ethanol and flavor compounds.

Yeast utilize the simple sugars first glucose, fructose, and then sucrose. While glucose typically makes up 14% of wort sugars, maltose is the centerpiece making up about 59%
Yeast metabolize more complex sugars like maltotiose last
Some strains cannot ferment maltotriose at all and the ability to ferment these complex sugars determine each strain's attenuation range.

The height of yeast activity "High Kraeusen" occurs during this phase

STATIONARY PHASE: 3 – 10 DAYS

At this point, yeast growth slows down, and the yeast enter a stationary phase

Beer matures in the stationary phase

Yeast reabsorb much of the diacetyl and acetaldehyde produced during fermentation

Don’t rush your beer at this point, allow your yeast to clean up after themselves.
Different beers and different yeast have different requirments. It is suggested from a home brew stand point to wait until the yeast shows no more activity, let the fermentor clear naturally, and then package or transfer the beer.

YEAST NUTRITION

Yeast need an adequate supply of sugar, nitrogen, vitamins, phosphorus, and trace metals.

An all-malt wort contains all the nutrients yeast need for fermentation except oxygen and zinc. Adjuncts such as corn, rice, or sugar syrups do not contain many essential nutrients.

There are many products available to provide a balanced source of nutrients.

AERATION ! WHY YOU SHOULD BE USING O2

Yeast are not strictly anaerobic; they need oxygen for reproduction !

Proper oxygen levels during the early stages of wort fermentation are necessary in lipid synthesis for cell wall production.

Without an adequate supply of sterols, yeast cells characteristically display low viability and poor performance in fermentation.

THE NEED FOR OXYGEN

When yeast reproduce, they need to make new lipid membranes for their progeny.

In order to do this they need two types of compounds: Sterols and unsaturated fatty acids.

Sterols keep the structure of lipid cell membranes fluid and regulate permeability
While wort contains sterols, there are not always enough for adequate fermentation, so yeast need to make more!
Sterol syntheses and regulation is complex. Long story short yeast needs oxygen in a series of steps to form its own sterols.

METHODS OF AERATION

Using proper levels of dissolved oxygen is just as important as using proper pitching rates. Lack of oxygen can result in stuck fermentations, long fermentation times, under attenuated beers, yeast stress, and off-flavors are often the result of too little oxygen.

For average wort and yeast pitching rates, the proper amount of oxygen is 8-10ppm

Wort splashing methods implemented by most home brewers result in approximately 2.71ppm and the use of an aquarium pump with sintered stone will not result in more than 5ppm.

The best way to achieve adequate dissolved oxygen levels is with bottled oxygen.

METHODS OF AERATION	OBSERVED O2 PPM
Shaking, 5 minutes	2.741 ppm
30 seconds, pure O2	5.12 ppm
60 seconds, pure O2	9.20 ppm
120 seconds, pure O2	14.08 ppm

Dissolved oxygen levels with various aeration times in 20L of wort. 18.7P wort at 75F. Pure oxygen injection at 1 litter per minute using a 0.5 micron sintered stone. (Reference: Yeast the practicle guide to beer fermentation Chris White and Jamil Zainasheff)

THINKING OUTSIDE OF THE BOX

Home brewers have the ability to experiment and try new things !

Split batches and use different yeast strains

Use two different yeast stains blended together

QUESTIONS ?