A Compendium of Mead Knowledge

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Contents

1 Introduction

This is meant to consolidate knowledge of a more advanced nature. Thus this is more for those already somewhat versed in fermentation and mead. There will be some information that seems elementary, and some that is obtuse.

This is a work in progress and will likely never be completely finished. There may even be information in here that isn't entirely correct. As such references will be used whenever found and updates done with more information. Disputed sections will be marked and updated with knowledge as acquired. You are welcome to contribute. You can do this by submitting issues, asking questions, or adding content.

One of the best things you can do to make great mead is to use the best ingredients – the best honey, the best fruits, and the best spices. Skimping on one or more of your ingredients often results in meads less than the best you can do. Even the best process can't elevate poor ingredients to greatness, however we wish it might.

2 Fermentation

This is perhaps the most important aspect of mead making. You can have the best ingredients, but if you don't have a healthy fermentation, your honey, and other ingedients, won't shine. This section is ordered in approximate order of the magnitude of impact. The farther you read and apply, the better your meads will go. The earlier topics have more "bang for your buck" and are usually quite easy to implement.

Nutrient addition and yeast pitching rates are quite easy to implement. Temperature control can be done quite low-tech (with manual effort) or high-tech with automation. Oxygen stones aren't incredibly cheap but they do have a fair bit of benefit. The usage of pH meters, while relatively expensive, can give you quite a bit of useful information on the current status of your mead.

2.1 Yeast

There is a vast variety of high quality yeasts available to the average meadmaker. Highlighed below are a few of the favorite more easily available ones. In general, the best results from a given yeast are usually obtained when fermenting in the lower third of the yeast's fermentation temperature range.

D-47: A classic yeast for white wines which is often used to great effect in traditionals. Be careful of letting it get to warm (above 70°F) as it throws off fusels and harsh alcohols. It can Sur Lie for quite some time, adding floral characteristics.

DV10: A champagne isolate of a bayanus strain that produces minimal esters and phenols. Also tends to not blow off more delicate honey aromas. Ferments to 18% regularly. Good for dry meads and high alcohol sweet meads. It is a low nutrient yeast, but tends to produce sulfur unless front-loaded with nutrients (50/25/25 schedule or 75/25 seems to work well).

71B-1122: Narbonne yeast that can metabolize some malic acid. This is good in that it can reduce the overall acidity, resulting in a more palatable mead with less aging if used with malic acid fruits, useful for young meads (low alcohol) or those with a fruit containing a large percentage of malic acid. Some report that using low malic acid fruits with this yeast produce a higher apparent acidity.

K1V-1116: A generic fruit wine yeast. Good results have been reported in high temperature fermentation environments such as in excess of 75°F.

Uvaferm 43: A bayanus yeast strain that has an alcohol tolerance of 18%+. It is commonly used for high alcohol wines and tends not to blow off delicate aromas. Also commonly used with dessert wines and stuck fermentations.

2.2 Yeast Nutrients

Nutrients are used to make up for the lack of proper nutrients in the must, to aid in fermentation speed, or to overcome a stuck fermentation. They are typically added in relatively small amounts throughout the fermentation process. Because of the small amount needed, adding too much can be done easily, so care should be taken when calculating and adding nutrients to the must.

GO-FERM: Used in rehydrating yeast. 1.25g of GO-FERM per gram of yeast with 17g grams of water. Mix GO-FERM and water together and add yeast at re-hydration temperature (typically 104-109F).

DAP: Also known as Di-ammonium phosphate, chemical name $(NH_4)_2HPO_4$ is a source of inorganic nitrogen, which provides YAN (Yeast Available Nitrogen) for nitrogen deficient musts (such as honey). 1g/L provides 210ppm of YAN. 1g/Gallon provides 50ppm of YAN. Do not add past 2/3 sugar break. The yeast cannot consume the nutrient at this stage and it will likely result in Urea type aromas and flavors in the finished mead. Do not add to hydrating yeast as DAP is somewhat toxic to re-hydrating yeast.

Fermaid K: Provides micro-nutrients and YAN for yeast health. Pyridoxine and Patothenate are two of these micro-nutrients. 1g/Gallon provides 25ppm of YAN.

