Making Hard Cider

A Guide for Small-Scale Producers

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Introduction

This document guides the reader through the process of analyzing apple juice and fermenting hard cider on a small scale. It is intended for the serious hobbyist or small-scale commercial producer of hard cider. The reader is not expected to have scientific background or brewing experience. This procedure assumes that you already have juiced the apples and blended the juices. There are three primary sections to this document: juice analysis, preparing for fermentation, and fermentation.

Juice Analysis

Measuring specific gravity with a hydrometer

The specific gravity of a liquid is the ratio of its density to the density of water. Water's specific gravity is 1.000 and adding sugar raises the specific gravity. The hydrometer, a device used to measure specific gravity, is a weighted bulb connected to a glass stem which floats in the liquid. The percentage alcohol by volume (ABV), an important property of alcoholic beverages, is proportional to the difference in specific gravity before and after fermentation. State and federal regulations require labels which accurately list the ABV. Specific gravity measures the sugar content and potential ABV. An ABV over 6% inhibits spoilage organisms.

Materials

- Cleaning supplies & bleach solution
- Wine thief
- Graduated cylinder (250 mL)
- Hydrometer
- Sugar

Caution: the hydrometer is made of glass and is extremely fragile so it must be handled with care.

1. Clean and sanitize the hydrometer and the graduated cylinder using a bleach solution.
2. Allow the hydrometer and the graduated cylinder to air dry.
3. Transfer approximately 150 mL of juice into a 250 mL graduated cylinder using a wine thief, a turkey baster-like device for sampling beverages in progress.
4. Hold the hydrometer by its top and slowly lower it into the test cylinder.
5. Slowly spin the hydrometer shortly before letting go of it. This keeps bubbles from clinging to the hydrometer. Bubbles elevate the hydrometer and increase the measured alcohol content. If bubbles are a problem, transfer liquid back and forth between the graduated cylinder and another sanitized container until the bubbles dissipate.
6. Take the specific gravity reading by measuring the line on the hydrometer which intersects the meniscus, the bottom of the liquid's concave surface.

