Lallemand Australia Technical Note 803A:
Sugar to ethanol conversion by wine yeast

Some basic observations reported in the literature:

- It is a known fact that YEAST (type & strain), vary in their ability to utilise carbohydrates in the formation of ethanol and other by-products

- The Gay-Lussac Equation

  $$C_6H_{12}O_6 \longrightarrow 2CH_3CH_2OH + 2CO_2$$

  180g Sugar is converted to 92g Ethanol and 88g Carbon Dioxide
  BUT, this can only be achieved if there is no yeast growth and ethanol is not lost as vapour. In practice, ethanol yields observed are 90 to 95% of theoretical.

- A number of studies have attempted to accurately predict the sugar to alcohol conversion ratio during wine alcoholic fermentations. However in the absence of a fermentation model that takes all contributing factors into consideration, it has not been possible to declare a reliable sugar to alcohol conversion factor.

- The generally acceptable approach to estimating potential alcohol is to use the measurement of mass per unit volume (density). However we must not forget that sugar is not the only substance in grape must that contributes to density. Density measures (e.g. hydrometry) are used to approximate the amount of sugar present in grape juice.

- Using a density measure, during a normal wine yeast alcoholic fermentation, approximately 17g of sugar per litre produces 1% (by volume) of ethanol.

- The higher the conversion ratio, the lower the alcohol yield

- The official EEC sugar to alcohol conversion ratio is 16.83g sugar per litre for 1% v/v alcohol

Lallemand Investigations:

- Laboratory based investigations, using a standard fermentation environment and 56 wine yeast strains, have shown differences in sugar to alcohol conversions of no more than 0.51% (v/v). These results are consistent with sugar to alcohol conversion ratios between approximately 16.5 to 17.2gm Sugar per litre for 1% v/v Alcohol.

- Revealed that the sugar to alcohol conversion rate is significantly influenced by the fermentation conditions. With any one yeast strain, the quantity of alcohol and carbon dioxide formed from carbohydrates, as well as the nature and concentration of by-products, vary with fermentation temperature, extent of aeration and Yeast Assimilable Nitrogen (YAN) levels.

- For example when individual yeast strains were studied under low and high YAN levels, the sugar to alcohol conversion rate was not consistent. For example, some yeast strains had higher conversion rates at the LOW YAN level, while other strains had higher conversion rates at the HIGH YAN level. The Lallemand study concluded that due to the various influencing factors, characterisation of sugar to alcohol conversion rates for wine yeast remains inconclusive. Perhaps the only exception is that non-*cerevisiae* and non-*Saccharomyces* yeast DO DIFFER from *Saccharomyces cerevisiae* strains. The *S.cerevisiae* strains generally are more efficient at converting sugar to alcohol.

LALLEMAND AUSTRALIA PTY LTD, PO. BOX 327, BROOKLYN PARK, SOUTH AUSTRALIA, 5032
Telephone (08) 8352 7300 **Fax** (08) 83527333. **Email**: amarkides@lallemand.com; jamos@lallemand.com
Revised AJM 080215

Further observations from a Winemaking perspective:

- In general, yeast fermentations at lower temperatures result in higher alcohol yields (partly due to reduced losses in evaporation). This is also a function of the ratio of the fermentation surface to volume ratio and the rate of CO_2 evolution.
- Red wines often have lower alcohol levels than white wines produced from the same initial sugar concentration. Major reasons for this is that:
  - Reds are fermented at higher temperatures (to aid colour extraction) than white ferments
  - Whites are fermented at more reduced (low oxygen) conditions, yielding higher alcohol levels

Final Note*:*

- Where sugar to alcohol conversion ratios are reported for any one yeast strain, it is important that the fermentation conditions are qualified in detail

- Critical to the practical relevance of such reported values is the:

  - Degree of similarity between the reported fermentation conditions with the proposed fermentation conditions under consideration

  - Difference between the initial and final yeast cell biomass for both the reported and the proposed fermentations

Andrew Markides
Lallemand Australia Pty Ltd

References:

Boulton, R.B., Singleton, V.L., Bisson, L.F., and Kunkee, R.E. (1996) Principles and Practices of Winemaking. Chapman & Hall.

Ough, C.S., and AMerine, M.A., (1963) Regional, varietal and type influences on the degree Brix and alcohol relationship of grape musts and wines. Hilgardia 34:585-599

Palacios A., Raginel, F. & Ortiz-Julien, A. (2007) Can the selection of *Saccharomyces cerevisiae* yeast lead to variations in the final alcohol degree of wines ? The Australian & New Zealand Grapegrower & Winemaker. Issue 527. pp71-75.

Ribéreau-Gayon P., Dubourdieu D., Donèche B. & Lonvaud A. (1998) Handbook of Enology Volume 1 The Microbiology of Wine and Vinifications. John Wiley & Sons

Zoeklien, B.W., Fugelsang, K.C, Gump, B.H, & Nury, F.S. (1995) Wine Analysis and Production. Chapman & Hall, New York.