Yeast Hulls: also called Yeast Ghosts, are dried yeast cells. Used to aid in unsticking of a stuck fermentation or to combat H_2S formation at the end of a fermentation (usually past 2/3 sugar break).

2.3 Yeast Feeding

The process of yeast nutrient additions is relatively simple at the core. Yeast need nutrients and honey does not have enough, therefore small amounts of nutrients need to be added in order to keep the fermentation healthy. The Nanaiomo Winemakers have additional detail on nutrient addition for fermentation[1].

It is a very good idea to mix powders in liquids that you plan on putting into a fermenting liquid. Adding a powder to a fermenting liquid will introduce nucleation points which will in turn produce lots of foam. Mixing the powder into a liquid allows one to gently stir the mixtur into the must without huge amounts of foam.

2.3.1 Guidelines

There isn't a set amount of nutrients to add, although there are guidelines. One of the easier (and common) to use nutrient combinations is Fermaid K and DAP at a ratio of 70% Fermaid K and 30% DAP[7]. Ratio is based on weight.

2.3.2 Calculating YAN

2.4 Yeast Pitching Rate

Yeast need to be pitched at the proper rate in order to have a high enough cell count to ferment cleanly. There are numerous calculator online, although most are focused on beer. Generally, one 8g packet of yeast is enough to properly ferment a 5 gallon batch of an under 1.120 O.G. mead. If over 1.120 O.G. pitching two packets is recommended.

Sometimes a starter is necessary. The ideal starter for wine yeast is generally 1.070. Using a stir plate is generally a good idea since it oxygenates and stirs, which keeps the yeast in solution and pushes off CO_2.

2.5 Stirring

Something as simple as stirring during fermentation can be one of the most important steps in producing an amazing mead. Stirring drives off CO_2 which is a toxin to yeast. It mixes together the yeast and the must, bring the yeast back into suspension, thus making it more readily able to consume the sugars. It also allows a slight mixing in of oxygen which is necessary for yeast growth. Mixing makes it easy to add your nutrients. Having a touch-point with your mead often makes it easy to check for H_2S or other issues.

Stirring tends to make fermentations faster and healthier.

There is a higher risk of infection with frequent stirrings. However, if you are careful with sanitation and keep your fermentation area clean, the risk is minimal. The rewards of a proper stirring schedule far outweigh the risks of infection.

2.5.1 Stirring Schedule

The easiest schedule to follow for a traditional mead is every 12 hours until 50% sugar break or 2/3 sugar break. Stirring much past that tends to introduce oxygen at a stage that can be harmful to the mead. Oxygen at a late stage can begin oxidation of your mead. You also want to let the yeast drop at some point so that you can more easily rack.

2.5.2 Stirring Schedule with Fruit

2.5.3 Tricks and Tips for Stirring

Get a drill attached stirring device.

When beginning to stir, start slowly so as not to be overwhelmed by foam.

Put a Star-San soaked rag around the top of the carboy or under the drill to help prevent infection or particles from the drill dropping into your mead.

2.6 H_2S and Mercaptans

One of the simplest indicators of yeast stress is the production of H_2S. H_2S smells of rotten eggs or sulfur. Yeast stress indicates that there is something off in the fermentation dynamics. The most common reason for H_2S is low nutrients. Other causes are temperature (either too low or too high for the yeast) and pH (too low or too high).

2.6.1 Eliminating Before 2/3 Sugar Break

The closer you get to the 2/3 sugar break mark the more careful you have to be adding inorganic nitrogen (DAP). It may be safer to consider this section as good before 1/2 sugar break, and sometimes helpful between 1/2 sugar break and 2/3 sugar break.

The easiest thing to add here is DAP. If you've added no DAP or Fermaid K you should add a 70/30 mix of Fermaid K and DAP. Add an amount to increase YAN by 50ppm, stir and the H_2S should lessen in under 5 minutes. If it doesn't, then add another 50ppm and stir again. It is unlikely that adding YAN at a total dosage higher than 450ppm will be helpful to the yeast. It is most likely to add off flavors to the final mead as the yeast will either be unable to metabolize it, or metabolize it too quickly resulting in fusels. Notable exceptions where high YAN rate can be helpful are high gravity and high sugar musts. If, at this point, it is still smelling of H_2S then the issue is likely not because of lack of nutrients, but rather from a low pH, low/high temperature, insuffcent O_2, or insufficient yeast pitching rate. It should be noted that it is often quite easy to test for pH or temperature before adding nutrients.

