achieve desired sugar and alcohol concentrations?

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Fortified wines, such as Port-style wines, can be made by choosing to ferment the juice or must to a desired sugar concentration and then adding a sufficient amount of a distilled spirit to arrest the fermentation and raise the alcohol to a predetermined level.

In order to carry this out, we have to know the amount of sugar left in the juice at anyone moment in time. In small wineries, a hydrometer is often used for this purpose, because it gives an instant answer and is economical to buy. However, using a hydrometer to estimate sugar concentration is complicated by the presence of alcohol in the juice and causes the hydrometer to sink more, thus indicating a lower Brix than is actually present. One percent v/v alcohol obscures 0.47 Brix (Rankine, 1991). The true Brix is given by:

True °Brix - Obscured °Brix + Measurable °Brix

Measurable Brix is that which is detected by a hydrometer. True Brix is the targeted sweetness of the resulting fortified wine.

Calculations for fortification have two stages. Initially we have to calculate the *measurable* Brix that is associated with the *true* Brix at which we wish to fortify (the fortification point). Then we have to calculate the gallons of distilled spirit to add using Pearsoll 's Square (Rankine, 1991). The calculation will be illustrated by considering the fortification of one barrel of wine to 19% alcohol at a true Brix of 8, using 97% distilled spirit and where the Brix of the grapes at harvest was 34.

Calculating the measurable Brix at the fortification point

Step 1. Calculate the amount of alcohol produced by the time the required sugar concentration has been reached (the fortification point):

% v/v Alcohol produced at the fortification point =
(Initial °Brix at harvest - "True Brix at fortification) x sugar: alcohol conversion factor '
= (34 - 8) x 0.60 = 15.6

1. To calculate the fortification point, we have to make an assumption about the efficiency of conversion of sugar to alcohol. In theory, 1 g sugar is converted into 0.511 g ethanol (Boulton *et al.*, 1996). In practice, production of compounds other than alcohol and carbon dioxide, and evaporation change the observed conversion factor to between 0.55 and 0.63 (Boulton *et al.*, 1996), making it difficult to predict. Some wineries overcome this problem by collecting data over several years and estimating an average value for their white and red varieties. Here, I have assumed it to be 0.60.

Step 2. Calculate *obscuration at the fortification point:*

Obscuration of °Brix = Alcohol at fortification point x 0.47°Brix 15.6 x 0.47 = 7.33

Step 3. *calculate the measurable Brix at the fortification point:*

Measurable Brix at fortification point = True Brix — Obscured Brix

= 8 — 7.33 = 0.67

Therefore, the must should be fortified at a measurable Brix of 0.67 when it will contain 15.6% v/v alcohol.

Calculating the volume of spirit to add

The actual volume to add at the fortification point is calculated using Pearson's Square (Rankine, 1991):

$$\text{Volume of distilled spirit to be added} = \frac{V(D - A)}{C - D}$$

where V = volume of juice or wine, *D -=* desired % v/v alcohol, *A = %* v/v alcohol at fortification point and *C = %* v/v alcohol of distilled spirit.

For our example of fortifying one barrel of wine (220 L) to 19% v/v alcohol with 95% v/v distilled spirit:

$$\text{L of distilled spirit required} = \frac{220(19 - 15.6)}{95 - 19} = 9.84 \text{ L}$$

In conclusion, the calculation indicates that the barrel needs to be fortified with 9.84 L of 95% v/v distilled spirit at a measurable Brix of 0.67. Figure 1 illustrates how a spreadsheet may be set up to help with the calculations.

N.B. Adding alcohol will change the equilibria in the juice or wine and so pH and titratable acidity will need to be checked and adjusted accordingly.

References

BOULTON, R. B., V. L. SINGLETON. L. F. HISSON and R. E. KUNKEL 1996. *Principles and Practices of Winemaking,* New York, Chapman & Hall.

RANKINL, B. C. 1991. *Making good wine,* Australia, Pan Macmillan Publishers.

Fortification calculations using Pearson's Square

Pearson's Square

$$\text{Litres of distilled spirit required} = \text{Liters of wine} \times \frac{\text{Desired Alc} - \text{Initial Alc}}{\text{Alc in distilled spirit} - \text{Desired Alc}}$$

Estimating Brix at which to fortify

$$\%\text{ alc produced before fortification} = (\text{Brix at Harvest} \times 0.60) - (\text{True Brix at fortification} \times 0.60)$$

1% alcohol obscures 0.47 Brix of sugar
Obscured Brix = alcohol × 0.47
Targeted Brix = obscured Brix + measurable Brix
Assume sugar conversion to alcohol is 0.60

User-provided data

Liters of must/wine =	220
Brix at harvest =	34
Targeted Brix at fortification =	8
%v/v alc in distilled spirit =	95
Desired %v/v alcohol =	19

Calculations

Step 1	% alc produced before fortification =	15.60	=(D14*0.6)-(D15*0.6)
Step 2	Obscured Brix at fortification =	7.33	=D19*0.47
Step 3	Measurable Brix at fortification =	0.67	=D15-D20
	Liters of distilled spirit to add =	9.84	=$D$13*($D$17-$D$19)/($D$16-D$17)
	Final sugar concentration (g/L) =	76.6	=10*$D$16*$D$14/($D$14+$D$25)

Fig. 1 Spreadsheet equations for calculating fortification using Pearson's Square.