IN-CIDER SERIES™: CIDERMAKING 101

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Overview

- Topics For This Session:
  1. *Cidermaking process overview*
  2. *Stages of cidermaking*
     1. Pre-fermentation (make or obtain apple juice)
     2. Fermentation
     3. Finishing Steps
     4. Storage / Aging
     5. Packaging / Serving
  3. *Q&A*

The Basic Process

- Basic Cidermaking Process:
  1. *Grow apples*
  2. *Harvest apples*
  3. *Grind apples*
  4. *Press apples into juice*
  5. ***Ferment juice (naturally or with cultivated yeast)***
  6. *Maturation – barrels, tanks, totes, etc*
  7. *Packaging – bottles, cans, kegs*
  8. *Serving -- bottles, cans, draft*

PRE-FERMENTATION

Make – or obtain – apple juice

Sourcing Apples
...your mileage may vary

- Largely dependent on where you live
  - *Top 10 apple-producing states: WA, NY, MI, PA, CA, VA, NC, OR, OH, ID*
  - *Of 32 apple-producing states, CO is #25 (wah, waaaaaah)*
- Options:
  - *Easy Mode*
    - Farms that press/sell juice
    - Farms that sell apples
    - Juice you buy from a retailer (NO preservatives—they kill your yeast)
  - *Medium Mode*
    - Scavenge apples from those who aren’t using them
  - *Hardcore Mode*
    - Grow your own apples

Units Of Quantity

Noncommercial: Bushel (42 lb box)

Commercial: Bin (825 lb) (4’ x 4’ x 3’ deep)

Apple Math
spoiler alert: you'll need a lot

- Rules of Thumb (all are approximate)
  - *1 bushel = 42 lb apples*
  - *1 bushel = 2-3 gal juice, depending on factors such as*
    - *Press efficiency (basket vs. hydraulic)*
    - *Apple contents (varies by maturity, variety)*
  - *1 bin = 825 lb, or approximately 40-60 gal juice*
- Examples:
  - *5 gal batch = 2-3 bushels of apples (80 - 120 lb)*
  - *30 bbl batch = 15 - 25 bins (6 – 10 tons)*

Apple Contents

- An apple contains:
  - *80% water*
    (varies with irrigation practices and weather conditions)
  - *10% carbohydrate*
    - Sugars (mostly fructose, with some glucose—**100% fermentable**)
    - Fiber/cellulose – removed by pressing
  - *4% vitamins/minerals*
  - *6% of:*
    - Organic acids (primarily malic acid)
    - Pectin – **pectinase highly recommended**
    - Polyphenols – flavonoids and, to a varying degree, tannins
    - **Very small amounts of proteins (added yeast nutrition is often needed!)**

Apples → Juice

Why grind/press?

- Must release the juice for an even fermentation

Pressing differences between apples and grapes

- Apples are fibrous and hard, so they **must be ground up prior to pressing**
- Apples are not typically fermented on the skins/pomace (their tannins aren't concentrated in the skins)
  - *Therefore, no 'red wine' vs 'white wine' process difference*
  - *Can macerate the pomace prior to pressing, however*
- Various grinding / pressing options exist

Press Types

Noncommercial: Basket

Commercial: Hydraulic

Press Types, cont.

