The Chemistry of Wine

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Facts!

- Wine is Awesome!
- Wine is produced by the fermentation of grape juice, using specialized yeast cells.
- Sugar in the grape juice is converted into ethanol and carbon dioxide under anaerobic conditions:

$C_6H_{12}O_6 + 2\ ADP + 2\ P_i = 2\ C_2H_5OH + 2\ CO_2 + 2\ ATP$




Quality of Wine

1. Sweetness

Sugar content can be measured using refractometry.

2. Alcohol content

The exact determination of the alcohol content in commercial wines is performed by distilling the ethanol, then measuring the viscosity of the distillate using sophisticated apparatus. A hydrometer can also be used to measure the alcohol content of wine.

3. Acid content

A well balanced wine needs a certain amount of fruit acid; the total acid content is very important because it directly affects the flavor of the wine. The acid content can be measured using pH titration.

Sweetness

Determined by the amount of sugar remaining after fermentation, combined with the total acidity of the wine.

- Dry
  - 9 g/L of sugar and an acidity level that is at least 2 g/L lower than the sugar content
- Medium-Dry
  - 9-18 g/L of sugar and an acidity level that should be no more than 10 g/L lower than the sugar content
- Sweet
  - 18-45 g/L of sugar

Sweetness

Refractometry, or density measurements can be used to measure the sugar content, which is expressed in Brix (°Bx), or in Germany Oechsle (°Oe). This represents the concentration of dissolved sugar, in weight percent (wt%).

1°Oe corresponds to approximately 2.37 g/L sugar (i.e. about 0.237 °Bx),

Therefore,

Sugar concentration (g/L) = must weight x 2.37

Must weight (°Oe) = (density – 1 (g/L)) x 1000

If all fermentable sugar is fermented = 100 °Oe (sugar concentration 237 g/L or 23.7 °Bx)

Then,

Approximately 100 g/L ethanol (or 10 wt% alcohol) will be produced.

Ethanol has density = 0.79 g/mL

So,

This converts to 12.67 vol% ethanol

Thus,

Alcohol concentration (in % volume) = alcohol concentration (in g/L) x 0.1267

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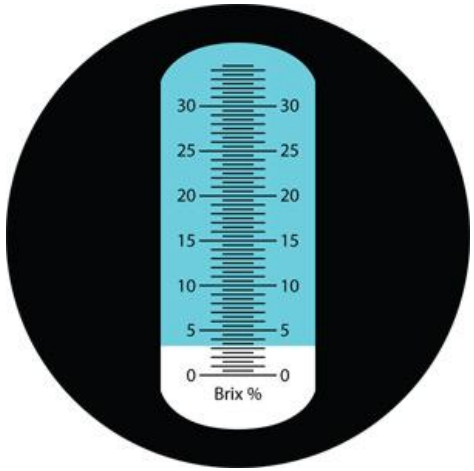
Refractometry

A refractometer instantly reads specific gravity, in Brix, by measuring the degree that light passing through the sample is bent. To use, apply 2-3 drops to the prism face, close cover, and look through the eyepiece while aiming your refractometer at a light source. Calibration is done with Distilled Water, and the small turning of a screw on the devices top surface. In unfermented products, the sugar content can be determined immediately. In fermented products, the calculations are necessary to determine the alcohol concentration.



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Activity 1

Refraction is the change in direction of light when it passes from one medium to another. The light-scattering behavior of a solution changes as the concentration of solutes increases. A refractometer uses this principle to determine the concentration of dissolved particles ina solution. In wine, those particles are primarily sucrose.

1. Pipette 2 drops of distilled water onto the glass surface of the refractometer and close the lid.
2. Take a reading through the eyepiece. If the blue line does not sit at 0, adjust with calibration screw.
3. Using a paper towel, clean the glass surface and then dry it.
4. Repeat the measurement with each wine sample.

