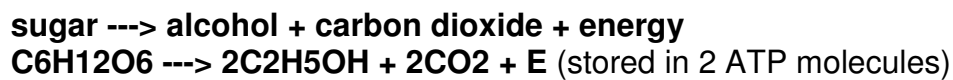


## Fermentation and Respiration

The fermentation process is completed with the liberation the waste products of alcohol and carbon dioxide. At that point all of the chemical energy in glucose has been extracted that *can* be extracted without using oxygen. In a stepwise series of chemical reactions, fermentation converts the single glucose fuel molecule to one ethyl alcohol molecule, one carbon dioxide molecule, and energy. If we look at the overall reactants and products of fermentation, we see that the energy produced is that which was produced early in the process and was sufficient for storage in two ATP molecules. Important: The two NADH molecules that were formed during glycolysis are both used up during the last stage. Therefore, during fermentation you cannot count the NADH as energy production.



The ethyl alcohol produced in fermentation is the alcoholic component of beverages such as beer, wine, and whiskey. Brewer's yeast is the organism used to produce alcoholic beverages. If yeast is placed into a solution containing sugar (such as natural grape juice) and air is excluded from the container by an air lock, the yeast will metabolize the organic fuel of sugar to extract energy to sustain and perpetuate its life processes.

Since yeast does not have any oxygen available during brewing, it must use the process of fermentation to obtain the energy it needs.

The fermentation process used by the yeast yields the alcohol the brewer is interested in. The carbon dioxide produced by the reaction is allowed to escape from the fermentation vat. If a brewer wants to control the amount of alcohol in a product (beer, 4 to 6%; wine, 10 to 12%), it is clear that he/she must control the amount of sugar in the original solution.

The amount of sugar made available to the yeast will limit the amount of *all* products of fermentation-the alcohol (for the brewer), the carbon dioxide (as waste), and the energy (for the yeast). The yeast cells will die after a while if more sugar is not made available to them. Why?

*Answer:* They need the energy to survive.