Noncommercial: Bladder

Photo credit: turtlevines.com

Commercial: Hydraulic

Grinder Types

Noncommercial: Hand Crank

Commercial: Electric

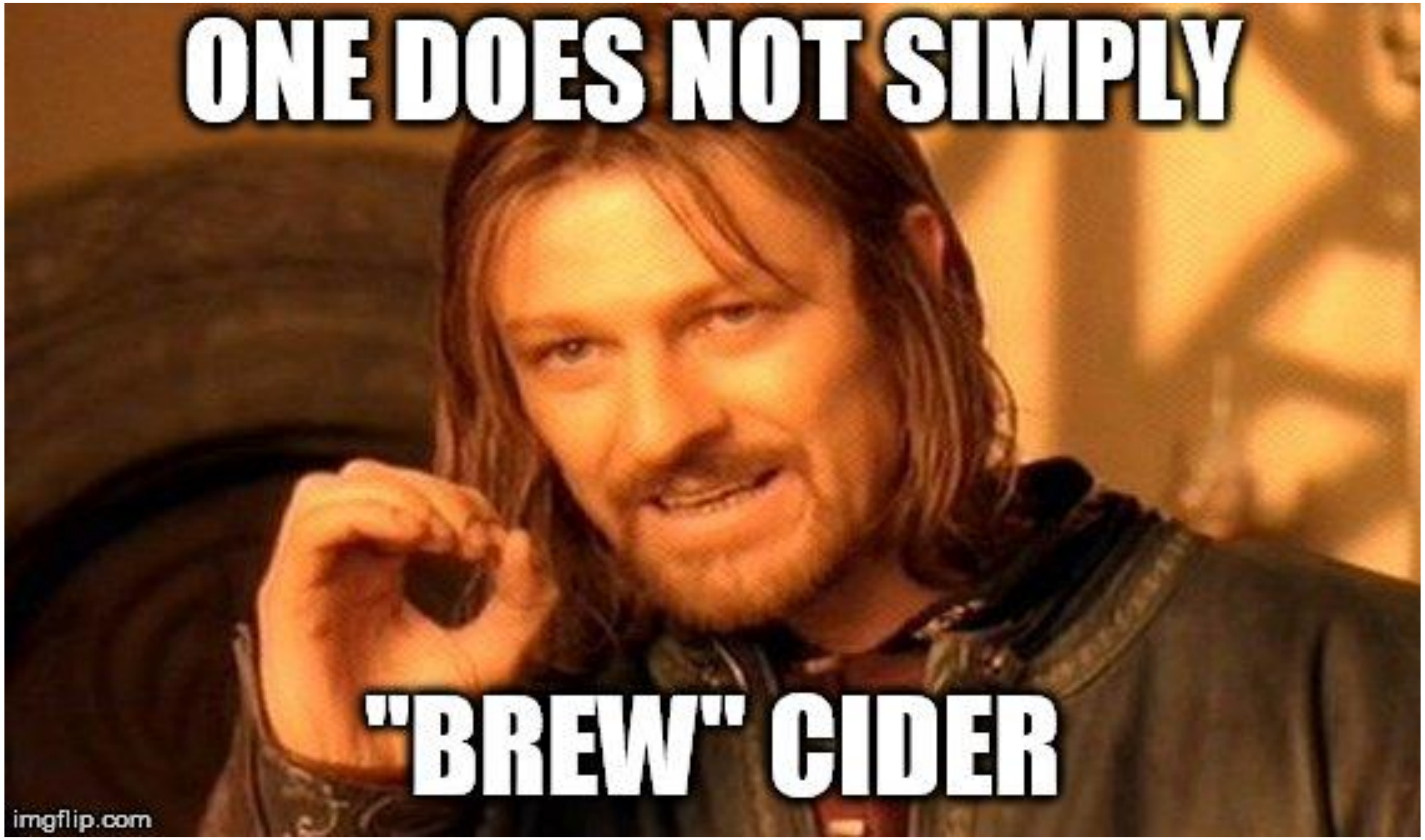
Hydraulic Press In Action

FERMENTATION

It’s simple: Yeast + apple juice = cider.

But…the devil’s in the details.

First Order Of Business: Cidermaking != Brewing



Apple Juice Contents

- Apple Juice contains (approximately):
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    (varies with irrigation practices and weather conditions)
  - *10% carbohydrate*
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  - *6% of:*
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    - Pectin – **pectinase highly recommended**
    - Polyphenols – flavonoids and, to a varying degree, tannins
    - **Very small amounts of proteins (added yeast nutrition is often needed!)**
  - ***Wild yeast and bacteria – <u>will</u> spontaneously ferment without intervention (unless pasteurized)***

Once you have juice, you can…

- Sulfite it (add potassium metabisulfite / campden tablets) and let sit for 24 hours before adding yeast
  - *Allows control of fermentation (characteristics=those of selected yeast)*
- Freeze it (and store up to 2-3 years)
  - *Eventually results in oxidation*
  - *Freezing does not sterilize the juice*
- Pasteurize it (and store up to 1 year)
  - *Sterilizes the juice*
  - *Can add oxidation/caramelization flavors*
- Ferment it
  - *Add cultivated yeast (predictable flavors)*
  - *Allow wild fermentation (complex, less predictable flavors)*

Fermentation Factors

- Yeast strain selection
- Non-yeast and wild yeast organisms
  - *Sulfite / SO2*
- Fermentation temperature
- Sugar content
- Acidity
- Yeast Nutrition
- Oxygen

