RESEARCH & EDUCATION FUND

INFLUENCE OF WATER CHEMISTRY ON THE FERMENTATION AND FLAVOR PROFILES OF TRADITIONAL MEAD

American Homebrewers Association®

Influence of Water Chemistry on the Fermentation and Flavor Profiles of Traditional Mead

By Aaron Kueck

Water chemistry is a well-known and often-discussed factor in both the brewing process and eventual flavor profile of beers. Profiles of famous brewing cities are widely published; calculators for adjusting water are passed around homebrewing forums. Like beer, water is a major ingredient in mead, typically constituting 70-80% of the initial must. Unlike beer, the impact of water chemistry on the fermentation process and flavor profile of meads is unknown.

A set of four water profiles was chosen to test the fermentation kinetics and flavor profiles of a simple traditional mead. A single must of distilled water (~3.5 gallons), local upstate NY fall wildflower honey (1 gallon), and a small amount of yeast nutrient (2 g Fermaid K) mixed to an OG of 1.100 was divided into four containers. A ½ gallon DV10 yeast starter, SG 1.060 using NY summer honey, was used to reduce the need for nutrients (and their associated salts and buffering properties) during the fermentation. The starter was decanted off the yeast after 2 weeks and approximately 70 grams of thick yeast slurry was added to each batch. Salts (calcium sulfate, magnesium sulfate, calcium chloride, calcium carbonate, potassium carbonate, sodium chloride, and sodium bicarbonate, measured to 0.01 g) were added to three batches to generate soft water, hard water, and hard water with high sulfate-to-chloride ratio profiles; the fourth batch was unaltered (distilled water), as a control. Water profiles were not specifically tailored to any particular regional water profiles, but are intended to span a typical range of water sources.

The fermentation process was monitored by weight loss. The starting volume of each batch was calculated based on the measured initial weight and the measured initial SG. The SG was thereafter calculated based on the measured weight and the initial volume. Volume loss during fermentation and biomass accumulation introduce small errors into the weight loss method, but the magnitude of the error was less than 0.010 SG at the end of fermentation. The finished meads were evaluated after approximately 6 and 18 months. Samples of the finished meads were analyzed by Ward Labs (Kearney, NE) for chemical content.

Table I provides the calculated starting water chemistry in ppm added to each batch based on the weight of added salts. Note that 0.5 g/gallon of FermaidK is expected to add an additional 15 ppm Ca, 8 ppm Mg, 10 ppm SO_4, and 100 ppm HCO_3 and the initial pH of a distilled water-honey must prior to salt additions was measured as 3.7.

TABLE I: Calculated Initial Salt Additions, ppm

	Na	K	Ca	Mg	SO4	Cl	HCO3
#1 Distilled	0	0	0	0	0	0	0
#2 Soft	10	15	25	10	55	25	50
#3 Hard	25	50	100	25	133	60	250
#4 Hard, High Sulfate:Chloride	25	50	100	25	133	25	300

Figure 1 shows the progress of fermentation. The soft water batch, #2, fermented slightly faster than the other batches, but there was little difference in overall fermentation speed between the batches and the final gravity of each was essentially identical. Images of the meads during fermentation are shown in Figure 2.

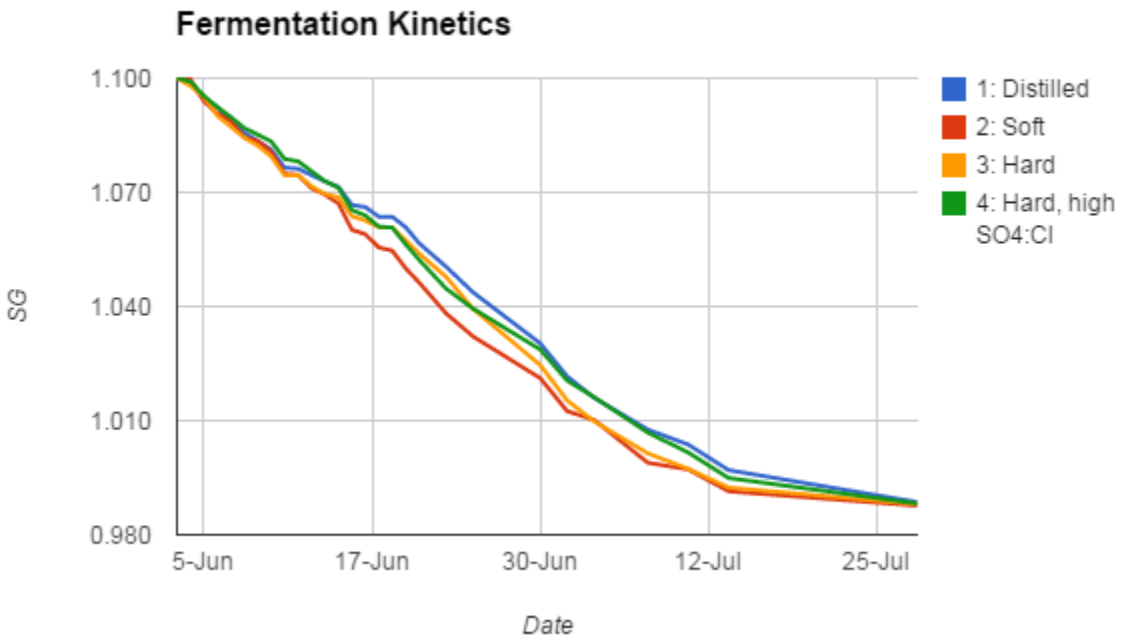

Figure 1: Specific gravity (SG) vs. time for each batch.

