Umami Flavored Wine
Heather McDade
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Abstract

There are five basic tastes, four of which are well-known; bitter, sour, salty, and sweet. The lesser known fifth sense is Umami. Savory flavor in wine is not a well-known characteristic. Umami is often established by adding monosodium glutamate or just glutamic acid. In this experiment glutamic acid was added during fermentation in different concentrations to three trials which were duplicated. Graphs are presented to depict the overall acceptability of the wine, the fruit intensity, and the total acidity. The fruit intensity decreased with the higher concentration of glutamic acid and the total acidity increased with the higher concentration of glutamic acid. The glutamic acid is preferred in a smaller concentration which also shows that overall acceptability at higher glutamic acid concentrations is not preferred. Glutamic acid did change the flavor of the wine to a savory, salty taste but this was not preferred among wine judges and consumers as a drinkable wine but could be used in further applications such as cooking.

Introduction

During the primary fermentation of wine, the two grape sugars, glucose and fructose are converted to alcohol (ethanol) by the action yeast. The by-products of primary fermentation are aromas and flavors, the gas carbon dioxide, and heat. The production of heat during fermentation (an exothermic process) means that during fermentation the temperature of the fermentation vessel will rise, and will require action on the part of the winemaker to cool it down. Red wine fermentations are typically allowed to run at between 25 and 32°C. At temperatures higher than this, there can be a loss of desirable aroma and flavor compounds, and unattractive aroma characters in the spectrum of caramel, burnt, or cooked characters can be produced. There are many types of yeast, but two closely related types known as Saccharomyces cerevisiae and Saccharomyces bayanus are the ones that are responsible for fermentation. The yeast used to produce this experimental wine was S. cerevisia. Fermentation is completed when all the fermentable sugars have been converted to alcohol. This end point is measured chemically. Once the wine is deemed free of fermentable sugar, i.e. dry it is cooled to 4°C and the dead yeast cells (known as gross lees) are allowed to settle. The relatively clear wine is then racked to remove the gross lees before it is stabilized and filtered ready for bottling (Gawel, R. 2005). A great deal of wine research has been focused on the fermentation process and how to prevent the loss of color, aromas, and sugars.

Malolactic fermentation (MLF) is a research topic most often discussed in terms of its effect on wine quality and methods currently available for its control. Benefits of MLF include the lowering of acidity in high acid wines, enhancement of sensory characteristics through bacterial activity, and enhanced microbiological stability (Davis, CR., Wibowo, D., et al, 1985). Other studies often done are the health attributes of red wine. Although this research does go into sensory it takes a different turn by using an amino acid as a yeast nutrient during the process of fermentation.
Ammonium and glutamate are key components in the nitrogen metabolism of *S. cerevisiae*. Ammonium assimilated via the formation of glutamate, which is the main donor of nitrogen in the biosynthesis of amino acids. The amino group glutamate is transferred to amino acid precursors, leaving 2-oxoglutarate, which may be either excreted or further, converted in the cellular metabolism. Previous studies have shown that the kind of nitrogen source affects the product formation and the carbon flow *S. cerevisiae* (Albers, E., Blomberg, A, Liden, et al. 2005). Umami, a savory flavor is often associated with Asian cuisine and certain foods such as soy sauce, parmesan cheese, tomatoes, mushrooms, and bacon. Umami is the sensation associated with consuming foods rich in glutamates (Yamaguichi, S., and Ninomiya, K. 1998.)

Further studies dealing with sensory components to enhance the flavor and aroma is an experiment on inoculating yeast cultures versus not inoculating yeast. By inoculating yeast, the fermentation process was found to be much quicker than by not inoculating it with a starter culture. The only other found attributes in this experiment was the uninoculated yeast treatment gave higher sensory scores (Henick-Kling, Edinger; Daniel, Monk). Other studies done on yeast fermentation of the wine have found at different stages of the spontaneous fermentation different phenotypes of the non-Saccharomyces yeasts were represented, characterized by consistent differences in some by-products involved in the wine bouquet, such as acetaldehyde (Romano, P., Suzzi, G., et al. 1997).