Yeast Selection

- Most common cultivated yeast choice = **white wine yeast strains**
  - *Why?*
    - Clean, fruit-centric fermentations (yeast contribute few flavors)
    - Sulfite-tolerant
    - Tolerant of lower fermentation temperatures than most red or beer strains
    - Acidity-tolerant
  - *Examples*
    - 71B (Narbonne)
    - D47 (Cote Du Rhone)
    - DV10 (champagne)
    - QA23 (Vinhos Verdes)
- But…other yeast categories (beer, in particular) can be used

Non-yeast and wild yeast organisms

- What organisms are in my juice before I add cultivated yeast?
  - *Examples of wild yeasts*
    - Wild saccharomyces cerevisiae
    - Brettanomyces ("funky", earthy flavors)
    - Apiculate yeasts (low alcohol tolerance (around 2%), high flavor complexity)
  - *Examples of Bacteria*
    - Lactobacillus (malo-lactic fermentation)
    - Acetobacter (acetic acid / vinegar production)
- Where do they come from?
  - *Basically, everywhere*
    - In the air, on the skins of apples, on your pressing equipment

Non-yeast and wild yeast organisms, cont.

- Sulfite / SO2
  - *Is a preservative*
  - *Is an antioxidant*
  - *Is antimicrobial in low pH conditions*
    - Moreso to bacteria than to yeast (particularly cultivated)
  - *Is used extensively in the wine and cider world to suppress microbial growth*
  - *Is a respiratory irritant*
  - *Can present problems for people with asthma*
  - *Is not allergenic (allergic reaction = immune response to a protein; sulfite is typically delivered as an inorganic salt, potassium metabisulfite ($K_2S_2O_5$))*
  - *Is different from sulfide (H2S, or 'rotten egg' taint)*

Non-yeast and wild yeast, cont.

- Management options
  - *Do nothing, allow nature to take its course*
    - The ‘natural winemaking’ approach
    - Manage conditions to favor selected organisms
  - *Add sulfite (SO_2)*
    - Wild yeast and bacteria are much less tolerant of SO_2 than cultivated yeasts (wine yeasts in particular)
    - pH-dependent (more acid = takes less sulfite)
  - *Pasteurize the juice*
    - If done right, kills all microorganisms
  - *Stop the clock (freeze the juice)*
    - Yeast can survive freezing and wake up during thawing, so sulfiting pre-freezing is advisable

Temperature

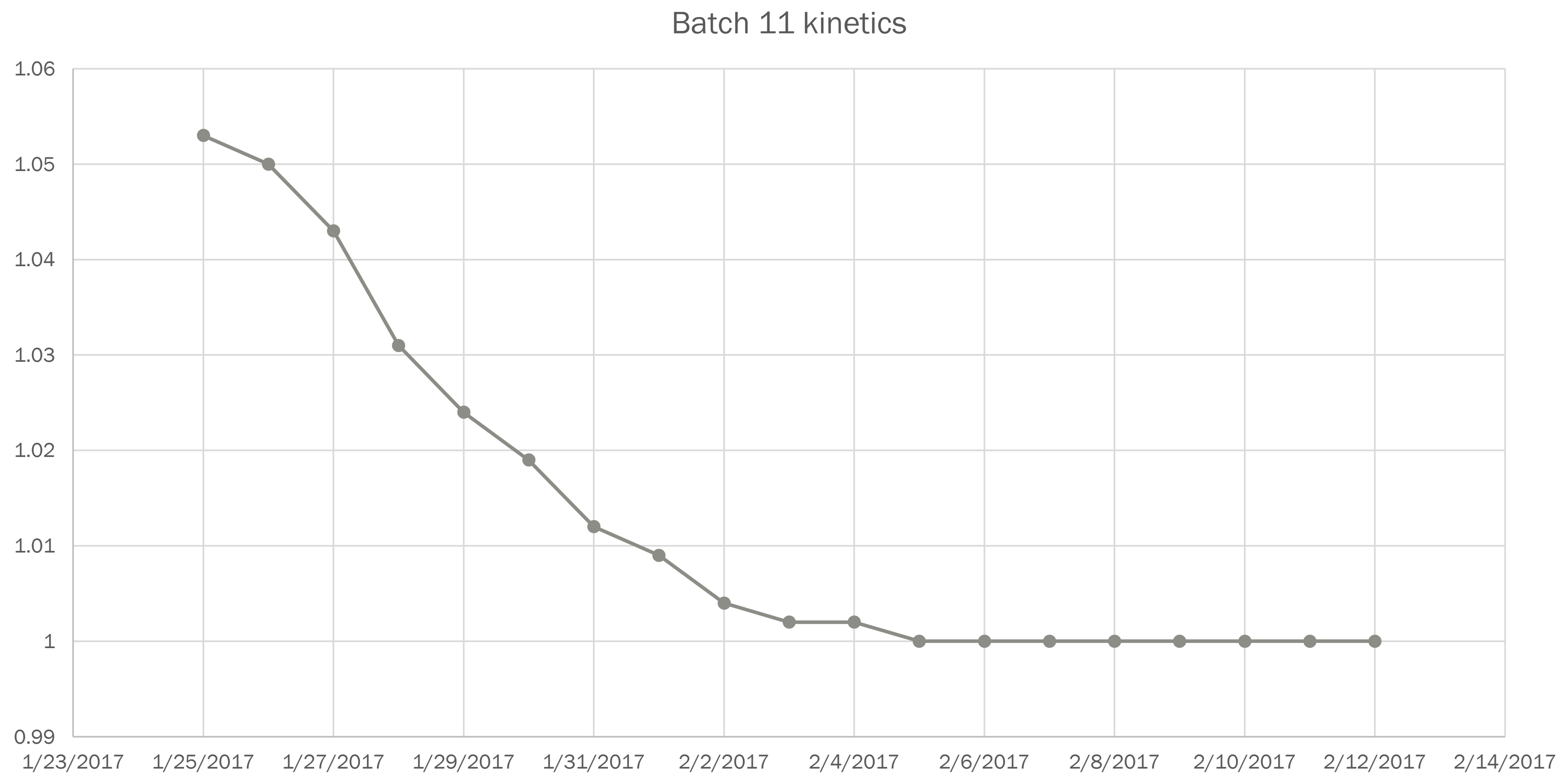
- In general, the colder the fermentation:
  - *The slower the fermentation*
  - *The fewer yeast-derived flavors*
  - *Less loss of aromatic character*
- Fermentation temperature is yeast strain-dependent
  - *Review the data sheets for your selected yeast—should contain an optimal temperature range*
  - *Generally:*
    - White and sparkling wine yeasts = lower optimal temp range
    - Red wine yeasts and beer yeasts (lager excepted) = higher optimal temp range