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Activity 1 - Data

Wine	°Bx Value	Wine	°Bx Value
Relax Riesling	9.2 °Bx	Hazlitt Red Cat	14.8 °Bx
Zonin Primo Amore Moscato	14.0 °Bx	Sheffield Tawny Port	17.6 °Bx
Noble Vines 446 Chardonnay	7.0 °Bx	Fuego Old Vines Grenache	7.8 °Bx

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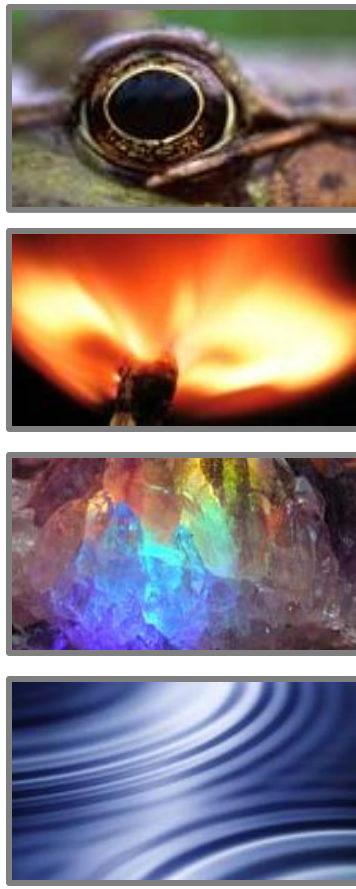
Alcohol Content

- The amount of alcohol obtained by fermentation depends on the sugar content of the grape juice and the alcohol tolerance of the yeast strain.
  - Most yeast strains tolerate up to 16% alcohol.
- The amount of alcohol can be measured quite accurately using a hydrometer.
  - Typical Alcohol Content By Volume ranges from 9-18%



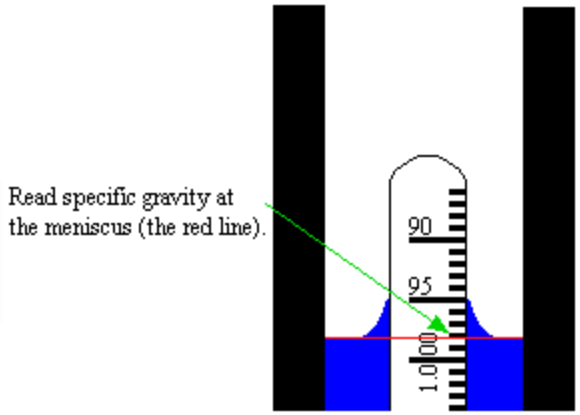
Hydrometer

The Hydrometer is based on Archimedes principle that a solid suspended in a liquid will be buoyed up by a force equal to the weight of the liquid that it displaces.

The lower the specific gravity of the substance, the lower the hydrometer will sink.

The reading is taken at the point where the surface of the liquid crosses the scale on the stem of the hydrometer.

Temperature can change the reading on the hydrometer, so a reference thermometer is often recommended.



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Activity 2

1. Obtain a clean graduated cylinder
2. Pour a sample of wine into the graduated cylinder (This method uses a large sample of wine).
3. Carefully insert the hydrometer into the graduated cylinder, being sure that it is able to float freely in the liquid and is not touching the bottom of the cylinder.
4. Spin the hydrometer to dislodge CO2 bubbles, which will cause errors.
5. Try to read spinning hydrometer before the bubbles reform and sku your reading.
6. Pour wine out, rinse and repeat using a different wine.




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Activity 2 - Data

Wine	Specific Gravity	Wine	Specific Gravity
Relax Riesling	1.012	Hazlitt Red Cat	1.021
Zonin Primo Amore Moscato	1.038	Sheffield Tawny Port	1.011
Noble Vines 446 Chardonnay	0.989	Fuego Old Vines Grenache	0.992

