Biofuel Blast

Key Concept:
How biofuels are made through the process of fermentation

Grade Level: 1-7

Education Subject: Science

Success Indicator:
After participating in this activity, learners will be able to:

- Explain that sugar in corn and other cellulose (plant materials) can be converted into biofuels through fermentation.
- Conduct a science experiment.
- Demonstrate how to compare and contrast treatment results from an experiment.

National 4-H Curriculum:
2009 National 4-H Science Experiment Biofuel Blast, 4-H National Youth Science Day

Materials and Methods

Preparation Time:
10-20 minutes

Lesson Time:
45-60 minutes; 10 minutes (or longer) to observe bottle

Space: Any

Materials:

- Clean, empty 20-ounce plastic water bottles with caps (one per learner and two additional bottles to be used as controls; fewer if learners will be working in groups)
- White granulated sugar (3 tablespoons per learner or group if learners will be working in groups)
- Warm tap water (enough to half fill each plastic bottle)
- One packet (equal to 1 tablespoon if using a jar or bulk package) of active dry yeast or dry quick-rise yeast per learner or group
- 9-inch latex balloons (one per learner; use nonlatex balloons if you or any learners are allergic to latex)
- Scissors (one per group)
- String or yarn to measure diameter of balloon
- Measuring tape or ruler (one per group)
- Small plastic or paper funnels (one per learner)

Instructions:

Preparation time:

Read through the activity and gather the supplies from the materials list.

Lesson time:

1. Tell the learners they're going to learn about biofuels in this activity. Read aloud or paraphrase the following:

   Yeast breaks down sugars to get energy, the same way that eating sugars gives your body energy. In the process, the yeast releases two waste products: carbon dioxide (the same gas that you exhale) and ethanol (a liquid that can be used as a biofuel). Ethanol is mixed with water in the experiment and is invisible.

   *Ethanol is a type of **biofuel** energy obtained from recently harvested plant materials. (**Fossil fuels** such as coal or oil are sources of energy from plants and animals that died a very long time – millions of years – ago.). The sugars inside of corn kernels can be broken down by yeast to make carbon dioxide and ethanol. In a chemical plant, the ethanol is removed from the mixture to make a fuel that is mixed with gasoline and sold at some gas stations.* You may have

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Developed jointly by the University of Wisconsin-Madison Extension Service, Wisconsin 4-H, the Great Lakes Bioenergy Research Center, the National 4-H Council, the National 4-H Headquarters at U.S. Department of Agriculture, and the National 4-H Science, Engineering and Technology Leadership Team, as part of the 4-H National Youth Science Day initiative.

Vocabulary:

Biofuel – A fuel (a material that can be burned as a source of energy) that comes from recently harvested material such as corn kernels, as opposed to fossil fuels such as oil and gas, which come from material that died a long, long time ago.

Carbon dioxide – A gas that is released when you exhale; is a product of fermentation of sugars by yeast in this experiment; and is implicated in global warming when present in high levels in our atmosphere.

Cellulose – A major component of plant material; it is not digestible by humans and is part of dietary fiber. It is the most common organic compound on earth.

Circumference – A measure of the distance around a sphere.

Control – A part of a scientific experiment that acts as a standard and does not include the variable being tested.

Ethanol – A liquid produced by the fermentation of sugars by yeast; it can be mixed in a refinery with gasoline and used as a fuel in car engines.

Fermentation – Generally, the process by which organisms such as yeast break down substances for energy without using oxygen. In this experiment, the fermentation of sugars by yeast produces energy for the yeast and releases carbon dioxide and ethanol as waste products.

Fossil fuels – Sources of energy such as coal and oil, which come from plants and animals that died a very long time ago.

Renewable energy – Energy from sources such as the sun or wind that can be replenished.

Variable – Something that can vary, or differ, in a scientific experiment.

Yeast – A type of fungus that is made up of only one cell per organism (as opposed to a mushroom, for example, which is a fungus that is made up of lots of cells per organism).

noticed this at the gas pump, where signs may read "E10," which means the fuel mixture is 10 percent ethanol and 90 percent gasoline.

In the United States, most ethanol is made from corn. In this experiment, we're going to observe how yeast can break down processed sugars (such as granulated sugar and sugars found in corn syrup) through fermentation. We'll also see if yeast can use other plant products to make biofuels.

2. (**Note:** Depending on your space, time and equipment constraints, you may want to have the learners work in small groups. For simplicity, these instructions are written as if the learners will be working individually.) Have the learners collect the supplies they'll need for the experiment.

3. Tell them to use a funnel to add 1 tablespoon of yeast and 3 tablespoons of sugar to their empty bottles, then fill each bottle half full with warm tap water. (The water should be very warm to the touch but not so hot that it is painful or scalding.) Tell them to replace the cap on the bottle tightly, then shake it to mix the yeast and sugar in the water.