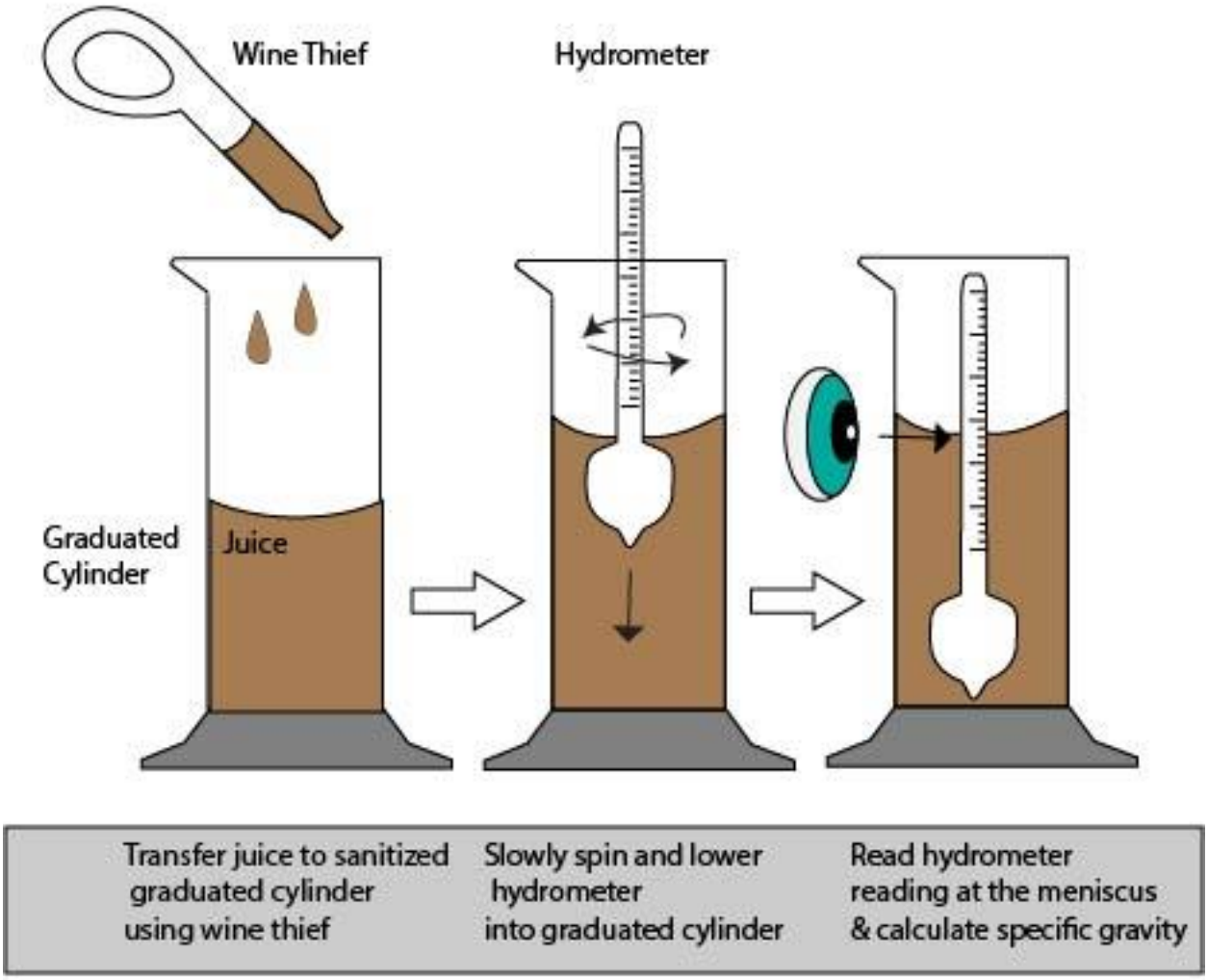

Figure 1: Using the hydrometer

Calculating the percent alcohol by volume (ABV)

To determine the percent alcohol by volume (ABV), one must measure the specific gravity before fermentation (SG) and the specific gravity after fermentation or final gravity (FG). Calculate the percent alcohol by volume using this formula: *ABV= (SG-FG)*1000/7.5*. Because the final gravity of fully fermented cider is approximately 1.000, a modified formula can be used to estimate the potential alcohol content: *ABV= (SG-1.000) *1000/7.5.*

Note: Juice with a specific gravity of 1.050 will ferment to 6.5% alcohol. To find target specific gravity, use this formula: *SG= 1+ (ABV* 7.5/ 1000)*

Achieving desired alcohol content

More than 6.0% alcohol by volume (ABV) is desirable to prevent spoilage, optimize taste, and meet industry standards. Adding sugar increases the cider's alcohol content. Sugar added at this stage will fully ferment so it will not sweeten the cider. For most apples, fermentation with no added sugar produces cider with an alcohol content of 4.0 to 5.0%, which is too low. Usually, adding at least a pound of sugar per five gallons is necessary.

Adding sugar

1. Add sugar to reach your desired alcohol content. 1 lb. of sugar per 5 gallons raises the ABV by approximately 1% and the specific gravity reading by approximately 0.0075.
2. After adding sugar, measure the specific gravity again with the hydrometer.

Potential hydrogen (pH)

The acidity of cider is critical to both its flavor and its resistance to micro-organisms. There are two common ways to measure acidity—titratable acidity and potential hydrogen (pH). Potential hydrogen is the inverse logarithm of a solution's free hydrogen ion (H^+) concentration. This means that a cider with pH 3.0 is ten times as acidic as a cider with pH 4.0. An acceptable pH range is 3.3 to 3.7.

- Measure pH using a pH meter or litmus paper. To use litmus paper, dip a paper test strip into a sample of solution and compare it to the color chart. To use a pH meter, follow the directions included with the meter. Here is a link to a recommended meter.

Titratable acidity

The other main measurement of acidity is titratable acidity. To determine the quantity of acid in solution, acids can be titrated, or neutralized with a base in a precise and measurable manner. Titratable acidity measures both free hydrogen ions and hydrogen ions bound to weak acids to estimate the total acidity of the cider. A cider with double the titratable acidity as another should taste twice as sour. An acceptable range of titratable acidity is 4 to 8 grams per liter and is measured using acid titration.

Materials

- 250 mL Erlenmeyer Flask
- 5 mL volumetric pipette
- 25 mL burette and burette stand
- Syringe
- Safety Bulb
- 0.20 M sodium hydroxide (NaOH)
- Phenolphthalein indicator solution
- Stirrer Bar
- Distilled Water
- Juice Sample
- Small stir stick
- 10 mL syringe

Caution: Sodium hydroxide (NaOH) is highly caustic and contact between it and the skin or eyes can cause irritation, burns, and even blindness. Consequently, wearing gloves and eye protection is necessary when handling NaOH.

