An Aerobic Exercise: Yeast Metabolism with and without Aeration

https://www.sciencebuddies.org/science-fair-projects/project-ideas/MicroBio_p009/microbiology/yeast-metabolism-aerobic-anaerobic (http://www.sciencebuddies.org/science-fair-projects/project-ideas/MicroBio_p009/microbiology/yeast-metabolism-aerobic-anaerobic)

Last edit date: 2017-07-28

Experimental Procedure

Working with Biological Agents

For health and safety reasons, science fairs regulate what kinds of biological materials can be used in science fair projects. You should check with your science fair's Scientific Review Committee before starting this experiment to make sure your science fair project complies with all local rules. Many science fairs follow Intel® International Science and Engineering Fair (ISEF) regulations. For more information, visit these Science Buddies pages: Projects Involving Potentially Hazardous Biological Agents (http://www.sciencebuddies.org/science-fair-projects/project_src_biological_agents.shtml) and Scientific Review Committee (http://www.sciencebuddies.org/science-fair-projects/project_src.shtml). You can also visit the webpage ISEF Rules & Guidelines (http://www.societyforscience.org/Page.aspx?pid=312) directly.

Setting Up the Gas Collection Apparatus

1. Remove the small red cap from one of the squeeze bottles. Then connect the tubing to the tip opening, as shown in Figure 2. Make sure that you have a tight fit.

Figure 2. Tube connected to the bottle opening.

2. You will be collecting carbon dioxide from the yeast by displacing water trapped in an inverted graduated cylinder. Here's how to set it up:
    a. Fill your plastic dishpan (or bucket) about one-third full with water.
    b. Fill the 100-mL graduated cylinder with water.
        i. If your dishpan is deep enough, fill the graduated cylinder by tipping it on its side inside the dishpan. Allow any bubbles to escape by tilting the cylinder up slightly, while keeping it under water. Keeping the opening of the cylinder under water, turn it upside down and attach it to the side of the dishpan with packing tape (or have your helper hold it in place).
        ii. If your dishpan is not deep enough, fill the graduated cylinder completely using the faucet and cover the top tightly with plastic wrap. Quickly invert the cylinder and place the opening in the dishpan, beneath the surface of the water. Remove the plastic wrap. Attach the cylinder to the side of the tub with packing tape (or have your helper hold it in place).
    c. The graduated cylinder should now be upside down, full of water and with its opening under the surface of the water in the dishpan. Place the free end of the tubing from the plastic bottle inside the graduated cylinder. Your apparatus is now ready to trap carbon dioxide from the yeast (see Figure 3).

Figure 3. Picture of the inverted graduated cylinder gas collection apparatus.

d. You can test your gas collection apparatus by removing the tube from the bottle top and blowing gently into the tube. The bubbles you create should be captured inside the cylinder. (You will need to reconnect the tube to the bottle and re-fill the cylinder before starting your experiment.)

Running the Experiment

1. Make a data table in your lab notebook to record your data in.
    a. The conditions you will be testing are with oxygen and without oxygen. You will do at least three trials for each condition.
2. Label one bottle "+air" and the other bottle "−air".
3. You will be making one solution at a time (unless you decide to set up more than one gas collection apparatus). It is important to use the same water temperature each time you make a solution, since yeast activity is temperature-dependent.

4. Test the yeast with a solution that has oxygen.
    a. Boil ½ cup of water and let the water cool to between 43–46°C (about 110–115°F).
    b. Dissolve 1 teaspoon (tsp.) of sugar in ½ cup of warm water. Stir slowly and gently.
    c. When the sugar is fully dissolved, aerate the solution with the aquarium aerator pump and airstone, as shown in Figure 4, below. After 5 minutes, stop aerating the solution.
    d. Next add and mix in ½ tsp. of yeast.
    e. Pour the entire solution into the "+air" bottle. Be sure to note the actual temperature of the water in your lab notebook.
    f. Cap the bottle tightly with your "tube cap," and place the open end of the collection tube inside your gas collecting cylinder. Note the starting time in your lab notebook.
        i. There should be water in the tubing as soon as it is submerged in the water. The CO_2 gas will push some water out of the tubing before the graduated cylinder starts to fill with CO_2 gas.
    g. Within 5–10 minutes, the yeast solution may start foaming, and you may see bubbles collecting in the graduated cylinder. If you observe them, note the time when you first start seeing bubbles in your lab notebook.
    h. To promote oxygen circulation in the yeast solution, periodically gently "swirl" the bottle to stir the contents.
    i. Decide how long to collect CO_2 (somewhere between 15–30 minutes is probably good, but you may need to adjust for your particular conditions). Use the same amount of time for all of your tests.
        i. *Note:* Do not let the graduated cylinder become completely filled with CO_2, but instead stop it before this point. If you let it become completely filled, and the next condition you test makes even more CO_2, this could lead to poor and inaccurate results because your graduated cylinder may fill up before your test time is over.
        ii. *Tip:* If your solution makes a large amount of CO_2 very quickly, you can try to make it produce less CO_2 by using less sugar and possibly less yeast. For example, you could repeat this step using ½ tsp. sugar (instead of 1 tsp.) and ¼ tsp. yeast (instead of ½ tsp.).
    j. When the time is up, note how much CO_2 was collected. Record your results in the data table in your lab notebook.