2.6.2 Eliminating After 2/3 Sugar Break

If you smell H_2S after 2/3 sugar break you should not use DAP or fermaid K to remidy the situation. Both of those contain inorganic nitrogen (DAP) that the yeast can't metabolize very well at that point of the fermentation. The best thing to add is Yeast Hulls at 0.2g to 0.9g per Gallon. Start with 0.2g/Gallon, and then, if after stirring and waiting 5 minutes the H_2S smell doesn't go away, add additional Yeast Hulls in 0.2g/Gallon increments (stirring and waiting inbetween additions).

2.6.3 Eliminating After Fermentation is Complete

If all else fails, and there's still H_2S in your mead after the fermentation is done you still have a chance of fixing the mead. It is more difficult and must be caught and fixed quickly. The earlier you catch the H_2S and deal with it, the less mercaptans you'll have in your mead.

Grapestompers[5] recommends sulfiting and doing what is often called "Splash Racking." This is a technique to aerate the sulfited mead to blow off the H_2S. If that's not sufficient to remove the H_2S it is recommended to rack the mead over copper.

The British Columbia Amatuer Winemakers Association[6] recommends aerating and racking the wine through a one inch PVC pipe with copper pot scrubbers inside, mentioning that the surface area is critical. They also do not recommend waiting, but doing the aeration and copper treatment as soon as possible as H_2S is converting to sulfides and then disulfides within 2 days of the beginning of H_2S production.

You will also likely want to fine and/or filter your mead after using copper as some report a decrease in shelf life of beverages treated with Copper[CITATION WANTED]. Fining can also reduce the 'dull' flavor sometimes introduced by adding Copper.

2.7 Temperature control

This is a very important part of a proper fermentation. In general you want to keep the temperature to the bottom 1/3 of the temperature range of the chosen yeast. This tends to produce the cleanest flavor profile with the least amount of fusels and other off flavors. Increasing the temperature tends to speed up the fermantation. It can also help kickstart struggling fermentations. If the temperature is too low fermentation will slow, or even completely stop.

2.8 Oxygenation

2.9 Must pH

[This section on pH is a work in progress and may contain wrong information]

Important in maintaining a healthy fermentation. Keeping the pH between 3.7 and 4.6 for initial fermentation is key.

2.9.1 H_2S or Sluggish Fermentation

If you're finding that your mead is producing a large amount of H_2S and that temperature, and/or Yeast Hull or nutrient additions are not eliminating it, chances are your pH is off. You will need to measure your pH to see if that is the cause. If you can measure your pH and it is below 3.5 then you'll want to add some $CaCO_3$ (Calcium Carbonate) at [DOSING RATE] until you've reached a pH of 3.7. If your pH is too high, above 4.8, you can add some acid blend to adjust below 4.6. There are issues with using too much acid blend or $CaCO_3$.

If your temperatures are outside the recommended yeast temperature range, slowly adjust the temperatures up or down with a water bath with ice to cool or warm water and/or a heating device such as a fermwrap or brewbelt. You'll want to slowly adjust the temperature, going fast will likely shock the yeast which could stop fermentation. Generally, changing the temperature of the must/mead faster than [RATE] can make the yeast drop out and end fermentation.

2.10 Step Feeding

2.10.1 Classical Step Feeding

2.10.2 Bottom Dwelling Continuous Diffusion Yeast Feeding (BDC DYF)

3 Honey

4 Spices

4.1 While Aging

4.2 Tinctures

4.2.1 Alcohol Tinctures

4.2.2 Water Tinctures

5 Oak

Oak is a complex and enjoyable addition to mead. It can add complexity as well as structure. However it can easily be overdone. Aging with oak is a bit of an art and is about balancing the flavors of oak and mead. It is also possible to drastically change the flavor of a mead simply by aging it in a barrel that was previously used for spirits or another type of beverage. Rum, Bourbon, and Whisk(e)y are quite common and can easily overwhelm your mead if not careful.

5.1 Types of Oak

There are quite a few different types of oak, each giving its own characteristic flavor and aroma. In general the denser the oak variety the longer it takes to impart its characteristics.