Most of the research found in the literature is related to different yeast strains and the process in which yeast is used in the fermentation process and were very few studies dealing with glutamic acid or the affects of glutamic acid. The dependent variables that are studied are intensities of aroma, appearance, flavor, and total acidity. The independent variable is the different concentrations of the amino acid, glutamic acid added to the red grape variety juice. The objective of this paper is to investigate the effects of flavor by adding glutamic acid which will add a sense of savory to the wine, also known as umami, the fifth sense.

**Methods and Materials**

Grapes for this research project were provided by the Purdue University horticulture farms. The varieties used were 40 gallons of NY 73.136.17, 8 gallons of Rubin T, and 8 gallons of Chambourcin. Throughout the rest of the paper these grapes will be referred to as a red variety. The grapes were delivered a day ahead of time and left in the cooler for storage before further processing.

**Grapes to Juice**

Before processing of the grapes can take place the crusher destemmer and the containers must all be sanitized. The sanitizer solution is made by mixing one teaspoon potassium metabisulfate with one tablespoon citric acid in a gallon of warm water. Throughout the rest of the methods section this solution will be called sanitizer solution. The equipment must all be washed down with hot water and sanitized. A container is placed at the back of the crusher destemmer for collection of the stems and a container is placed under the
spout of the crusher destemmer for collection of the grape juice and skins. After sanitation is complete, plug in the crusher destemmer and dump the first variety of grapes into the machine for processing. After the NY 73.136.17 grapes were processed, put the juice and skins into a fermenting tub and place in a cooler. Do this same process for each grape keeping the different grape varieties separated at this time. After each grape variety has been processed, add 50ppm of potassium metabisulfite and refrigerate the skins and the juice. Pull a juice sample of 50mL from each grape variety at this time for juice analysis.

**Fermentation**

The 56 gallons of grape juice and skins will be divided equally in two fermenting tubs. Fermenting tub ‘A’ will have 20 gallons of NY 73.136.17, 4 gallons of Chambourcin, and 4 gallons of Rubin T. Fermenting tub ‘B’ is mixed in the same way with the exact gallon of each grape variety. These fermenting trials ‘A’ and ‘B’ are left out at room temperature for two days for the skins and juice to warm up to room temperature (23°C). After the juice and skins are warmed up the yeast may be prepared and placed in each trial. The yeast culture needed is 10mL per gallon of wine. The culture is made by heating tap water to 45°C then adding one gram of yeast nutrient (GoFerm) per 10mL of water. Let the culture cool to 40°C and add one gram yeast EC 1118 (S. cerevisiae) per 10mL of solution. Stir the solution for ten minutes and then let sit for another ten minutes. Finally this is mixed thoroughly into each fermenting tub. After yeast has been added one must press the caps down on the trials every day. The caps are the grape skins that have risen to the top. Fermentation on the skins goes on for three days and then remove the skins by pressing the juice off into a 4 gallon glass carboy. One can use a strainer to press the juice from the skins. The skins may be placed in a recycling container. Eight carboys must be sanitized by using the sanitizer solution. Label carboy coming from trial ‘A’ and trail ‘B’. The pumice is disposed of by recycling. A stop cock must be sanitized and placed in each carboy to allow the pressure to be seen and prevent oxygen from entering the carboy. The four carboys from trial ‘A’ and four carboys from trial ‘B’ are labeled for the addition of glutamic acid. A carboy from trial ‘A’ and a carboy from trial ‘B’ are labeled controls and nothing should be added to them. Trial 1 ‘A’ and trial 1 ‘B’ should have 100 mg of glutamic acid/100 mL of wine (11.35g glutamic acid/4 gallons of wine) added to each carboy. Trial 2 ‘A’ and trial 2 ‘B’ should have 150mg glutamic acid/100 mL of wine (17.025g glutamic acid/4 gallons wine) added to each carboy. Trial 3 ‘A’ and trial 3 ‘B’ should have 200mg of glutamic acid/100mL of wine (22.70 glutamic acid/4 gallons wine) added to each carboy. After the addition of glutamic acid stir each carboy thoroughly with the exception of the controls. Sanitize the stirrer between each carboy. Let the fermentation take place for seven days before checking the balling. Before bottling use a hydrometer and take a balling reading. It must be below zero in order to bottle and rack.
Racking and Bottling