Figure 2: Meads near the start of fermentation, 1-4 left to right.

Table II provides the measured final water chemistry of each batch. Sodium concentration is essentially unchanged after fermentation. The potassium, sulfate, and chloride concentrations of all four batches are very similar at the end of fermentation. Magnesium increased by approximately 15 ppm for all four batches, and calcium increased slightly for all but the distilled water batch in which it increased dramatically. Increases in calcium and magnesium content may be due to yeast autolysis; if that is the case then the distilled water batch appears to have caused the most autolysis. The increase in calcium and magnesium during fermentation also creates a high final hardness. Final pH mirrors the buffering capacity of the original musts, with the distilled water batch having the highest acidity. The salt profiles are remarkably similar after fermentation, showing that the action of the yeast tends toward a constant environment. Images of the finished meads are shown in Figure 3. It was notable that no batches experienced a pH crash leading to a stuck fermentation, although the use of a yeast starter is likely highly influential in this aspect.

TABLE II: Final water chemistry

Final results	Na	K	Ca	Mg	SO4	Cl	HCO3	hardness as CaCO3	pH	FG
Distilled	12	223	93	15	51	102	0	295	3.4	0.996
Low	16	229	46	25	60	127	0	219	3.5	0.996
Hard	32	291	109	39	83	116	0	435	3.8	0.998
Hard, high SO4/Cl	35	267	130	38	79	122	0	483	3.8	0.999

Ion concentrations in ppm.

FIGURE 3: Finished meads 1-4, left to right, after 1.5 years.

The tasting comments of each batch are summarized below. Judging was conducted blind, other than the author's notes. 6 judges evaluated the meads at six months, and four tasters evaluated them again at 18 months. Overall, the softer water profiles were strongly preferred. Perception of phenolic flavors was greatly influenced by initial hardness and somewhat by sulfate content, and the detection of cooked vs. fresh fruit flavors was correlated positively with water hardness.The consensus favorite was sample #2, the moderately soft water profile, with #1 distilled water a close second. Mead #3, hard water with lower sulfate:chloride ratio was the least preferred, although #4 was not well received either. Both of the hard water batches were perceived as flat, hot, and waxy while the softer waters produced meads with brighter acidity, minerality, and overall approachability. Some tasters noted that the distilled water batch produced an overly acidic product, consistent with expectations of a poorly buffered fermentation. Tasting after 18 months produced similar notes concerning the waxy/phenolic aspects of the high hardness meads as the tastings conducted after 6 months and there was no change in relative ranking over this time period. The additional year of aging did increase the presentation of fruit/honey characteristics in all four batches.

#1, Distilled Water: Pale straw and Hazy. Dry, mineral, drying mouthfeel. Floral with light honey, pear/apricot, slightly dank aroma. Acidic, light phenolics especially on the finish.

#2, Softer Water: Pale straw and clearer than #1. Less mineral/chalky than #1, but with a more noticeable sharp acid edge. Fresh apple, pear. Drying. Very slightly phenolic/pithy. Rounder than #1 and easy to drink.

#3, Hard Water: Very clear, pale straw with a hint of gold. Overripe pear, cooked peaches. Phenolic, pungent, chemical. Low honey expression, noticeable alcohol/fusel presence. Flat and hot with an acrid finish. Generally considered the most unpleasant of the set.

#4: Hard Water, high Sulfate:Chloride: Clear and lightly golden like #3. Heavy mouthfeel, flat and lacking acidity. Musty, salty, waxy. Very subdued honey. Cooked fruit, light sherry notes, bitter edges with a soapy finish. Generally considered better than #3 but still unloved.

Based on the results of this test, meadmakers with high hardness water should take steps to soften their water in order to reduce the perception of phenolic off-flavors. Typical home water softeners that exchange calcium and magnesium for sodium ions may not produce the desired results, so diluting hard water with RO or distilled water or otherwise treating the water to reduce the overall ionic content is recommended. Low hardness water is preferred for the perception of fresh fruit flavors and reduction of fusel production, but distilled water is not recommended due to unbalanced acidity and increased presence of phenolic flavors, possibly due to increased autolysis, compared to soft water. Further experiments are recommended to study the effect of residual sugar and fruit additions, especially in light of the influence of initial must buffering capacity on the production of phenolics and fusels.

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