5.2 Barrels

Barrels are the traditional way of aging with oak. The size and type of barrel makes a significant impact on aging. Bigger barrels take more time, and smaller barrels less. This is approximately linear with respect to surface area per volume. Of course a 100 gallon barrel has less surface area per gallon than a 10 Gallon barrel. You can take the surface area of the cylinder and divide by the volume to get a comparison number. Treating the barrel as a cylinder is probably good enough for the approximation. This number basically allows you to compare the approximate speed of aging. That is, if 100 days was a good number for the amount of oak characteristics you wanted from that 53 gallon barrel, you'll need considerably less time in a 15 Gallon barrel. Maybe as little as one sixth of the time. The higher the ratio of surface area to volume the more often one should taste the barrel.

For tasting, it is worth noting that having a way to get a taste without opening the barrel is ideal. This can be accomplished with a 316 stainless steel nailed drilled into the end about 1/4 to 1/2 of the way from the bottom of the barrel. Most folks recommend a 1.5 inch 4D stainless steel nail (McMaster-Carr #97990A102 seems to be common).

5.2.1 Downsides of Barrels

It is worth mentioning that there are a few downsides to barrels. They can leak, be an inconsistent size, get moldy, get infected, oxidize, can be awkward to move, and annoying to keep when empty. All of these can be dealt with to some degree or other, be it prevention or mitigation.

Leaking can be dealt with by making sure the rings are tight and the barrels are full. A half full barrel has a higher likelihood of leaking as the upper half is drying out and shrinking. An empty barrel will most certainly dry out after a period of time. Doing a cold water soak, until it stops leaking through, then a hot water soak will help. Never leaving a barrel empty is the easiest way to deal with this. A full barrel is a happy barrel.

Since many barrels are hand made products using natural materials, the amount of variance can be large. Most barrels are +/- 10%, but some Hungarian barrels may have a variance as large as +/- 20%. Because of this variance, it is important to have enough mead on hand to fill a 20% bigger barrel than you expect. Also, don't be that surprised if your barrel is smaller than expected.

Since barrels are a wet and dark environment, mold is a possibility. The issue becomes more likely in humid environments as you may get mold outside the barrel, making it more likely to contaminate the inside. It is important to keep your barrels full and, if possible, purged of oxygen. That means opening the barrel as seldom as possible is advantageous. If mold character develops in high levels the batch is unlikely to be salvageable. You should stop using the barrel at this point. However, if you must continue using the barrel you can open the barrel and scrape the mold away. This is a time consuming process involving cooperage tools and a bit of practice.

Another issue with barrels is that they can become infected. That is, organisms other than saccharomyces may be living in the barrel in significant enough numbers to impact flavor. Common ones are brettanomyces, lactobacillus and pediococcus. These are the common 'bugs' in sour beers. If over 10% ABV the only likely one is brettanomyces. Flavors of these organisms range from earthy, to sour, to 'butterscotch', to 'barn-yard', and more. That isn't to say that none of these bugs make good beverages, just that you need to watch out for them. Once any of these infect your barrel, that barrel is 'sour' forever. These organisms burrow deep into the oak, so removing them is nigh impossible. Either live with them, or retire that barrel. If you've used any plastic with that barrel you should probably throw it away, or keep for sour barrels only. Stainless you can sterilize by boiling or pasteurizing in an oven. A long bleach/water soak for glass works good as well. Just remember that bleach does bad things to stainless. If you have access to peracetic acid (a.k.a. peroxyacetic acid or PAA) then this is also an excellent sterilizer for brettanomyces. An important thing to mention is that brettanomyces only needs a handful of cells to change the flavor of a batch. It is quite happy fermenting anaerobically. So, once 'infected' either retire the barrel, or experiment with the fun, being careful to not infect anything else unintentionally.

5.3 Barrel Alternatives

There are many barrel alternatives. The big positive of barrel alternatives is you can use them in glass or stainless, and don't need to worry about many of the downsides of barrels. However, the alternatives are not perfect. Barrels are made of all edge grain, where some of the barrel alternatives are contain a significant portion of edge grain. Edge grain extracts much faster and can have a higher tannin flavor. If you are looking for something as close to a barrel as possible then you will want to get an alternative with a high a percentage of edge grain as possible.