After the residual sugar reads below 0.5%, the fermentation is complete. Another good check is watching the stop cocks and when they no longer show pressure the fermentation is complete. For racking of the wine each carboy needs to be set because it will disturb the settled gross lees on the bottom of the carboys. First one needs to gather a five gallon bucket, a plastic hose, sixteen bottles, and eight four gallon buckets. These supplies need to be sanitized with the sanitizer solution. A hot iron also needs to be turned on to be heating up while one gathers supplies. The wine then can be sifted out of the carboy with the plastic hose into the five gallon bucket. Caution, do not let the hose hit the bottom of the carboy, keep the hose eight to ten inches from the bottom to prevent disturbing the gross lees. After the wine has been removed from the carboy 50ppm SO2 solution needs to be stirred into the wine. The wine can then be funneled into two bottles. One bottle is for tasting and the second bottle is for analysis. A plastic heavy duty bag, placed in the four gallon bucket, is used with a slit in the top to place the excess wine in and then the small hole in the bag can be closed by using a hot iron and sealing it shut. Be very careful to remove as much of the air as possible. This same procedure should be done to each carboy. Remember to label every bottle and bucket for further evaluation.

Analysis of Samples

pH

First turn pH meter on and allow several minutes of “warm up” in order to become stable. Follow the directions for your instrument to standardize to pH 7.0 and 4.0 buffers. Then pour about 20 mL of the wine sample into a clean beaker. Heat sample in microwave until bubbles begin to appear (about 12 sec). Temperature should be around 90°C. Cool the sample in a cold-water bath until it reaches a temperature of 25°C. Degassing is done in order to eliminate CO2 from the sample. Dissolved CO2 in wine will make the pH read lower than it actually is. Immerse electrode into the wine sample and gently swirl the beaker. Be careful not to damage the fragile electrode. Take pH reading when stabilized and record results. This is done a total of eight trials of wine made. The pH meter is not in use and between measurements, store electrode according to the manufacturer’s recommendations, usually in a potassium chloride (KCl) solution.

Total Acidity

Checking the NaOH Normality starting with a volumetric pipette, put 10 mL of 0.1 HCl into a 50 mL beaker. Then add a little bit of distilled water and a few drops of phenolphthalein (about 2-3). Fill buret with 0.1 N NaOH, put beaker beneath buret, insert electrode (optional), continuously swirl beaker, and titrate carefully until a light pink color holds for 15 sec or more or pH is 8.2. Compare the volume of NaOH used with what was recorded on the notebook the last time titration was made. If the volumes are the same, then use the same Normality as before. If the volumes are different, calculate the new Normality for NaOH. Which is N NaOH = 1 / mL NaOH.
Titrating by pipeting a 10 mL room temperature wine sample in a 50 mL beaker. First heat sample in microwave until bubbles begin to appear (about 12 sec), should be around 90°C. Cool the sample in a cold-water bath until it reaches 25°C (degassing is done in order to eliminate carbon dioxide from the sample. Carbon dioxide is a major interference in the TA measurement and a source of error.) Fill buret with 0.1N NaOH, put beaker beneath buret. Insert electrode (optional). Add 0.1 N NaOH slowly with stirring, while watching pH meter. As pH approaches 7.0, slow addition to drops. Continue adding drop-by-drop and stirring between additions until light pink color holds for 15 sec or pH reaches 8.2. Record the mL of NaOH used. Calculate the Total Acidity in g/100mL with the formula Titratable Acidity = mL NaOH * N NaOH * 0.75.