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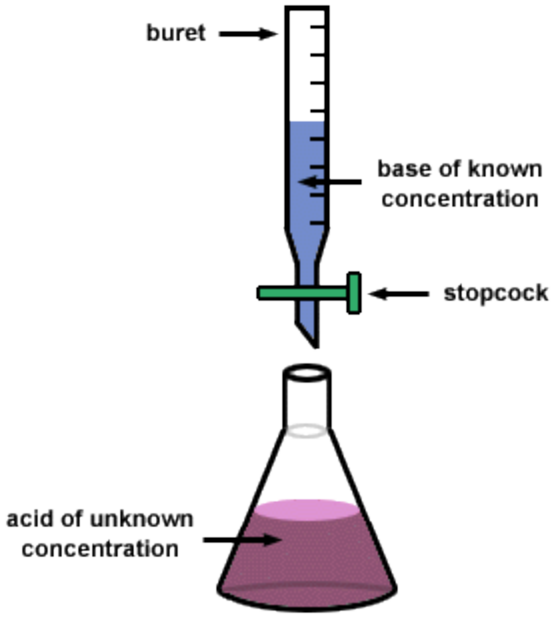
Acid Content

- Fruit juices can contain several different acids, including tartaric, malic, citric and oxalic acid, in differing ratios, depending on the type of fruit.
- The predominant acid in wine is tartaric acid, which has a pH between 3 and 4. However, due to the complex mixture of different acids and bases, proteins and salts, the total acid content of wine cannot be estimated from the pH value alone.
- It is instead determined by titration to neutrality and expressed as a total equivalent amount of tartaric acid in g/L.

  The acid content of wine is typically 4-8.5 g/l but can be as high as 15 g/l.




Acid Content

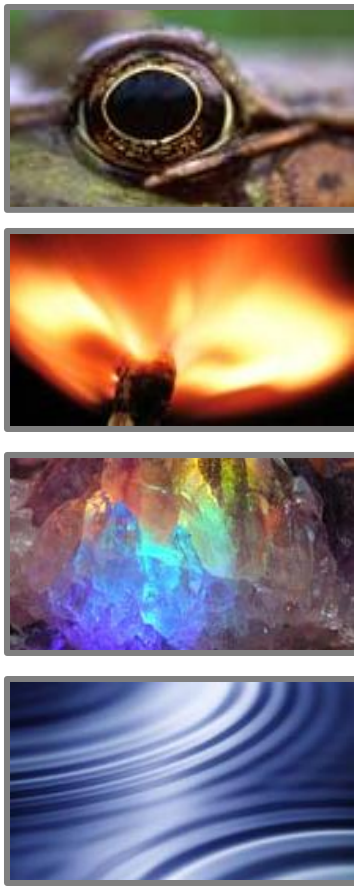


Tartaric Acid

- MW 150 g/mol
- Diprotic acid
  - Two hydrogen atoms per molecule that can dissociate in water as protons
- Fully neutralizes with sodium hydroxide

1 mol NaOH neutralizes 0.5 mol tartaric acid (75 g/l) 1 ml 0.1 M NaOH neutralizes 7.5 mg tartaric acid.

$HOOC\text{-}CH(OH)\text{-}CH(OH)\text{-}COOH + 2NaOH \rightarrow Na^{+}\text{-}OOC\text{-}CH(OH)\text{-}CH(OH)\text{-}COO\text{-}Na^{+} + 2\ H_2O$



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Activity 3

1. Fill burette with 0.1M NaOH solution. Record the starting volume.
2. Measure 10 mL of wine sample and place it in a beaker. Add 100 mL distilled water.
3. Start the magnetic stirrer and insert the pH electrode so that the tip is in the sample, but not touching the sides of the beaker or the magnetic stirrer flea.
4. Add NaOH solution dropwise until neutral pH is reached. Take a reading on the burette and enter it on data table.
5. Calculate the amount of NaOH used and the acid concentration.

Ex. 14 mL of 0.1 M NaOH Used to Neutralize

(14 x 7.5 mg/mL x 100) = 10.5 g/L acid

Activity 3 - Data

	Relax Risling	Zonin Primo Amore Moscato	Noble Vines 446 Chardonnay	Hazlitt Red Cat	Sheffield Tawny Port	Fuego Old Vines Genache
pH at Start	3.25	3.13	3.38	3.10	3.88	3.65
Starting volumn NaOH (mL)	0.0 mL	0.0 mL	0.0 mL	0.0 mL	0.0 mL	0.0 mL
End volume NaOH (mL)	20.6 mL	16.9 mL	12.8 mL	21.4 mL	8.9 mL	12.5 mL
Volume NaOH used (mL)	20.6 mL	16.9 mL	12.8 mL	21.4 mL	8.9 mL	12. 5 mL
Concentration of acid (g/L)	**15.4 g/L**	**12.7 g/L**	**9.6 g/L**	**16.1 g/L**	**6.7 g/L**	**9.4 g/L**