Sugar Content

- Determines ABV (most apple juice in the 5-9% ABV range, but can be higher with late-season or ‘sweated’ apples)
- Measured by density (specific gravity, SG)
  - *Concept: dissolved sugar increases density of a fluid relative to water*
  - *Tool: hydrometer*
  - *When to measure: before fermentation (OG), throughout, to confirm completion (FG)*
- Measurement by refraction effect of the juice
  - *Concept: light bends differently in juice depending on dissolved sugar content*
  - *Tool: refractometer (units: brix (% sugar) and/or SG)*
  - *When to measure: before fermentation only (OG) (alcohol in solution invalidates the test)*

Manage the factors = The yeast will rock!!

Fermentation Kinetics Example (SG)



Acidity

- Concept 3: Acid content of apples
  - *In the apple: predominantly malic acid*
    - Unless you add acid blends, other fruit, or experience malolactic fermentation or acetification (vinegar production)
- Concept 2: pH
  - *pH is a measure of acidic activity (not acid content) within a given liquid*
  - *Varies by temperature and other factors*
  - *Determines effectiveness of a given concentration of SO2*
    - Lower pH = less SO2 needed
    - Higher pH = more SO2 needed (don't bother at 3.8 or higher, as SO2 is ineffective at that level)
- Concept 3: Total Acidity (TA)
  - *In cider, often expressed as g/mL or g/L as malic acid*

Acidity, cont.

- Measurement
  - *pH:*
    - Electrode or pH paper (pH strips). Electrode is much more accurate
  - *TA:*
    - Titration – reagent plus visual indicator or pH test. Incrementally add base until your sample neutralizes
- Why test?
  - *Influences flavor (tartness)*
  - *Influences fermentation kinetics*
    - very low pH=stressful for yeast
    - wild swings in pH=stressful for yeast
      - *common in mead, fairly rare in cider, given buffering capacity of juice*
  - *Determines SO2 effectiveness*

Acidity, cont.