WHen using barrel alternatives you will want to sanitize the oak. The most common ways are by boiling or soaking in spirits. Boiling pulls out some tannins, which can be useful to reduce the impact of end grain from cubes. Soaking in spirits for a while imparts a bit of the spirit flavor into the wood. Once soaked for a while you can simply throw the oak into your fermenter. Some add the spirits as well, although that can be a little over the top depending on volume.

5.4 When to Use Oak

5.5 Aging with Oak

Aging with oak is rather straightforward after deciding that your mead needs some oak. Your goal is to get the appropriate balance and blending of oak and mead. For some styles, such as traditional, the oak should be supporting and not overpowering. If the flavor is particularly strong or dominant than it isn't a traditional mead anymore. Some styles, such as high alcohol sweet meads can take a significantly larger amount of oak compared to low alcohol dry meads. So the amount of oak aging can change drastically based on the type of mead you are doing.

Another thing to take into consideration is that not everyone appreciates oak in the same amount. It may be worth doing a taste testing with others to get a feel for where you land on oak preferences. And as taste changes over time, it is probably worth doing more than once.

Be sure to taste every so often. Once the amount of oak you want is achieved you may think it is time to rack and bottle and you've captured that flavor. However that is not entirely the case. First, Over time you will notice that the oak characteristics will fade. Second, you may notice that significant sediment can drop out in the bottle. This is often more true with barrel aging. Dealing with the first is a bit of an art, the second is just patience.

To combat the oak flavor fading you can simply aim for a slightly over oaked flavor when racking off of oak. It isn't a large amount of time that this takes, often it is only 1-10% more time. Then rack it away from the oak. This is of course not very precise. Another method is to go to your threshold for oaking, then rack at this point. Over time the flavor will change and soften.

6 Fruit

7 Water Chemistry

In general clean good tasting water is best. Low chlorine and low/no chloramines. High gravity musts do require a certain amount of Zinc and Magnesium for yeast health, but in general those are provided by products like Fermaid-K and GO-FERM.

7.1 More Research Needed

Unfortunately there is not a lot a information on the impact of various salts on the mead. Especially in regard To fermentation dynamics and final taste characteristics. Some speculate that applying similar knowledge from beer making may have a similar impact. For example perhaps a small amounts of sodium may increase sweetness or a higher ratio of chlorides to sulfates may increase body.

In conclusion it seems that water chemistry is an understudied area of mead making.

8 Fermentation Vessels

8.1 Carboys

8.2 Kegs

8.3 Connicals

8.4 Buckets

9 Sanitation

10 Clarifying

Many, especially at the homebrew scale, advocate longterm aging for most clarification. However, there are times when other means of clarification are wanted. In general filtering requires more equipment and can be gentler on the mead, while fining requires no special equipment and can strip more flavors.

10.1 Filtering

10.2 Fining

11 Aging

This is the process of letting the mead mellow, integrate, and mature. In most cases you want to combine both bulk aging and bottle aging to get the best result. You can bulk age in oak or not. Oak imparts additional characteristics such as structure and complexity[8]. A rule of thumb is when the mead doesn't seem to be changing much in bulk, it is time to consider bottling.

11.1 Bulk Aging

The process of letting finished mead sit in large containers. Primary benefits include[8]: clarification; slower temperature swings due to volume; more gradual esterifcation, phenolic evolution, oxydation, oak character extraction (if used or stored in oak); ease of management to measure, test, and store.

Long term aging in carboys requires checking airlocks regularly or risking the entire batch due to oxidation or infection. It easier to get vented stoppers (commonly silicone) for both barrels and carboys instead. These stoppers, while more expensive than bungs with stoppers, do not have the maintenance of airlocks.

11.2 Bottle Aging

Generally aging for 3 months in bottles is good minimum.

12 Recipes

12.1 General Process

Mix your honey with some warm water (in order to make the honey easier to work with). Gradually add cool water until you've reached your volume. Make sure the honey and water is completely mixed. At this point take a gravity reading. If you're shooting for a gravity add honey or water if you're gravity is low or high respectively. Keep in mind that the sugar in honey varies from year to year and hive to hive.

