

**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  $VF_{EiOH}$  is the volume fraction of Ethanol in the produced wine (gal ethanol/gal wine).

## **Examples:**

(a) Red Wine  $\rightarrow$  Volume %  $\approx$  14% which equates to a Volume Fraction  $VF_{FiOH}$  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  $\rightarrow$  Volume %  $\approx 13\%$  which equates to a Volume Fraction  $VF_{EiOH}$  of 0.13

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

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

Then,

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



## **Derivation:**

Sugar + Yeast 
$$\rightarrow$$
 CO<sub>2</sub> + Ethanol

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

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

$$EF = \begin{pmatrix} Vol. \ Fraction \\ Ethanol \ in \ Wine \end{pmatrix} \times \begin{pmatrix} density \\ Ethanol \end{pmatrix} \times \begin{pmatrix} Molar \\ Ratio \end{pmatrix} \times \begin{pmatrix} MW_{CO_2} \\ MW_{EtOH} \end{pmatrix}$$

$$EF = \left(\frac{gal\ EtOH}{gal\ Wine}\right) \times \left(\frac{lb\ EtOH}{gal\ EtOH}\right) \times \left(\frac{1\ lb\ -mol\ CO_{2}}{1\ lb\ -mol\ EtOH}\right) \times \left(\frac{lb\ -mol\ EtOH}{46\ lb\ EtOH}\right) \times \left(\frac{44\ lb\ CO_{2}}{lb\ -mol\ CO_{2}}\right)$$

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

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

Where  $VF_{EtOH}$  is typically:

Red  $\approx 0.14$  (i.e., 14% ethanol by volume)

White  $\approx 0.13$  (i.e., 13% ethanol by volume)

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

$$EF \left( \begin{array}{c} white @ 13\% \\ by Volume \end{array} \right) = 819 \frac{lb CO_2}{1000 \ gal \ wine}$$

Note: See SBCAPCD Winery Spreadsheet for VOC calculations (<a href="www.sbcapcd.org/eng/winery.htm">www.sbcapcd.org/eng/winery.htm</a>)

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