1. Dilute the juice sample. Add 6.7 mL juice and 93.3 mL water to 250 mL flask using a 10 mL syringe.
2. Add 4 drops of phenolphthalein indicator solution to the juice sample.
3. Swirl the juice solution until the juice and water are well-blended.
4. Fill a titration burette with a metering valve using 0.1M NaOH solution and record its initial volume.
5. Place the flask under the burette's metering valve.
6. Slowly dispense 0.1 M NaOH into the juice sample while swirling the flask continuously. When the juice sample stays consistently pink for 30 seconds, the titration is complete.
7. Record how the final volume of NaOH.
8. Calculate the difference between the initial and final volumes of NaOH and record it.
9. Calculate the titratable acidity using the following formula:
   *TA (% malic acid) = mL of NaOH used * 10* 0.067/ (volume of sample) =0.1*mL of NaOH used*
   TA in g malic acid/L= 10 (%malic acid) = mL of NaOH used*

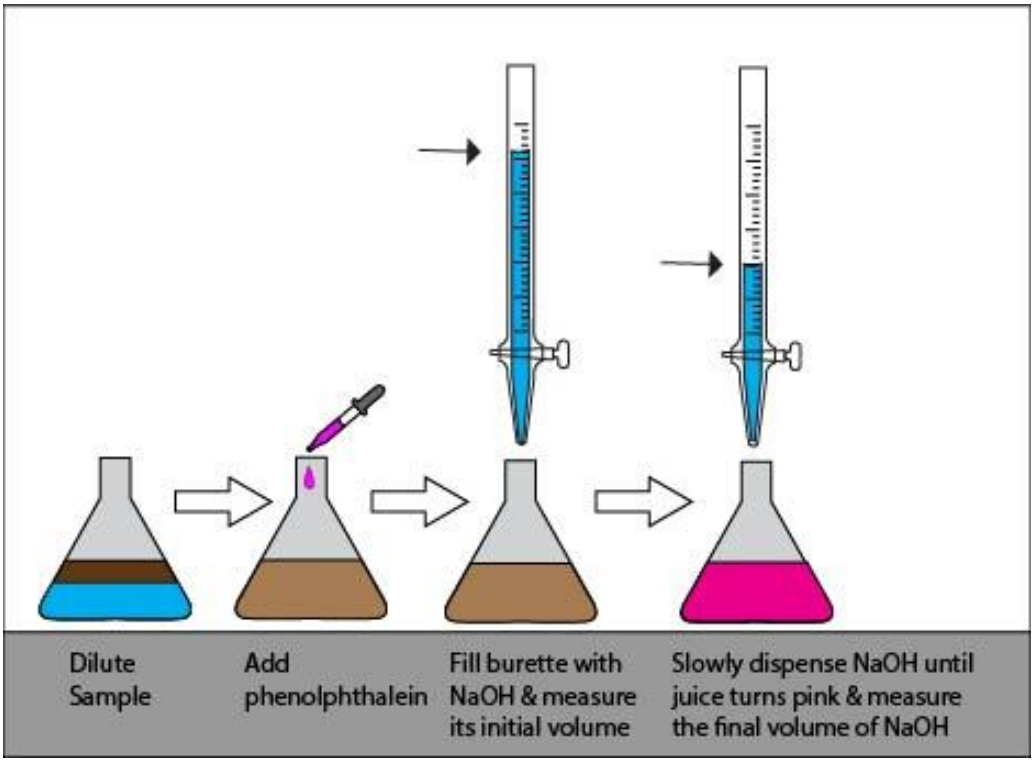

Figure 2: Steps of acid titration

Adjusting the cider's acidity

Adjust the acidity if the titratable acidity and pH readings are outside of the desirable range. Two methods for adjusting acidity include blending different varieties of apple juices and using food-grade chemicals, as described below.

Note: Different apple varieties have varying levels of acidity and sweetness. Apple varieties can be classified as bittersharp, bittersweet, sharp, and sweet. Sweet apples are low acidity and high sugar. Sharp apples have high acidity and low sugar. Bitter apples contain considerable quantity of tannins, which produce tart, lip-puckering flavors.

Materials:

- Wine thief
- Laboratory scale (precision ± 0.01 g)
- Calcium carbonate powder
- Malic acid power
- 250 mL graduated cylinder

1. Use a wine thief to transfer 200 mL of cider into a 250 mL graduated cylinder.
2. Weigh out 0.200 g of calcium carbonate or malic acid and add it to the cider sample.
3. Measure pH of the cider sample using pH meter.
4. When the pH is within the target range (3.2 to 3.8), perform acid titration again. Adding 0.2 g of malic acid to the 200 mL sample should raise the titratable acid by 1 g/L.
5. Repeat steps 2 to 4 until the pH and titratable acidity are both within the target range.
6. Multiply the grams of calcium carbonate or malic acid used by 95.
7. Add the resulting quantity to the 5 gallon batch.

