SUSTAINABLE BIOECONOMY

FOR ARID REGIONS

SBAR

# MEASURING

# FOOD AS FUEL

## OVERVIEW

In this lesson students learn how to calculate the number of calories in a food item. Through a lab experiment, students will calculate changes in mass and temperature to determine calories. Students will gain an understanding of the way to measure energy content in food.

Matthew Katterman, Tracy Klein and Matt Swanson

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# Measuring Food as Fuel

STUDENT LEARNING OBJECTIVES:

After completing this lesson, students will be able to:

1. Understand the nutrient content of foods and that food contains energy measured in units of calories.
2. Understand concept of energy conservation and the transference of energy from one object to another.
3. Demonstrate that they can effectively use a graduated cylinder to measure volumes and a balance to measure mass.
4. Calculate the energy in the food by multiplying the difference in temperature and mass of water in the heated container.

TIME REQUIRED:

60-70 minutes

20 min teacher preparation

RESOURCES:

1. Measuring Food as Fuel Lesson Plan
2. Measuring Food as Fuel PowerPoint Presentation
3. Measuring Food as Fuel Worksheet

EQUIPMENT AND SUPPLIES NEEDED: All materials are 1 per group or per demonstration

1. Marshmallows, cheetos, almonds (other foods to use: peanuts, walnuts, potato chips)
2. Lighters: one for each educator working with students
3. Petri dish – *glass only*
4. Paperclip (uncoated)
5. Cork
6. Ring stand
7. Ring with clamp for ring stand
8. Thermometer
9. Mass balance
10. Graduated cylinder – 50mL or 100 mL
11. Aluminum can
12. Aluminum pan or aluminum foil
13. Ruler
14. Oven mitt

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Items required for every student:

15. Safety Glasses
16. Copy of Food to Fuel worksheet for each student
17. Pen or pencil
18. Paper

THIS ACTIVITY PLAN WOULD WORK WELL AS PART OF:

- Chemistry curriculum
- Biofuels curriculum
- Biology curriculum
- Nutrition curriculum

THIS LESSON IS ALIGNED TO NGSS, AFNR, AND FFA STANDARDS. Expanded standards listed on page 9.

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LESSON PLAN:

1. Bell Ringer:

On your paper answer the following questions:

- What is energy?
- How do you receive energy from food?

2. Introduction:

Students will burn a food item and calculate the number of calories from the change in temperature of the water in the can above the flame, thus gaining a first-hand understanding of the concept of a calorie as a measure of heat energy. Students will also make the connection between the energy contained in food and the energy contained in other fuels.

3. Experiment Set Up (10 minutes)

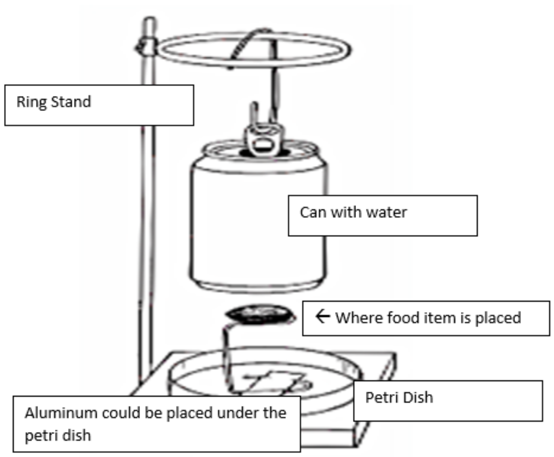

Figure 2

1. **1.** Put the mass balance, graduated cylinder, safety glasses, aluminum pan or aluminum foil, ring stands, rings, paperclips, aluminum cans, and thermometers on one main table for the teacher demo station.
2. **2.** The lab tables will have ring stands, petri dish, ring stands, paperclips, aluminum cans, mass balances, graduated cylinders, safety glasses and thermometers. The above figure shows the set-up (also described starting in step 3 below). The teachers' lecture table should also have a lab setup with all the equipment to do a demonstration.
3. **3.** Bend the paper clip as show in the diagram and create a shelf for the food item. Then, tape the other side to the base of the petri dish.
4. **4.** Stretch the other paper clip as shown in the diagram above, one end will hook onto the ring stand and the other will hook onto the tab of the aluminum can.
5. **5.** Record initial weight of food item.