- Acidity and Sulfite requirements
- From cider.org.uk:

Sulphite Addition Table

pH	*Approx TA (% malic)*	For total yeast kill (when adding cultured yeast)		For partial yeast kill (for wild yeast fermentation)	
		SO_2 (ppm)	Campden tablets per gallon	SO_2 (ppm)	Campden tablets per gallon
3.0 – 3.3	*1.2 – 0.8*	50	1	nil	nil
3.3 – 3.5	*0.8 – 0.6*	100	2	50	1
3.5 – 3.8	*0.6 – 0.3*	150	3	100	2
> 3.8	*< 0.3*	add more acid!	add more acid!	150	3

Yeast Nutrition

- Problem: Yeast need nitrogen to reproduce and build cell walls, but apple juice is often low in nitrogen
  - *Specifically, Yeast Assumable Nitrogen (YAN)*
- Solutions:
  - *Use yeasts (e.g., QA23) with low nitrogen requirements, and/or:*
  - *Add a yeast nutrient*
    - Inorganic: Diammonium Phosphate (DAP)
    - Organic: Fermaid O (yeast hulls, etc)
- How much to add?
  - *Minimum recommendations vs. juice YAN content*
    - Add at least the minimum regardless of juice content
    - Measure juice YAN content and incorporate into additions

Yeast Nutrition, cont.

- YAN levels recommended by the 2016 Scott Labs Cider Handbook:

YEAST PROTECTION AND NUTRITION — RECOMMENDED ADDITION RATES

	Step 1 Yeast Rehydration*	**Step 2** Fermentation Nutrition	
Juice/Must YAN		Start of Alcoholic Fermentation	⅓ AF Completion
>200 mg/L	Go-Ferm 30 g/hL (2.5 lb/1000 gal)*	Fermaid O 10–20 g/hL (0.8-1.7 lb/1000 gal)	Fermaid O 10–20 g/hL (0.8–1.7 lb/1000 gal) or Fermaid K 25 g/hL (2 lb/1000gal)
125-200 mg/L	Go-Ferm 30 g/hL (2.5 lb/1000 gal)*	Fermaid O 10–20 g/hL (0.8-1.7 lb/1000 gal)	Fermaid A 10–30 g/hL (0.8–2.5 lb/1000 gal) or Fermaid K 10–25 g/hL (0.8–2 lb/1000 gal)
<125 mg/L	Go-Ferm Protect Evolution 30 g/hL (2.5 lb/1000 gal)*	Fermaid A 10–30 g/hL (0.8–2.5 lb/1000 gal) or Fermaid K 10–25 g/hL (0.8–2 lb/1000 gal)	Fermaid A 10–30 g/hL (0.8–2.5 lb/1000 gal)** or Fermaid K 10–25 g/hL (0.8–2 lb/1000 gal)**

Note: Knowing the initial YAN in the must/juice is only one piece of the puzzle. Other factors are critical as well. Do not forget to consider the balance and availability of nitrogen, micronutrients and microprotectors, relative nitrogen needs of the selected yeast strain, SO_2, temperature, fruit condition, oxygen, and the variety of other factors which can impact yeast health and a successful fermentation.

* *Quantity may change based on yeast dose.*

** *DAP may be required to further adjust the YAN*

Oxygen

- Yeast need oxygen during growth phase (aka, ‘lag phase’) while cells are reproducing
- Less necessary later on when they go anaerobic
- Approaches to adding it
  - *Oxygen stone -- force oxygen or air into the must*
  - *Small scale: vigorous stirring prior to pitching yeast*

INTERMISSION

Hint: The bar is open!

FINISHING STEPS

Completion of yeast fermentation,
then what comes after(or not)

2ndary fermentations

The yeast go dormant. Then, something else wakes up (or is added).

- Malolactic
  - *Mechanism: lactic acid bacteria consume malic acid and transform it into softer, lactic acid*
    - Raises pH (lactic is a weaker acid than malic)
    - Does NOT require any sugar
  - *Spontaneous (e.g., with unsulfited, unpasteurized juice)*
  - *Inoculated*
    - Pitch an O. Oeni culture
- 'souring' – adding cider to a barrel with a bacterial or Brettanomyces culture

2ndary fermentations, cont.

- Acetobacter / Vinegar
  - *Spread by the common fruit fly*
  - *Requires Oxygen in order to produce*
  - *Produces Acetic acid (can be pleasant at low levels (e.g., Spanish cider styles), but intense at higher levels*
  - *Produces Acetaldehyde (nail polish remover taint– difficult to deal with)*
  - *Prevention:*
    - Keep airlocks on all storage vessels (make sure they don’t dehydrate)
    - Sulfite
    - Minimize O2 exposure
    - Store cold