Preparing for fermentation

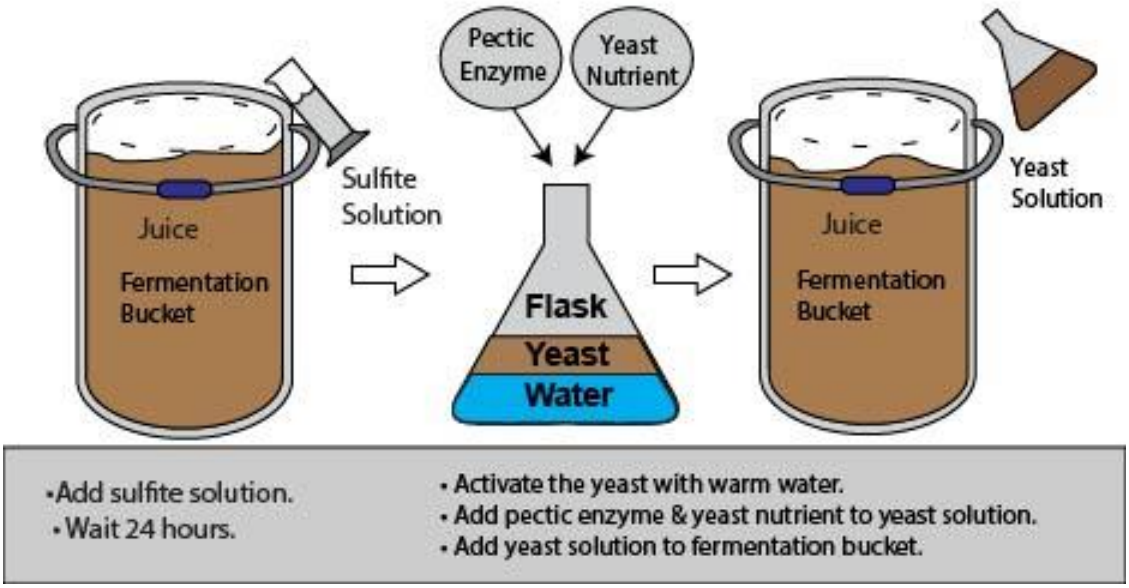

Figure 4: Preparing for fermentation

Sanitizing the cider with sulfites

Sulfites, specifically sulfur dioxide, are used to kill off the spoilage organisms: yeasts, bacteria, and fungi which naturally occur on the apple surface, allowing the cultured yeast to thrive.

Materials:

- Graduated cylinder
- Water
- 1/16 tsp. measuring spoon
- Stir stick

1. Put 100 mL of water into a graduated cylinder.
2. Measure out the potassium metabisulfite to achieve the desired concentration of SO_2 in table 1. Use a 1/16 of tsp measuring spoon to measure the sulfite and stir the solution with a stir stick. 1/16 tsp. creates imparts about 75 ppm of SO2 to a one gallon batch of cider.
3. Add the sulfite solution to the fermentation bucket.
4. Next, wait 24 hours for the sulfites to take effect.

pH	Approximate Titratable Acidity (% malic acid)	SO_2 (ppm)
3.0 – 3.3	1.2 – 0.8	50
3.3 – 3.5	0.8 – 0.6	100
3.5 – 3.8	0.6 – 0.3	150
> 3.8	< 0.3	Add more acid!

Table 1: pH, titratable acidity, and desired sulfur dioxide levels. Adapted from Craft Cider Making (Lea, 2013))

Pitching the yeast

Three types of yeast are common to cider making: ale, white wine, and cider. They vary in the time they take to use up sugar, the temperature they are active at, and the taste they impart on the cider, among other factors. Various types of yeast may be used, including white wine yeast, champagne yeast, cider yeast, and ale yeast.

Materials:

- Measuring containers: 1 cup, 1 tsp, 0.25 tsp
- Warm water
- Red Star Premier Blanc Active Dry Yeast
- Pectic enzyme
- Yeast nutrient

1. Activate the yeast by dissolving it in a cup of warm water and waiting 15 minutes.
2. Add 2.5 tsp. of pectic enzyme per 5 gallons to the yeast mixture (to clear the haze in the finished cider).
3. Add 1.25 tsp of yeast nutrient per gallon to the yeast mixture (to help the yeast complete the fermentation).
4. Pour the yeast solution it to the fermentation bucket.

