Question: What are the Carbon Dioxide (CO_2) emissions from the fermentation of wine?

Answer: Emission Factors (as derived below):

$$EF\left(\frac{lb\ CO_2}{1000\ gal\ wine}\right) = 6303 \times VF_{EtOH}$$

Typical VF_{EtOH} : Red = 0.14
White = 0.13

Where VF_{EtOH} is the volume fraction of Ethanol in the produced wine (gal ethanol/gal wine).

Examples:

(a) Red Wine → Volume % ≈ 14% which equates to a Volume Fraction VF_{EtOH} of 0.14

$$EF\left(\frac{lb\ CO_2}{1000\ gal\ wine}\right) = 6303 \times 0.14 = 882\ \frac{lb\ CO_2}{1000\ gal\ red\ wine}$$

If annual red wine production is 20,000 cases per year:

$$20{,}000\ \frac{cases}{yr} \times 2.378\ \frac{gal}{case} = 47{,}560\ \frac{gal}{yr}$$

Then,

$$CO_2\left(\frac{Lb}{yr}\right) = \left(882\ \frac{lb\ CO_2}{1000\ gal\ red\ wine}\right) \times \left(47{,}560\ \frac{gal}{yr}\right) = 41{,}948\ \frac{lb\ CO_2}{yr}$$

(b) White Wine → Volume % ≈13% which equates to a Volume Fraction VF_{EtOH} of 0.13

$$EF\left(\frac{lb\ CO_2}{1000\ gal\ wine}\right) = 6303 \times 0.13 = 819\ \frac{lb\ CO_2}{1000\ gal\ red\ wine}$$

If annual red wine production is 20,000 cases per year:

Then,

$$CO_2\left(\frac{Lb}{yr}\right) = \left(819\ \frac{lb\ CO_2}{1000\ gal\ red\ wine}\right) \times \left(47{,}560\ \frac{gal}{yr}\right) = 38{,}952\ \frac{lb\ CO_2}{yr}$$

Derivation:

$$\text{Sugar} + \text{Yeast} \rightarrow CO_2 + \text{Ethanol}$$

$$C_6H_{12}O_6 + \text{Yeast} \rightarrow 2CO_2 + 2\,C_2H_6O + \text{dead yeast}$$

The premise is that for every lb-mole of ethanol produced we get one lb-mole of CO2.

$$EF = \begin{pmatrix} Vol.\,Fraction \\ Ethanol\,in\,Wine \end{pmatrix} \times \begin{pmatrix} density \\ Ethanol \end{pmatrix} \times \begin{pmatrix} Molar \\ Ratio \end{pmatrix} \times \left(\frac{MW_{CO_2}}{MW_{EtOH}} \right)$$

$$EF = \left(\frac{gal\ EtOH}{gal\ Wine} \right) \times \left(\frac{lb\ EtOH}{gal\ EtOH} \right) \times \left(\frac{1\ lb\text{ - }mol\ CO_2}{1\ lb\text{ - }mol\ EtOH} \right) \times \left(\frac{lb\text{ - }mol\ EtOH}{46\ lb\ EtOH} \right) \times \left(\frac{44\ lb\ CO_2}{lb\text{ - }mol\ CO_2} \right)$$

$$EF = (VF_{EtOH}) \times (6.59) \times \left(\frac{44}{46} \right) \times \left(\frac{1000\ gal}{1000\ gal} \right)$$

$$\boxed{EF\left(\frac{lb\ CO_2}{1000\ gal\ wine} \right) = 6303 \times VF_{EtOH}}$$

Where VF_{EtOH} is typically:

Red ≈ 0.14 (i.e., 14% ethanol by volume)
White ≈ 0.13 (i.e., 13% ethanol by volume)

$$\therefore EF\begin{pmatrix} red\ @\ 14\% \\ by\ Volume \end{pmatrix} = 882 \frac{lb\ CO_2}{1000\ gal\ wine}$$

$$EF\begin{pmatrix} white\ @\ 13\% \\ by\ Volume \end{pmatrix} = 819 \frac{lb\ CO_2}{1000\ gal\ wine}$$

Note: See SBCAPCD Winery Spreadsheet for VOC calculations (www.sbcapcd.org/eng/winery/winery.htm)
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