Volatile Acids

Turn on water for condenser; adjust water flow to give adequate vacuum when aspiration stopcock is opened to chamber. Snap to close the clamped tubing at bottom of boiling chamber. Fill outer chamber with distilled water up to a level about 1 inch above heating element. Pipette exactly 10 mL of wine sample in a 50 mL beaker. Heat the sample in microwave for 12 seconds to remove CO₂. Turn stopcock on Cash Still so that passage runs from funnel to inner chamber. Add the wine sample and add 2 drops of anti-foam, rinse sample cup 2x’s with 5 mL distilled water, and add to inner chamber and place 250 mL Erlenmeyer flask under condenser to collect distillate. (It is recommended to place about 1 in of Tygon® tubing on the condenser outlet in order to avoid chipping of both the outlet and the flask). Turn upper stopcock to outer chamber and turn on power. As soon as outer chamber is hot and bubbles begin to break surface, close stopcock (horizontal position) to begin distillation. Collect 100 mL of distillate, and turn off power. Open the clamp to allow water and wine to exit from the chambers, rinse whole unit with distilled water. To 100 mL distillate, add 5 drops of phenolphthalein indicator, and insert pH meter titrate with 0.1 N NaOH to light pink end point or to pH of 8.2. Record mL of NaOH used. Finally, calculate the volatile acidity in g/100mL. Calculate each of the eight trials ran by using the formula Volatile Acidity = mL NaOH * N NaOH * 0.75.

Hydrometer

This is done to each trial to determine if fermentation is complete. Collect a homogeneous representative sample of wine, removing gross particulates by filtering through several layers of cheesecloth. Transfer the liquid into the hydrometer cylinder to a level of about 3 in. from the top. Record the temperature of the sample. Accuracy is improved if the sample temperature matches the temperature notation on the hydrometer. Select a hydrometer of appropriate scale range and insert into the liquid, carefully holding the top of hydrometer stem in a pendulum effect. Gently spin the hydrometer in the sample to free the instrument from surface tension and bubbles. Take a reading at the bottom of the meniscus, just before spinning stops and record results. If it is necessary to make temperature compensation, an approximate correction factor of +0.06 for each
degree above 20°C and –0.6 per degree below 20°C may be utilized. Temperature must be in centigrade for this factor.

**Residual Sugar–CLINITEST**

Collect the wine in a small container. With the dropper in upright position, place 5 or 2 drops, depending on the test being followed, into a test tube. Rinse the dropper with water and add 10 drops of water to the test tube. Drop one tablet into the test tube. Watch while complete reaction takes place to see if the color goes past the orange state and turns brown. If color does not pass orange take the reading from the color chart. If color does pass orange, sample must be diluted and place a tablet into the test tube. Ignore changes after the 15-second waiting period. Write down the percent (%) result which appears on the color block that most closely matches the color of the liquid. Repeat this step for each trial on the finished wine.

**Free SO2 - Aeration/Oxidation**

Assemble glassware according to the figure in the appendix. To the receiving flask add 10 mL of 0.3% H2O2 and 6 drops of indicator solution (Should be gray-green, if too purple add 1 drop of 0.01 N NaOH, if too green add 1 drop of HCL). Replace with receiving flask top. Place an ice bath around the round bottom flask. Remove the bubbler/stopper. Add 20 mL of the wine sample and 10 mL of 25% phosphoric acid to the round bottom flask. Quickly replace the bubbler/stopper. Connect aspirator to vacuum source and aspirate vigorously for a timed 10 minutes at a flow rate ca. 1000mL/min. (Solution in receiving flask will become bright purple in the presence of Free SO2). Stop the aspiration. Remove the receiving flask; rinse the inside of the vacuum adapter and the outside of the pipet connected to it. Collect the rinse in the receiving flask. (Note: keep the wine sample in the round bottom flask if the Bound SO2 analysis is also needed). Add 0.01 N NaOH to a 10 mL buret and titrate the purple solution until it changes to the same original gray-green color (end point). Record the mL of NaOH used. Calculate the Free SO2 in mg/L (ppm). This analysis is done on each trial of finished wine. The formula used is Free SO2 = (mL NaOH * N NaOH * 32 * 100 )/(20 mL (sample size))