Fermentation

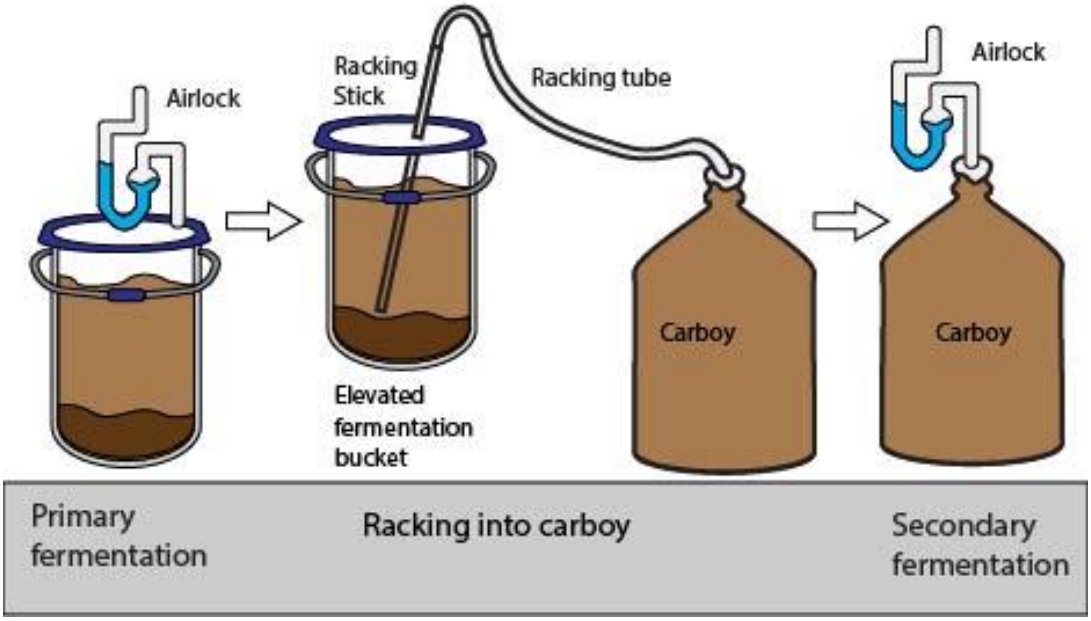

Figure 5: Fermentation process

Primary fermentation

Fermentation is when the yeast eats sugar and produces alcohol. During the fermentation process, the cider will bubble to signal that fermentation is occurring. However, during a lag period of 12 to 24 hours at the start of fermentation, the yeast is rapidly growing but not bubbling yet. When it becomes saturated with carbon dioxide, the cider will begin to bubble.

1. Cover the fermenter bucket with the lid, attach the airlock, and fill the airlock halfway with water.
2. Let the cider ferment for 7 to 10 days at 70 degrees F.
3. Every few days, top off the airlocks to keep the system airtight and check the specific gravity reading with the hydrometer. When the specific gravity drops to around 1.000, the fermentation is complete.

Racking

After the yeast consumes the available sugar, it forms sediment at the bottom of the fermenter, called the lees. The yeast can autolyze, or break down, which taints the cider's flavor. Racking is transferring the cider to a new container, while leaving this yeast behind. Avoiding aeration is critical, because it leads to the growth of acetobacter, bacteria which turn cider into vinegar. Using a racking cane and racking tube, siphon the cider from the fermenting bucket into the carboy leaving the yeast behind.

1. Elevate the fermentation bucket relative to the carboy
2. Fill the siphon tube completely with water and cap one end of it with your finger
3. Lower uncapped end into the fermentation bucket slightly above the yeast
4. Position capped end over another container
5. Release finger allowing the water to flow into container
6. Once siphon is filled with cider, cap the end again and aim it towards the carboy
7. Release finger from end of tube and allow cider to flow into carboy
8. Do this until the fermentation bucket contains no liquid on top of the yeast residue
9. If the carboy isn't full, top it up with pre-boiled water to eliminate air space.

Secondary fermentation

Attach the airlock and stopper to the carboy. Add additional yeast. Let the cider sit for at least 2 more weeks. Cider can be stored in the carboy for 2 to 6 months at a temperature between 34 degrees F and 60 degrees F. This maturation process leads to natural changes in the cider which enhance its flavor such as the polymerization of polyphenols. During this process, cider will clarify because particulates present will settle out. To let the cider mature successfully, prevent aeration and oxidation, monitor sulfite content over time, and store the cider until it is clear.

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Appendix 1: Full Process Diagram