Bubbly Yeast

Introduction: Yeast are single-cell microscopic fungi. When they grow using sugars as a source of energy, yeast produce the gas, carbon dioxide. This process is called fermentation. The formula for the chemical reaction is:

$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$
Sugar Ethyl alcohol Carbon dioxide

Fermentation has been used for thousands of years to make bread, as well as beer, wine, and other alcoholic products. In bread, the carbon dioxide produced from sugar causes the dough to rise to make a light, slightly spongy loaf of bread. In beer production, the carbon dioxide produced from sugar fermentation is trapped in the solution to make a fizzy, or carbonated drink (carbonated means that it has carbon dioxide under pressure in the solution).

The yeast that we are using in these experiments is baker's yeast. As the yeast ferment sugar they produce carbon dioxide. When carbon dioxide is bubbled through water some of it dissolves in water. When it is dissolved in water, carbon dioxide forms carbonic acid, making the solution slightly acidic. We can see this acidity by using a colored solution, cabbage water, that changes color when the solution is acidic or basic.

Objective: To observe the production of carbon dioxide gas by yeast.

Safety note: There are no specific safety concerns with this lab; however, students should always keep their work areas clear and clean and wash their hands after a lab activity.

Materials (per group)
- baker's yeast in a jar or beaker – about 2 tsp.
- sugar – about 3 tsp.
- warm water (about 85-90° F) – about 1 cup
- plastic spoon- about 1 tsp.
- water bottle with sipping spout
- modeling clay
- latex tubing to fit over spout of water bottle (about 12-15 inches per bottle)
- beaker of cabbage water solution

Procedure
1. Add entire amount of yeast to about one cup of warm water (about 85-90° F).
2. Add 2 tsp. sugar to the yeast and stir to mix. (At least one group of students should do a control experiment in which no sugar is added to the water and yeast.)
3. Pour the mixture into a plastic bottle that can be sealed and has a spout for latex tubing (many water bottles will work fine).
4. Seal the bottle tightly and attach the tubing.
5. Pour a small amount of cabbage water into a jar. Note the color of the cabbage water and describe it in your notebook.
6. Insert the tubing from the bottle containing the yeast into the cabbage water.
7. In a few minutes you should observe bubbles coming from the tubing. (If you do not observe bubbles after the yeast solution has started to froth, you probably have a leak in your bottle or tubing. Use modeling clay to seal leaks.)
8. Observe the gas bubbles coming from the tubing. Observe the color of the indicator solution as the bubbles come from the tubing. Every few minutes describe the color of the cabbage water in your notebook.

Results
Observe and record whether bubbles were produced by the yeast. You may also observe the rate of bubble formation (how fast the bubbles form). Compare your results with the control group that did not add sugar to the yeast. Observe and record the change in color of the cabbage water as the water becomes more acidic. Compare your results with the control group that did not add sugar to the yeast.

Teacher Instructions

In advance

1. Purchase baker's yeast and sugar. Various sugars can be used. Sucrose and fructose are readily available at the grocery store as powders. Dextrose is glucose.
2. Assemble bottles and tubing to be sure they are airtight.
3. An alternative to the plastic bottle is to buy fermentation locks from a store that sells beer and wine making equipment and attach it with a one-hole rubber stopper to a bottle (no more than 16 oz.) containing the yeast solution. The indicator solution is poured into the reservoir of the fermentation lock. Bubbles of carbon dioxide are easily observed in the fermentation lock.
4. Make cabbage water solution: 1) chop red cabbage and pack it into a quart jar, 2) cover cabbage with boiling water, 3) leave until cool and pour out blue cabbage water through paper towel filter into jar for use. Discard cabbage. May be stored in the refrigerator for several days or in the freezer for future use. Blue = basic; purple to pink = acidic.
5. An alternative to cabbage water is a 0.01% solution of bromthymol blue. You may have to add a few drops of 1% sodium hydroxide to make it bright blue, but do not add much or it will take too long to turn the indicator yellow in the experiment. Blue = basic; green to yellow = acidic.

Day of lab

1. Measure dry yeast and sugar into beakers for each group.
2. Assemble remaining materials, including the cabbage water.
3. Provide warm water just before the experiment. If the water is cool, the color change will be very slow.

Additional activities related to carbon dioxide production:

1. To demonstrate that carbon dioxide bubbled through the indicator causes the solution to turn color, students may place a small amount of fresh indicator solution in a jar and blow bubbles through the solution with a straw. The carbon dioxide in their exhaled breath will also cause a change in the indicator. (It takes a lot of breath to turn the color of cabbage water, but it is fairly easy to change bromthymol blue from blue to yellow with your breath.)
2. To demonstrate that ordinary air will not change the color of the indicator, tubing attached to an aquarium pump can be used to bubble air through the indicator. It should not change color.
3. Mix flour into a solution of yeast, sugar and water to produce a soft dough. As a control, make the same dough, but leave out the yeast. Leave the dough to rise and have the students observe the change in volume in each type of dough. Allow students to poke the dough to feel the soft spongy texture produced by the small bubbles of carbon dioxide produced by the yeast in one of the dough balls.
4. Repeat the experiment above using different sugars. Observe which sugars give the best fermentation by the rate at which bubbles are formed. In place of sucrose you may try fructose or glucose (dextrose). You may also try fruit or vegetable juices (tomato, apple, lemon, grape, grapefruit, orange, or any other). Milk contains lactose as the primary sugar but it also has other sugars. Non-nutritive sweeteners like aspartame can also be used (they do not have a fermentable sugar); however, be aware that the "inert filler" in some of these sweeteners is glucose (a good fermentable sugar)!

Points for discussion:

1. Carbon dioxide is made by yeast as they grow using sugars as a source of energy.
2. Carbon dioxide is a gas that makes bubbles.
3. Carbon dioxide produced by yeast and by humans can dissolve in water and change the acidity of the solution.
4. Sugar is required for carbon dioxide production and for growth by yeast.
5. Carbon dioxide produced by yeast causes bread dough to rise.
6. Carbon dioxide produced by yeast causes the bubbles in beer.
7. Fermentation by yeast is very important for many industries around the world.
8. Mold and mildew are undesirable fungi that grow on food, leather, and a variety of household surfaces.

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