**Alcohol – Ebulliometer**

Rinse the inside of the ebulliometer with distilled water. Drain valve and close. Fill upper reflux condenser jacket with cold tap water. Measure 25 mL of distilled water into a clean 100 mL graduated cylinder and carefully pour into lower chamber inlet. Very carefully insert thermometer into lower chamber inlet, holding top of thermometer in one hand in a pendulum effect and holding rubber stopper portion in the other hand. Slowly and gently twist rubber stopper into position for a snug fit. These thermometers are very delicate, expensive and break easily. Ignite ethanol burner and carefully position under lower chamber in the proper position. Observe thermometer mercury rising until it stops and holds for 15-20 seconds at the same temperature. Record the temperature of boiling water. Remove ethanol burner and cover to extinguish flame. Remove
thermometer carefully. Hold in vertical position until the mercury drops from the capillary. Dry with towel carefully and place upright in a safe place. Empty all the contents from the ebulliometer and rinse to cool. Rinse lower chamber with about 50 mL of the wine sample to be analyzed. Drain the instrument and fill upper reflux condenser with cold tap water. Ensure that no water goes down the inner tube. Rinse the 100 mL graduate cylinder with a few milliliters of the wine sample. Refill graduated cylinder with 50 mL wine sample and pour into lower chamber and place thermometer into the lower pendulum and record the temperature of the boiling wine. Take the boiling point of water and subtract the boiling point of wine. Use this number and look on the Ebulliometer chart to determine the percent alcohol.

**Senory**

A trained sensory panel was conducted by three professional wine analysts, Dr. Christian Butzke, Ellen Butz, and Jill Blume; each judges various wine competitions a year and is highly qualified. The panel is set up as a blind panel mixing the wines and labeling them with letters. This sensory the judges have to grade each wine on appearance, aroma/bouquet, taste/aftertaste, and overall acceptability. A sensory card is attached for one to follow. This is done two to three days after analysis have been done on the wine.

**Results**

**Table 1. Balling readings at the end of fermentation.**

<table>
<thead>
<tr>
<th>Trial</th>
<th>Balling-Hydrometer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control A</td>
<td>-0.5</td>
</tr>
<tr>
<td>Control B</td>
<td>-1.0</td>
</tr>
<tr>
<td>Trial 1 A</td>
<td>-0.5</td>
</tr>
<tr>
<td>Trial 1 B</td>
<td>-0.5</td>
</tr>
<tr>
<td>Trial 2 A</td>
<td>-0.8</td>
</tr>
<tr>
<td>Trial 2 B</td>
<td>-0.8</td>
</tr>
<tr>
<td>Trial 3 A</td>
<td>-0.5</td>
</tr>
<tr>
<td>Trial 3 B</td>
<td>-0.5</td>
</tr>
</tbody>
</table>