At this point you should create your 109°F water for rehydrating your yeast. You will also want to use GO-FERM when hydrating. Mix the water and GO-FERM, then add the yeast and let sit for 15-20 minutes. You will want to cover the yeast with sanitized tinfoil or something to prevent contamination.

Calculate your needed Fermaid-K and DAP additions. For 250ppm YAN (good for use with D47 where it'll go to 14% potential) you'll need 20.8g Fermaid-K and 9g of DAP. You'll add 16.6g Fermaid-K and 4.5g DAP at the end of the lag phase (when the yeast starts bubbling), and then the rest about 24 hours later. There are many schedules that spread the additions out over a longer time. Some claim that these are more effective. You do not want to add DAP (and Fermaid-K contains some DAP) past 66% sugar break (where 66% of the sugars have been consumed by the yeast).

Stirring is critical. It mixes up the yeast and honey mixture, blowing off toxic CO_2. It stabalizes the temperature and gives a good chance to check for H_2S. And it introduces just a little bit of O_2 which is needed for yeast growth. Stirring should be done twice a day until 66% sugar break. If you have fruit in your mead you will want to do what is known as punching down the cap. This basically means you submerge the fruit layer that is sitting on top. Heat builds up in the fruit cap and can result in nasty off flavors from dying yeast. The cap should be punched down about 3 times a day. You want to prevent the cap from getting dry or caking up, as this promotes off flavors such as mold or other bacterial growth. Thus the exact number of times per day depends on the speed of fermentation (faster means more frequent punching of the cap) and the temperature of the fermentation (higher means more frequent). This can be accomplished with a quick stir, or with a sanitized spoon (if in a bucket for primary). Larger operations are able to use pumps or horizonal axis stirring methods such as a rotary tank.

Three useful resources for when you are crafting a recipe are the Gotmead Mead Calculator[3], the Lallemand Yeast Chart[2], and the Nanaiomo Winemakers YAN Yeast Calculator[4].

12.2 Dry Traditional

Ingredients

12 – 14	lbs. Quality Honey
5	gal. water (to volume)
200 – 250	ppm YAN, depends on yeast chosen, 7:3::Fermaid-K:DAP
1	pkt. re-hydrated Yeast (D-47, DV10, 71B-1122, K1V-1116...)

Notes

This will make a standard strength dry mead. You'll want to shoot for around 1.085-1.100 for original gravity and look for a final gravity between 0.992 an 1.004 with final alcohol around 12-14% ABV.

12.3 Semi-Sweet Traditional

Ingredients

15 – 17	lbs. Quality Honey
5	gal. water (to volume)
200 – 250	ppm YAN, depends on yeast chosen, 7:3::Fermaid-K:DAP
1	pkt. re-hydrated Yeast D-47

Notes

This will make a standard strength semi-sweet mead. You'll want to shoot for around 1.110-1.120 for original gravity and look for a final gravity between 1.004 and 1.014 with final alcohol around 14% ABV. 1.004 is usually considered dry, but there can be some perceptual overlap. If it goes dry, you can always backsweeten by adding more honey. The reason this uses D-47 is because it is a 14% alcohol tolerant yeast and many of the others will take this all the way dry. If you use a stronger yeast, you may need to add more honey or backsweeten.

12.4 Sweet Traditional

Ingredients

18 – 21	lbs. Quality Honey
5	gal. water (to volume)
200 – 300	ppm YAN, depends on yeast chosen, 7:3::Fermaid-K:DAP
1	pkt. re-hydrated Yeast D-47

Notes

This will make a standard strength semi-sweet mead. You'll want to shoot for around 1.130-1.150 for original gravity and look for a final gravity between 1.025 and 1.045 with final alcohol around 14% ABV. The reason this uses D-47 is because it is a 14% alcohol tolerant yeast and many of the others will take this into semi-sweet or dry territory or into higher alcohol (and longer aging). If you use a stronger yeast, you may need to start with a higher gravity or backsweeten.

12.5 Semi-Sweet Session Mead

TODO

12.6 Session Dry-Hopped Mead

TODO

References

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[9] The Project Gutenberg EBook of The Closet of Sir Kenelm Digby Knight Opened http://www.gutenberg.org/files/16441/16441-h/16441-h.htm