Ethanol

Shannon and Ian Jacobs

Apples contain fructose, sucrose and a little glucose: download the pdf below and see … https://www.Apple sugars

McDonald's in Bangkok sell three apple slices in a sealed bag. The bagged apple makes an easy demonstration of fermentation, the production of alcohol from sugar by the action of yeast, which is a type of fungus. Enzymes in the yeast convert sucrose to glucose and fructose and the yeast converts these simple sugars to alcohol and carbon dioxide.

Leave a packet of bagged apple in a warm place for a week beyond it's use-by date. Room temperature here varies from 28ºC at night to 34ºC during the day. In a cooler climate find somewhere that's about 28ºC.

After about a week, if all goes to plan, the bag will have blown up like a balloon. The corner of this tight bag was cut off and the gas inside was carefully expelled into a glass. Assuming the gas is carbon dioxide, which is heavier than air, it will stay in the glass for a few minutes.

The inside of the bag smelt strongly of alcohol.

The gas in the glass put out a candle flame. The limewater test (see *Limewater* in the Chemistry index) would confirm that the gas was CO_2.

Carbon dioxide will not support burning.

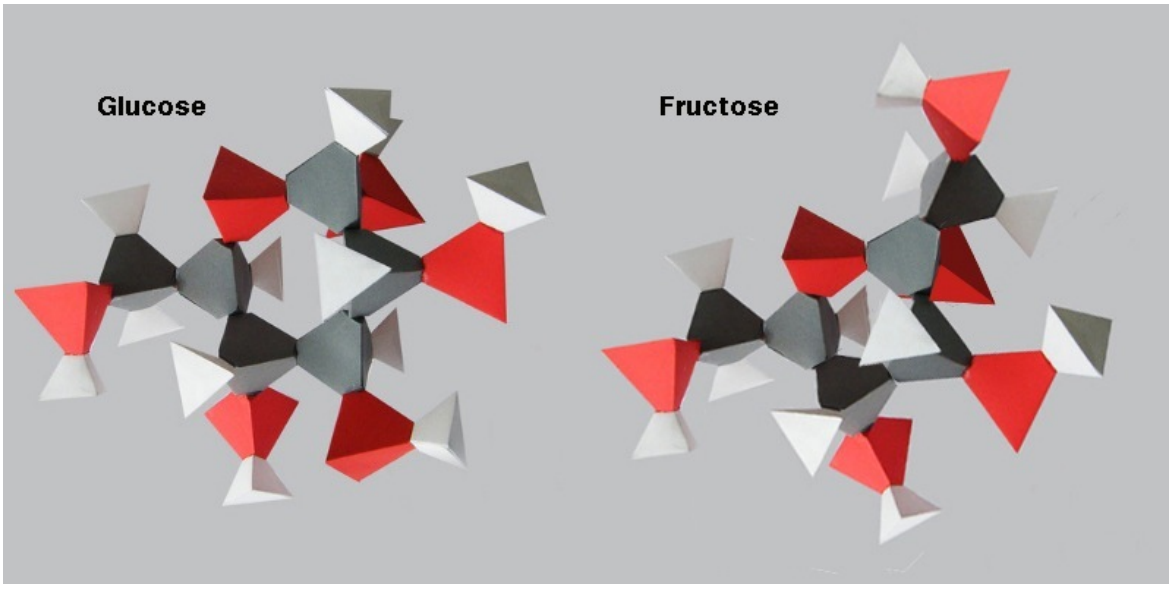
The fructose and glucose that are converted to alcohol are *isomers*, meaning, they have the same chemical formula, $C_6H_{12}O_6$, but their molecules have different structures.

The reaction of these simple sugars with yeast takes place in water to produce ethanol and carbon dioxide.

$$C_6H_{12}O_6 \longrightarrow 2C_2H_5OH_2 + 2CO_2$$

Note that fresh air (oxygen) is *not required* for this reaction which takes place in a sealed container.

Paper models of glucose and fructose molecules

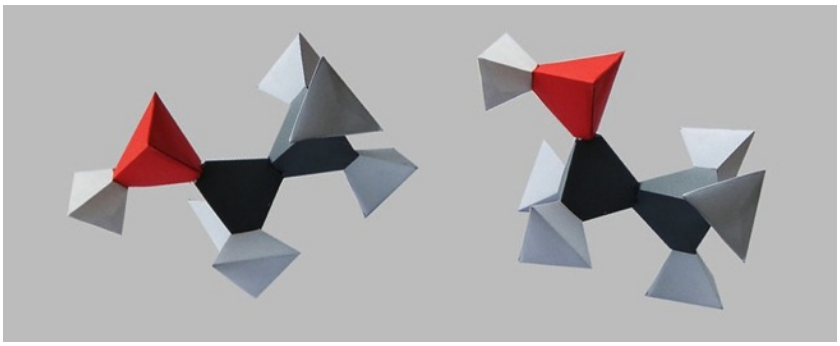


To make these models yourself, download the pdf below. Read Paper models in the Chemistry index.

Glucose (on the left) is a ring structure of five carbons and one oxygen. Four OH groups are linked to four ring carbons and the carbon next to the oxygen in the ring has a CH_2OH group attached.

Fructose (on the right) is a ring of four carbons and one oxygen. Two CH_2OH groups are attached, one on each side of the oxygen.

Two molecules of ethanol



The ethanol molecule (the alcohol that people have been drinking for thousands of years) has two carbon atoms, one OH group and five hydrogens attached to the carbons.

Preventing decomposition

Putting wedges of apple in a plastic bag yourself, sealing it, and leaving it for a week or two will probably not produce alcohol and CO_2. The apple will most likely become slimy, may turn black, and if left for long enough becomes a nasty smelly liquid. Bacteria, present on our skin and in the air, set up decomposition and prevent any yeasts present from turning the sugars into alcohol.

As everyone who has made their own wine or beer knows, the most important thing when brewing with yeast is to *sanitise* all the containers and equipment before a new brew is laid down. Chemical sanitising removes live bacteria and wild yeasts. The chemical that home brewers use to do that is sodium hypochlorite, NaClO, commonly known as bleach. It is diluted with water. Equipment that's been cleaned and sanitised with hypochlorite is rinsed to remove any taint to the finished product.

McDonald's packaged apple has been sanitised to prolong its shelf life and it ferments rather than decomposes over time, avoiding the need for us to handle chemicals to prevent decomposition.