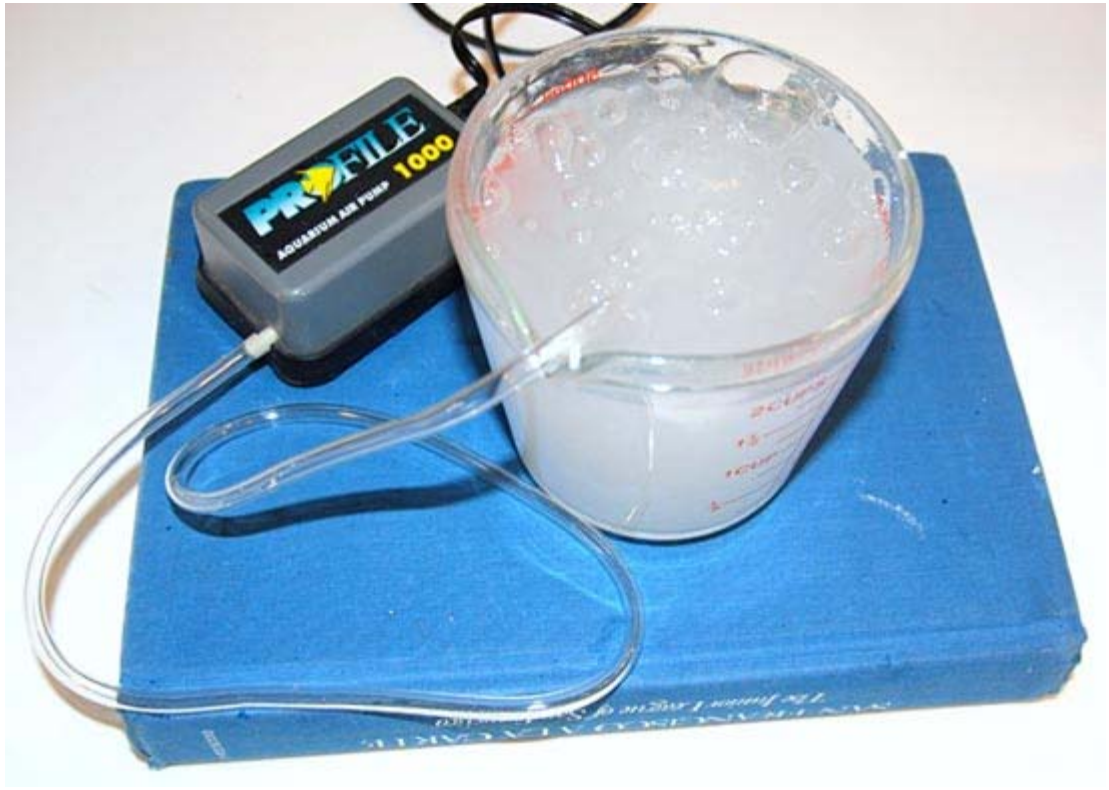

Figure 4. Aeration of the sugar solution using the aquarium aerator pump and airstone.

5. Re-fill your gas collection cylinder to reset your gas collection apparatus. Carefully rinse out the yeast solution from the bottle.
6. Repeat steps 4 and 5 at least two more times.
    a. You should run at least three separate trials for each condition.
7. Repeat steps 4–6 but this time test the solution *without* oxygen by making the following changes:
    a. Skip step 4 c so that you do not aerate the solution.
        i. Boiling the water should have minimized the dissolved oxygen in the water.
    b. In step 4 e, pour the solution into the "-air" bottle and cap it, placing the open end of the collection tube inside your gas collecting cylinder.
    c. Skip step 4 h, as you do not want to promote oxygen circulation this time.
    d. Be sure to note the starting time in your lab notebook and, if you observe them, note the time when you first start seeing bubbles in your lab notebook.

Analyzing Your Data

1. Calculate the average volume of the CO_2 produced for each condition you tested and write this in your lab notebook.
2. Make a graph of your results.
    a. Write the different conditions ("+air", "-air") on the x-axis (the horizontal axis).
    b. Plot the corresponding average volume of CO_2 produced on the y-axis (the vertical axis).

3. Which condition produced more CO_2? What is the ratio of CO_2 production between the two conditions? Is this consistent with your expectations from your background research?