THE ART AND SCIENCE OF

FRUIT DISTILLATE FERMENTATION

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PART 3

The final installment of this three-part series focusing on the fermentation of Eau De Vie (EDV) fruit brandy covers tooling and instruments, procedures, automation, and recaps lessons learned.

WHEN IS THE MASH READY FOR DISTILLATION?

During the fermentation process, yeast feasts on sugars in the fruit mash and converts them to alcohol. This process will take weeks and will depend on the type of fruit used, as well as other conditions such as temperature and yeast strain. Eventually, the yeast will run out of fermentable sugars and die off, ending the fermentation process.

During fermentation it is important to measure the sugar content of the mash to understand the activity levels inside the fermentation tank. The measure of sugar content, coupled with the pH and mash temperature, is an indicator of the overall health of the mash. pH levels can be measured with simple strips that indicate the acidity or basicity of the mash by color, or with more accurate digital readers.

The best way to track the sugar concentration levels in the mash is with a ***refractometer***, a laboratory device used to measure gravity during fermentation to determine the amount of fermentable sugars in the mash. This is the same tool that was introduced in Part 1 of this series to identify the sugar levels in fruit during selection and sourcing. When the refractometer measurements are the same for at least three straight days, this indicates that yeast cannot convert any more sugars into alcohol. There are several causes for this condition:

- Yeast molecules are stressed out by the synthesized alcohol and carbon dioxide
- Primary carbon-source is depleted from the mash
- pH has dropped to a critical level
- Lack of calcium, magnesium, or ammonium salts in the mash

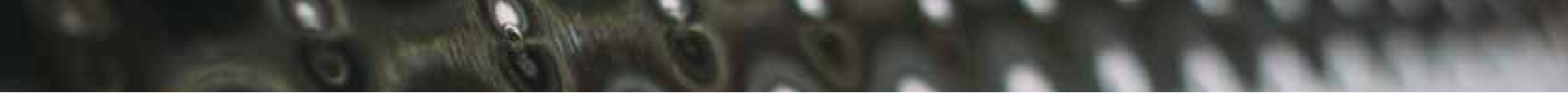
The causes above are another reminder about the importance of selecting the right yeast strain for your mash. Fermentation is a complex process, where some yeast is able to adapt to the new environment and stay alive for a long period of time, while other yeast cannot tolerate the stress and may die quickly before completing their job. There are also yeast strains that can utilize more carbon sources than others, thus producing more alcohol. At the end of the day, finding the right yeast strain is a critical step in fermentation and has a major impact on the final results of distillation.

INSTRUMENTS AND TOOLS

The last important measurement of the fruit mash is the volatile acidity. Fruit mashes, when compared to whiskey mashes, have higher acidity levels because fruit naturally contains higher acid levels than grains. The measurement of the volatile acids in the mash is important, because higher than normal levels could ruin the mash. Volatile acids are synthesized during fermentation, however if bacteria or oxygen are present in the mash the acid levels will rise, and as a result acetic acid and other volatile acids are developed. These acids will introduce bad flavors and reduce the alcohol content of the mash.

This measurement of volatile acids is necessary when you can detect vinegar-like, or nail polish remover-like aromas in the mash. The measurement process is a little more complex and requires basic chemistry knowledge. The steps are as follows:

- Measure a 20 ml mash sample
- Add 3 ml of 30% tartaric acid, or, as the alternative, a ***spoon tip*** of crystal tartaric acid



- Use a ***steam distillation unit*** to distill the mixture until you yield a sufficient quantity of final product (you can also add some water at the end of distillation if it is needed)
- Transfer the product into a glass flask and add 2 drops of phenolphthalein indicator solution
- Using a ***burette***, add 0.2 N (Normal Concentration) sodium-hydroxide drop-by-drop until the mixture gets a pinkish (fuchsia) color

After the liquid changes color in the flask, determine the quantity of sodium hydroxide used, and calculate the volatile acid content using the following formula:

$$C_{Volatile\ acid} = V_{NaOH}*f*0.3$$

Where:

$C_{Volatile\ acid}$ — is the volatile acid content

V_{NaOH} — is the volume of the used sodium hydroxide solution

f — is the factor number of the sodium hydroxide solution

It is always a good practice to capture the daily fermentation conditions and yields in the log and compare them to the past results.

Additionally, measuring acid, sugar, and alcohol quality and quantity can be performed through hyphenated analytical methods, such as HPLC (High Performance Liquid Chromatography) or GC (Gas Chromatography). This equipment can be expensive and they require some special technical and analytical knowledge to use them, but they give very precise information about the chemical compounds in your mash and spirit.

STORING THE MASH SHORT TERM

While it is not ideal, there will be times when the fully fermented fruit mash, with fine aroma and high alcohol content, cannot be distilled right away and you will have to store the mash for a period of time. The longer the mash sits, the more prone it is to spoilage. To reduce the risk of spoiled mash, several methods can be deployed depending on the storage period.

If the fermented mash needs to be stored for a short period of time (a few days), make sure that the mash is contained in the fermentation tank and does not get exposed to oxygen. Also, lower the temperature of the fermentation tank below the yeast's lower optimum temperature. You can check yeast's optimum temperature (this information is usually listed on the yeast package), but when in doubt, keep the mash between 10 and 14 degrees Celsius.