**Table 2. Analysis on finished wine trials.**

<table>
<thead>
<tr>
<th>Wine</th>
<th>Brix (%)</th>
<th>EtOH (%)</th>
<th>pH</th>
<th>TA (g/mL)</th>
<th>VA (g/mL)</th>
<th>FSO₂ (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control A</td>
<td>0.4</td>
<td>11.0</td>
<td>3.76</td>
<td>0.735</td>
<td>0.030</td>
<td>51</td>
</tr>
<tr>
<td>Control B</td>
<td>0.3</td>
<td>11.0</td>
<td>3.64</td>
<td>0.765</td>
<td>0.030</td>
<td>62</td>
</tr>
<tr>
<td>Trial 1 A</td>
<td>0.4</td>
<td>11.4</td>
<td>3.74</td>
<td>0.765</td>
<td>0.024</td>
<td>81</td>
</tr>
<tr>
<td>Trial 1 B</td>
<td>0.3</td>
<td>11.4</td>
<td>3.63</td>
<td>0.750</td>
<td>0.030</td>
<td>76</td>
</tr>
<tr>
<td>Trial 2 A</td>
<td>0.3</td>
<td>11.0</td>
<td>3.70</td>
<td>0.788</td>
<td>0.024</td>
<td>62</td>
</tr>
<tr>
<td>Trial 2 B</td>
<td>0.3</td>
<td>11.6</td>
<td>3.62</td>
<td>0.803</td>
<td>0.024</td>
<td>67</td>
</tr>
<tr>
<td>Trial 3 A</td>
<td>0.4</td>
<td>11.4</td>
<td>3.68</td>
<td>0.803</td>
<td>0.024</td>
<td>72</td>
</tr>
<tr>
<td>Trial 3 B</td>
<td>0.2</td>
<td>11.8</td>
<td>3.65</td>
<td>0.825</td>
<td>0.018</td>
<td>62</td>
</tr>
</tbody>
</table>

*All calculations done were completed in excel.
Figure 1  Total Acidity of Experimental Wine

Figure 2  Overall Acceptability
Discussion:

Effects of Glutamate added to Red Wine

The balling of the different treatments of the red wine was taken by a hydrometer to determine the completion of fermentation. This is outlined in Table 1. There was no significant difference from the addition of glutamic acid in the wines fermenting process.

The analysis on the finished wine trials is outlined in table 2. Starting with the pH measurements, this is the measure of free hydrogen ions. The lower the pH number, the higher the acid strength. It is known that the pH has a significant effect of biological stability, color, oxidation rate, protein stability, bitartrate stability, but you cannot “taste” the pH of a wine. Generally, less growth of spoilage bacteria and yeast occur as the pH decreases (Plant, Charles. 2001). The pH measurements from the different trials showed no significant difference although they were all at a good pH for a successful wine.

The total acidity (TA) is the measure of potential hydrogen ions in solution or acid concentration. TA is expressed in terms of grams of tartaric acid per 100 mL wine. The measurement is used to determine the amount of tartness in wine. Concentrations less than 0.5 g/100mL are generally considered bland. TA’s exceeding 0.8 g/100mL are usually ranked as tart. Residual sweetness balance TA and vice versa. (Pandell, A. 1999). The TA was calculated by using this formula in excel \(?mL \text{ NaOH} * ?N \text{ NaOH} * 0.75.\) As one can see the TA increases with the increased concentration of glutamic acid.
This is shown as an increasing linear correlation in figure one. As the concentration of glutamic acid increased the total acidity increased. This is a phenomenon that happened because the amounts of glutamic acid exceeded the fermentation process. This correlation also showed that the yeast used none of the glutamic acid in the fermentation process. Therefore, the grapes used in this experiment provided enough glutamic acid for the yeast fermentation. The glutamic acid that was added was in excess.

Most of the acids formed by spoilage bacteria are volatile and can be isolated by using a Cash Volatile Acid distillation apparatus. Commercial vintners rely on this instrument to monitor the extent of volatile acid formation in wine, and thus the extent of spoilage bacteria activity. The TTB limits volatile acidity in commercial red and late harvest wines are set at a 0.140 g/100mL maximum (Gawel, R). From Table 2 one can see glutamic acid did not have much affect on the volatile acid but the red wine made was within legal limits. The volatile acid was calculated by using the formula in excel \( \text{CLINITEST} \) reagent tablets are used to determine the amount of reducing substances (predominately glucose and fructose) in wine. The additions of glutamic acid once again have no impact on the %brix as seen in table one.

