Classroom Variation: Guided Inquiry

Overview: *Fermentation with a Bag, Bottle and Baloon*

Students work in small groups ("research teams") to investigate two guiding questions: 1.) "Which feedstock will produce the largest volume of CO_2 gas?" and 2.) "What methods could be used to collect data to measure volume of CO_2 produced?" Student teams a are given flexibility to choose reseach questions, feedstock options and data collection methods. Example feedstocks could include, ripe versus unripe bananas, breakfast cereals, sugar, corn starch, sawdust, etc. Example data collection could include measuring bag volume, time to bag inflation, baloon inflation circumference, or Vernier CO_2 gas pressure sensors. Dr. Ken Newberry, Science Methods Instructor at Bowling Green State University and alum of the GLBRC Bioenergy Institute for Educators, shared a variation on fermentation in a bag that he successfully uses with pre-service middle school science teachers.

Suggested Materials and Supplies:

The suggested materials and supplies listed on the follow page are necessary to provide flexibility in the inquiry lab. Teachers may choose to limit the supplies due to time and developmental needs of students. The basic supply list includes the feedstock, containers and simple means to measure the volume/production of CO_2 gas. Classrooms with ethanol, CO_2 or pressure probes may choose to use them to provide a more exact data measurement. Various solutions and the use of fruit for a feedstock are options for an extension to the lab presented here. Instructors and students are encourged to be creative with investating different feedstock options, measurement techniques and the effects of different treatments.

Students use the Fermentation in a Bag investigate a range of feedstocks, including breakfast cereals. They also develop creative method to measure volume of CO2 produces by different feedstocks. Students picitured above measure the circumference of baloons as an indicator of CO2 production during fermentation.

Suggested Materials and Supplies List:

- Feedstock options: Corn starch, sugar, saw dust, snack bag sample of different cereals (with nutrition label), (optional): ripe & unripe banana
- Solution: Water, salt (optional), corn syrup (optional)
- Microbes: Yeast
- Glassware: 250ml Erlenmeyer Flasks or flat bottom test tubes/round test tube, test tube holders
- Other: Snack size and Quart size Ziploc bags, balloons , graduated cylinders, measuring spoons, thermometers, Optional:s, rubber tubing, tape measure, gram scale.
- Safety: Goggles required

Procedure:

The following procedure for guiding students through this investigation is presented based on the "5E Instructional Model," this procedure can easily be adapted to different instructional approaches. Learn more about this instructional model here: *http://www.bscs.org/bscs-5e-instructional-model*.

1. **ENGAGE:** Prior to the introduction of this lab, students are asked to bring in one small snack size baggie with a favorite cereal and a copy or cutout of the nutrition label. Upon entering the classroom, students participate in a shortened version of the traditional GLBRC lab, "Fermentation in a Bag." This was used as a "Science Starter" or warm-up activity.

   An overview of the unit is provided after discussing the initial Fermentation in a Bag activity. Two essential questions are asked: "Which feedstock/cereal will produce the largest volume of CO_2 gas?" and "How can data/evidence be collected to measure CO_2 gas?" In small groups, students are asked to brainstorm their own questions which could lead to an investigation. (Optional: Distribute a "Claims-Evidence-Reasoning" sheet to structure student investigation) Prior to division into "research teams" a review of materials/supplies, procedures and safety procedures is provided.

2. **EXPLORE:** Divided into research teams, students complete the following steps as they plan and carryout their investigation:

   a. BRAINSTORM AT LEAST TEN RESEARCH QUESTIONS. SELECT ONE QUESTION TO INVESTIGATE. (Example: How does temperature affect CO_2 gas production).
   b. MAKE A CLAIM.
   c. IDENTIFY DEPENDENT & INDEPENDENT VARIABLES.
   d. DECIDE HOW TO MEASURE YOUR DEPENDENT VARIABLE.
   e. DESIGN AN INVESTIGATION THAT WILL PROVIDE RICH DATA (EVIDENCE) IN A CONTROLLED EXPERIMENT.
   f. CHECK WITH THE INSTRUCTOR BEFORE BEGINNING YOUR INVESTIGATION.
   g. CONDUCT AN INVESTIGATION WITH A CONTROL
   h. COLLECT DATA
   i. DISPLAY DATA
   j. PRESENT: USE DATA TO SUPPORT OR REFUTE YOUR CLAIM.

3. **EXPLAIN**: Research teams present preliminary findings during an informal data presentation session. Teams are asked to restate their "claim" or hypothesis, describe or prepare a data table or graph with their data and provide their reasoning for their results using the data they collected.

4. **EXTEND:** (Optional-time permitting) Students may refine or extend their investigations to explore new questions or collect new data with revised procedures based on what they learned in their first investigation.

5. **EVALUATE:** Students summarize findings across all research investigations. Teachers may provide an exit slip or ask students to provide a brief response to questions from the investigation.

COMMENTARY AND MODIFICATIONS:

With the constrains of a typic science classroom, there is rarely enough time, money for supplies or capability for students to do more than surface-level investigations. In this lab, teachers may allow students to design most phases of a true investigation including how to collect data, design and standardize procedures and ask questions that lead to investigations. Adding cereal as a feedstock to this lab added high interest for students and provided a surprising finding. In their lab, students found that Cheerios produced more CO_2 than Corn Pops. This led to a better comparison of the sugar content by weight and volume on the cereal labels.

When time is limited, teachers may select the data collection method of choice using 9" balloons (check for latex allergies) or probes (CO_2/pressure) from the lab. To further limit time, teachers may choose to allow a group brainstorm of research questions and then select one or two from the list that all groups will investigate.

Special thanks to Dr. Ken Newberry, Science Methods Instructor at Bowling Green State University and alum of the GLBRC Bioenergy Institute for Educators, who shared this variation on fermentation in a bag that he successfully uses with pre-service middle school science teachers.