If the mash needs be stored between one and two weeks, then the following precautions should be made:

- Make sure that there is little headspace (10%) in the fermentation tank above the mash—this is generally challenging to accommodate after fermentation has finished and transferring into a smaller fermentation tank may present challenges and introduction of additional bacteria that may affect the mash
- Floating solids should be submerged into the liquid mash to prevent bacterial and mold infections
- Check the pH level and lower the pH to 3.6
- Cool the mash below 14 degrees Celsius

In cases where mash must be stored for more than three weeks, then the mash must be kept in the tank where it is filled at 100% capacity with no floating solids on the surface of the mash. Before sealing the tank from oxygen, confirm that the pH levels of the mash are below pH 2.8 by adding phosphoric acid or sulfuric acid to the mash. Finally, adding yeast nutrients to the mash can extend yeast's lifetime and, at minimum, prevent yeast from decomposing in the mash. After all of these steps are completed, maintain the mash in the cold environment until distilling, which should be as soon as possible.

FERMENTATION AUTOMATION

Fermentation requires a lot of attention and daily monitoring. Depending on the size and scale of the operation and other duties of the distiller, maintaining a healthy fermentation can be a laborious tank. While fermentation cooling can be managed manually with appropriate engineering, it can also be automated with the right sensors, electronics, hardware, and software. Fermentation automation does come with a cost and is not always required for a distillery, but can provide operational efficiencies if implemented. Here are some options to consider when planning your fermentation process:

- **TEMPERATURE CONTROLS & MIXING**: With fermentation automation the distiller has complete control of the mash by regulating the temperatures (both cooling and heating if needed) and mash agitation cycles. To achieve this, the fermentation tanks should be integrated to the chiller and heating vessel (if a heating option is needed) and managed through software. The software is able to regulate the flow of the cooling or heating solution, such as glycol, to the fermentation tanks if the mash temperature is cooling or heating above a set threshold. This is ideal for non-temperature-controlled operations where weather may fluctuate with the seasons. Additionally, this allows for 24/7 control of the mash without having to come in late at night to run the cooling manually. Controlling the temperature of the mash allows the distiller to reduce the risk of a poor fermentation and allows for more consistency from batch to batch.
- **INLINE REFRACTOMETER**: Automation also allows for a periodic measurement of sugar content of the mash with minimal manual interaction. This is more challenging to set up, but can be achieved using a built-in refractometer in the fermentation tanks. The sample measurement schedule can be programmed to capture sugar samples based on your needs—for example, at the beginning of fermentation and

then every eight hours. In this scenario, when the same sugar content measurement is captured 12 times, that is the sign that the fermentation has completed.

- **GAS FORMATION, INJECTION & MONITORING**: Oxygen inside the fermentation tanks can negatively affect the alcohol formation in your mash. You can get rid of the oxygen by introducing inert gas into the tank, like CO_2 or N_2. During fermentation, carbon dioxide will naturally form in the mash. Having a monitoring system in place to measure the amounts (and headspace) of gases inside the tank is very helpful when there is a need to store the mash after the fermentation for a period of time. Further, the monitoring of carbon dioxide can be used as a safety mechanism to identify any leaks.
- **pH MEASUREMENT**: This can be achieved by programming the pH level measurement cycle for the fermentation period to allow the system to control the valves of the acid and base tank, and by turning on the agitator.

Although automation will support some of the activities during the fermentation cycle, it can never replace the trained professional's eye and nose. Your nose will tell you more about the potential issues during the fermentation than the instruments. Making a decision and checking on the mash should always be performed by professionals.

MEASURING THE ABV

At the end of fermentation, the distiller needs to be able to measure the alcohol content of the mash to plan his distillation strategy. Measuring the alcohol content of the fruit mash can be easily performed with a ***small glass distillation*** unit, or any small scale distillation unit that can hold up to 500 ml of mash. To run a simple distillation the volumes will vary on the size of your system, and we will use the following as examples:

- Start with 100 ml of mash, which will yield 20-30 ml of distilled product
- Fill the evaporating flask and run the distillation at a gentle heat—try to avoid burning the glass as it will make it very difficult to clean after distillation
- Turn on the condenser as the mash begins to form vapor and collect in a receiving flask
- Since we are measuring the alcohol concentration in this process, we do not need to make the traditional heads, hearts, and tails cuts
- Run the distillation until the mash is exhausted of all alcohol, extracting as much distilled spirit as possible

With the alcohol collected from the simple distillation, the

distiller can use a ***density meter*** or a digital ***alcoholmeter*** to measure the alcohol content of the mash. Knowing the ABV of the mash allows the distiller to plan for the yield that can be expected from the distillation and the quantities of heads, hearts, and tails based on the quality of the fermentation.

FERMENTATION LESSONS LEARNED

Fermentation of Eau De Vie (EDV) is a fun, scientific, and complex process that can be both rewarding and frustrating. Keep the following guiding principles in mind when you ferment your next batch of EDV:

- Fruit quality is critical—always pick the most aromatic, ripe, and sugar-rich fruit
- Yeast strain selection is important and is the second most important contributor to aroma formation after the fruit
- Cleanliness and sanitation is as important as fruit quality — otherwise you risk infecting your meticulously selected fruit
- Grinding is a must—always choose the right grinder depending on the fruit type—a finer grind will result in a better fermentation and a better final product
- Temperature control is important in fruit brandy production to provide an optimal environment for the yeast
- By adding specific acids you can gain control of the microbiota of the mash
- Track the fermentation, because stuck fermentations can produce a poor quality spirit with a low yield
- If mash intervention is required then react immediately
- Try to distill the mash once the fermentation has finished, avoiding extended storage when possible
- When you have no other choice but to store the mash, store it in a cold place, keep oxygen away from the mash and lower the pH to prevent mold development.

With an exceptional distillation that focuses on proper heads, hearts and tails cuts, the distiller can create a beautifully balanced, aromatic, flavorful, and smooth EDV, but we can cover that another day.

Ferment on!

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