   Prepare your two controls: use a funnel to add 1 tablespoon of yeast to each of the two additional bottles and fill each bottle half full with warm tap water. Do not add any sugar.

4. After the contents are thoroughly mixed, have the learners remove the bottle caps again and place a balloon over the open top of each bottle, then observe what happens. Do the same with the two bottles used as controls. It will take a few minutes for the yeast to start eating the sugar, but soon learners will see their balloons starting to inflate, but they will see no change in the two control bottles. Explain that carbon dioxide gas is filling the balloons. Carbon dioxide is the same gas that humans and other animals exhale when breathing. As the yeast organisms eat the sugar in the bottle, they release waste products, one of which is carbon dioxide. However in the two controls there is no sugar available for the yeast to eat and the yeast can not release any carbon dioxide, which would make the balloon inflate.

5. When the balloons seem to have reached a stable state, have the learners measure their balloons to find out which one contains the most carbon dioxide. Show them how to cut a long piece of string, wrap it around the largest part of the balloon and mark where the string begins and ends while it is wrapped around the balloon. Then have them measure the length of the string from mark to mark with a measuring tape. This is called measuring the circumference. Have them compare the circumferences of the balloons by placing all of the measurements side by side or hanging them on the wall.

Check for Understanding:

After the learners have compared the circumferences of all the balloons, return their attention to the group and ask them the following questions:

- What happened during the activity — what did you observe?
- How large was the circumference of your balloon after 10 minutes (in inches)?
- How large was it after one hour?
- What changes did you observe in the two controls?
- Can you convert that size between inches and centimeters? Why do most scientists use metric measurements?
- For older students: Can you calculate the approximate volume of the carbon dioxide inside the balloon and share it with everyone? (**Note:** You may have to remind them of the formula for figuring the volume of a sphere.)
- Were there any differences in the sizes of the balloons? Why do you think this might be?
- Do you think the yeast might eat other types of food to make carbon dioxide?
- When you make bread, you add yeast to make the bread rise. Now that you have seen what happens when yeast eats sugar, how do you think the yeast makes the bread rise?
- What do you think would happen if you added very hot water to the yeast? (Note: Do not attempt this without adult supervision. Hot water may cause injury.)

Ways to Extend:

In small-group experiments, see how yeast can break down processed corn sugars (such as those found in corn syrup) and other plant products (such as dried ground-up leaves or wheat bran from the grocery store) to make biofuels. Have learners experiment with other variables (water temperature, amount of sugar, yeast, cellulose source, etc.). Your possibilities are limitless!

Find more information at the archived 2009 4-H Biofuel Blast site at: *https://site.4-h.org/nysd/archive.php*.

- The youth work sheets are at *https://site.4-h.org/nysd/misc/pdfs/experiment_guides/4-H_NYSD_Youth_Worksheets.pdf*.
- The facilitator guide is at *https://site.4-h.org/nysd/misc/pdfs/experiment_guides/4-H_NYSD_Facilitator_Guide.pdf*.

Michigan Grade Level Content Expectations:

Grades 1-4: Manipulate simple tools (S.IP.01.14, S.IP.02.14, S.IP.03.14, S.IP.04.14); demonstrate scientific concepts through various activities (S.RS.01.11, S.RS.02.11, S.RS.03.11, S.RS.04.11); generate questions based on observations (S.IP.01.12, S.IP.02.12, S.IP.03.12, S.IP.04.12); plan and conduct simple investigations (S.IP.01.13, S.IP.02.13, S.IP.03.13, S.IP.04.13); share ideas about science through purposeful conversation (S.IA.01.12, S.IA.02.12, S.IA.03.12, S.IA.04.12); communicate and present findings of observations (S.IA.01.13, S.IA.02.13, S.IA.03.13, S.IA.04.13);

Grades 5-7: Design and conduct scientific investigations (S.IP.05.12, S.IP.06.12, S.IP.07.12); use tools and equipment appropriate to scientific investigation (S.IP.05.13, S.IP.06.13, S.IP.07.13); investigate/evaluate data, claims and personal knowledge through collaborative scientific discourse (S.IA.05.12, S.IA.06.12, S.IA.07.12); communicate and defend findings of observations and investigations using evidence (S.IA.05.13, S.IA.06.13, S.IA.07.13).

Grades 3-4: Make accurate measurements with appropriate units (S.IP.03.15, S.IP.04.15).

Grade 3: Describe ways humans are protecting, extending and restoring resources (E.ES.03.43); describe helpful or harmful effects of humans on the environment (E.ES.03.52); describe how materials taken from the earth can be used as fuels for heating and transportation (E.SE.03.32).

Grade 4: Identify current problems that may be solved through the use of technology (S.RS.04.17); compare and contrast the states of matter (P.PM.04.23).

Grade 6: Identify kinetic or potential energy in everyday situations (P.EN.06.11).

Grade 7: Identify evidence of chemical change through color, gas formation, solid formation and temperature change (P.CM.07.21).