Clarification

- Issue: My cider is super hazy!
- Solutions:
  - *Racking – transfer the cider off the lees/sediment, possibly several times*
  - *Enzymes – primarily pectinase, which helps break down pectin*
  - *Fining agents*
    - negatively charged (bentonite) to remove proteins (positive charge at low pH)
    - Positively charged (sparkalloid) to remove negatively-charged particles
  - *Time – cider will settle/clarify over time*
  - *Coarse Filtration – filter with plate/frame, lenticular/cartridge*
    - Depth media (pads, cartridges)
      - *Small scale homebrew options are available*
    - 1 micron – 50ish microns

Stabilization:

Preventing Re-fermentation

- Potassium Sorbate
  - *Prevents yeast from reproducing*
  - *Does NOT stop an active fermentation (existing yeast unaffected)*
- Sterile filtration – using a fine filter to filter out all yeast and bacteria (<.45 micron)
  - *Used to stabilize a back-sweetened (or cold-crashed) cider and prevent refermentation*
  - *Option: canister w/membrane media (polysulfone membrane with tiny pores) -- $1k canister plus $250k cartridge*
  - *Option: automated crossflow filter for large volumes. Truly a commercial scale option only. $100k+*

STORAGE/AGING

Ensuring stability while (optionally) adding character

Storage Considerations

- Microbial stability
  - *Factors: temperature, sulfite, pH, sugar content, pasteurization*
- Oxidation
  - *Factors: airspace /headspace in container*
    - Keep vessels as full as possible
    - Top up with CO2, Nitrogen, Argon if possible
  - *container material*
    - (steel>plastic>wood where preventing oxygenation is concerned)
- Common options
  - *Brite tank, kegs, topped-up fermenters, barrels*

PACKAGING/SERVING

From storage to your face

Packaging

- Kegs
  - *Fill from brite tank*
  - *Fill from fermenter and slowly carb with head pressure (homebrew method)*
- Bottles
  - *Fill from kegs or brite tank with bottle filler*
  - *Fill from fermenter or uncarbonated kegs and bottle-condition (champagne-method)*
  - *Fill from fermenter or uncarbonated keg and leave uncarbonated*
- Cans
  - *Fill from brite tank via canning machine*
  - *Fill from tap to crowler machine*
- Growlers

Serving

- Draft
  - *Served carbonated/cold*
- Bottles
  - *Generally served cold/carbonated*
  - *Still / uncarbonated (very wine-like)*
    - Generally served chilled or cellar temp
- Cans
  - *Generally carbonated*
  - *Generally served cold*
- Bag in Box
  - *Uncarbonated / chilled or cellar temp*

UPCOMING SESSIONS

Tangents In Apple Geekery

Future Session Ideas

- Cider Apples
  - *At St. Vrain Cidery, 8/14, 6:30-7:30 pm)*
- Cidermaking 101
  - *At Brewmented, 9/8, 1pm-3pm*
- Other ideas? Let me know: dan@stvraincidery.com

REFERENCES & RESOURCES

Down The Rabbit Hole…

Book Recommendations

(from www.cidersage.com/books ; these are Dan's affiliate links)

- *The New Cider-Maker's Handbook: A Comprehensive Guide for Craft Producers*, by Claude Jolicoeur. Claude is an engineer and includes do-it-yourself projects as well as cider-making process. Also an active contributor to The Cider Workshop. Amazon link.
- *Craft Cider Making* by Andrew Lea. A very scientifically-minded cider-making guide by Andrew Lea, a food biochemist who has encyclopedic knowledge of apples and cider, and who offers significant amounts of cider information on his website, cider.org.uk, as well as actively participating in The Cider Workshop (a Google Group), where you'll find him responding to numerous questions. Amazon link.
- *Cider, Hard and Sweet: History, Traditions, and Making Your Own*, by Ben Watson. Ben Watson is a food writer and a key figure in the Slow Food movement. An extensive review can be found here on Ciderguide. Amazon link.

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- *Apples to Cider: How to Make Cider at Home*, by April White. The cidermaking aspects of this book are similar to those you can find in the others, but the unique aspect is that the author spent time at Farnum Hill Cider and includes insights from the folks at Farnum Hill–as well as some good photographs–alongside the basic cidermaking information. Amazon link.

Other Recommendations

- Websites
  - *cider.org.uk – Andrew Lea's cider site, with excellent references to managing sulfite and acidity*
  - *Scott Labs Cider Handbook – yeast, YAN, fining agents, and more*
  - *Cidersage -- general cider info with a CO focus -- event coverage, cider reviews, cider and mead miscellany.*
  - *Ciderschool -- how-to content (cidermaking/orcharding) and cidery startup topics*
  - *This slide deck – email me at dan@stvraincidery.com for a copy*

Q & A(pple)

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