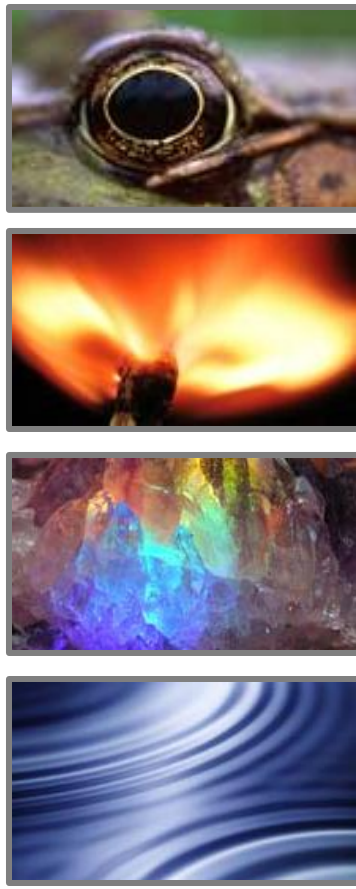
Final Alcohol Content

It is impossible to directly measure the ethanol content of wine using either a refractometer or hydrometer alone.

By their nature, these two instruments are designed for measuring binary, or single component, solutions. The direct measurement by a single instrument is precluded since the combination of water, alcohol, and sugar in the wine represents disparate factors, each differently influencing the readings of these instruments.

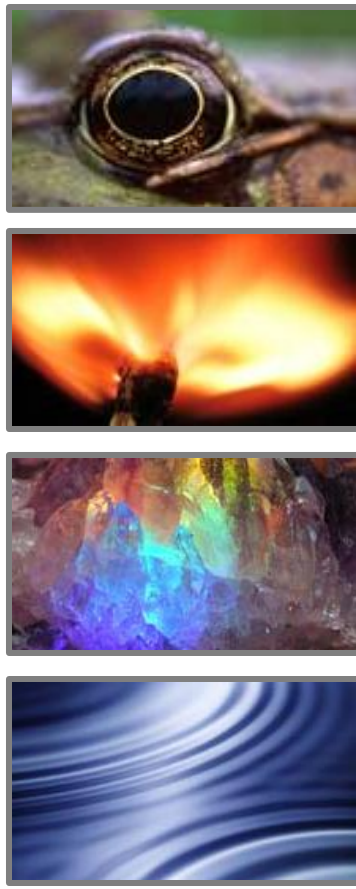
So What Happens???

- Ethanol increases the refractive index as measured by a refractometer and decreases the specific gravity as measured by a hydrometer
- Sugar increases the refractive index and specific gravity.



Final Alcohol Content

- Method Developed by Werner Roesener of the Aurora Wine Circle, in Ontario, Canada.
- Predicable alcoholic strength and residual solids measurement by exploiting the opposite effect that ethanol and sugar have on refractometers and hydrometers.



Final Alcohol Content

Using the Brix reading from Activity 1 and the specific gravity reading from Activity 2, calculate the alcoholic strength as follows:

Alcohol (% v/v) = (1.5184 x oBx) + (-365 x Specific Gravity) + 365

	Relax Riesling	Zonin Primo Amore Moscato	Noble Vines 446 Chardonnay	Hazlitt Red Cat	Sheffield Tawny Port	Fuego Old Vines Grenache
Brix Value	9.2 °Bx	14.0 °Bx	7.0 °Bx	12.5 °Bx	14.8 °Bx	7.8 °Bx
Specific Gravity	1.012	1.038	0.989	1.021	1.011	0.992
Calculated Alcohol % (v/v)	9.5%	7.4%	14.6%	11.3%	18.4%	14.7%
Actual Alcohol % (v/v)	9.0%	7.0%	14.5%	11%	18%	14.5%