Sulfur dioxide (SO2) is used for preserving wines from bacterial activity as well as reducing oxidation and browning. Dry table wines having lower pH concentrations can be protected with as little as 30 mg/L free SO2. Wines having residual fermentable sugar and higher pH concentrations may require more than 100 mg/L free SO2. Milligrams per liter expression is often made as parts per million (ppm). The most robust and commercially preferred way to test sulfite concentrations is the Aeration/Oxidation method. Wines need to be protected with SO2 based on their pH. The legal limit for sulfites is 350ppm (Waterhouse, A. 2005). The addition of glutamic acid showed no significant difference. The values presented in Table 2 represent that the wines made were under the legal limit and sulfites were also there to prevent the oxidation process. These values were calculated in excel by using the formula free SO2 = \( \frac{\text{mL NaOH} \times \text{?N NaOH} \times 32 \times 100}{20 \text{ mL}} \) (sample size).

The rationale of the ebulliometer is to compare the boiling point of water with the boiling point of the wine sample at a given time, the difference being due primarily to the alcohol content in the wine. The ebulliometer will not give an accurate reading for wines with high residual sugar concentrations. (Blume, J). The different trials did not exhibit any difference in the different alcohol percentages. This is portrayed in Table 2.

**Sensory Effects of Glutamic Acid**

A blind sensory was conducted and overall the glutamic acid was not an acceptable wine to drink. This is shown in Figure 2. Numerical values six through ten are acceptable to serve and less than that should not be served. The consensus of the blind panel was that wine had a very salty/harsh taste that made them want to gag. Glutamic acid was used instead of monosodium glutamate (MSG) because of the salty attributes of the sodium.
which have been correlated with saltiness in food (Yamaguichi, S., Ninomiya, K. 1998). From this sensory it was found that glutamic acid with the addition of wine also adds to the salty flavor. Besides the decrease in acceptability there was a great loss in fruit intensity with the increase concentration of glutamic acid. This is demonstrated in Figure 3.

**Sources of Error**

Sources of error that could have taken place in this experiment are the loss of juice from the skins when pressing and distributing exactly four gallons of juice to each carboy. Analysis sources of error that could have taken place are the inaccurate readings, calibration measurements, and human error. The sensory sources of error could have been since there was eight wines the judges could have exasperated their pallets and senses because of the strong smell of glutamic acid in the wine.

**Conclusion**

Although the savory flavor it produced was not acceptable it was much different than the controls. The glutamic acid is preferred in a smaller concentration which also shows that overall acceptability at higher glutamic acid concentrations is not preferred. Glutamic acid did change the flavor of the wine to a savory, salty taste but this was not preferred among wine judges and consumers as a drinkable wine but could be used in further applications such as cooking. Suggestions for future research would be when performing this experiment use much lower concentrations of glutamic acid because the lowest concentration was not quite desirable but did have a more acceptable taste. This experiment could also be done by measuring the glutamic acid in a grape variety and choosing a grape based on the measurement. By using a grape with a low glutamic acid concentration may make it possible for the yeast to use some of it during fermentation.
References


Butzke, Christian PhD. 2005. Associate Professor of Enology. Purdue University Food Science Department.


SO₂ – Aeration/Oxidation Unit

1. Support, black stamped steel
2. & 3. Impinger set
4. 100 mL side port flask
5. Stand for flask
6. Bubbler/stopper
7. Stopper/glass tubing adapter
8. Air ejector aspirator, metal or Nalgene
9. Quick disconnect
10. Amber latex tubing, per ft
11. Tygon tubing, per ft
12. Flowmeter
13. Clamps (two required to secure flow meter to support rod)
14. Green joint clamp

Illustration courtesy of Vinquiry