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6. Measure out 35 milliliters of water in a graduated cylinder and pour it into the empty soda can. Record the mass of the water in the data table ($M_{water}$) on the worksheet.
7. Place the food item into the paperclip under the can. Weigh the petri dish and paperclip setup and food item together and record it as $M_{initial}$ (initial weight) on the worksheet.
8. Bend the tab of the soda can. Hang it by a paperclip suspended by the metal ring of the ring stand.
9. Place the aluminum pan, petri dish with paper clip with food item, directly underneath the soda can. Adjust the height of the can so the food item is only 1.5 inches below the can. Check this with a ruler.
10. Insert a thermometer into the aluminum can so it does not touch the bottom. Record the Initial Temperature ($T_{initial}$) in the data table on the worksheet. The recorded values can be used during the activity to model the solving of the equation to find Calories (Q).

## 4. Slide Presentation (60 minutes)

11. **Slide 2 (5 minutes):** Have students write down their answers to the two bell ringer questions. Answers will vary but call on students to elicit ideas based on their answers. For question 1, the definitions of energy are varied but essentially, energy is the ability to do work, such as heating up a room. Question 2, how do you receive energy from food, should also elicit many responses, you may want to tell students that there is energy contained in the chemical bonds between different substances in that food.
12. **Slide 3 (2 minutes):** To further define how energy is stored in food, tell students about the three major nutrients in food: carbohydrates, fats and proteins. Show the four food items and ask which one of these major ingredients is most present. The meat is highest in protein and fat, the pasta in carbohydrates and the butter and oil are highest in fats.
13. **Slide 4 (1-2 minutes):** Explain that calories are shown on a food label, which most students will have seen on a food item in their home. Using the diagram in the slide, explain the definition of calorie as the amount of energy needed to raise 1 mL of water by 1 degree Celsius. You may want to further define calories as a measure of heat energy.
14. **Slide 5 (1-2minutes):** Explain that the energy content in a piece of food is measured in calories. Using the diagram on the slide, explain that when the food is burned, energy is transferred from the substance to the water inside the can. Therefore, measuring the temperature of the water before and after burning the food can tell us about the energy in the can.
15. **Slide 6 (1-2minutes):** Introduce the equation to find Calories, $\mathbf{Q = m \times C \times \Delta T}$ The equation will be explained in more detail at the end of the lesson but making the connection now between the activity and the equation will help students with their final calculations.

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16. **Slide 7 (5 minutes):** Introduce the food items. 1. Almonds, 2. Cheetos, 3. Marshmallows. Assign a food item and explain that each team will burn only one food item. Then have students produce a hypothesis: If various foods are burned and used to heat water, then _________ will have the most calories. Circulate the room and ask students why they picked that food item for their hypothesis.
17. **Slide 8 (1-2 minutes):** Read the four safety rules to the class and explain the consequence of not following a rule is not participating in the activity.
18. **Slide 9-10 (1-2 minutes):** Ask students to look at the pictures and try to determine the food item (out of the four used in this activity) burning. Reveal the answers on slide 10. The pictures will help students set up their experiment.
19. **Slide 11 (1-2 minutes):** Review with students the three main numbers recorded, the mass of the water in the can, the temperature before and after the burning food. This is a suitable time to check that groups all have their materials set up properly for the activity.
20. **Slide 12-14 (15-20 minutes):** The procedures for slide 12 are out of order, have students discuss in groups the proper order of procedures and write the sequence on a slate or paper. This activity will allow for greater understanding of the procedures and give students a set of written directions they can use during the activity. Go over the correct sequence of procedures and explain that step 7 where they calculate calories will be completed once the other parts of the activity are finished. Have students complete the procedures while circulating and monitoring their progress. You will want a well-ventilated room or to do this activity outside if you have more than two groups of students. Have students clean up the excess material from the burned food and throw it away.
21. **Slides 15-16 (3 minutes):** These two slides show the variables of the equation, which you can explain to students. Tell them that the next few slides have questions they must answer based upon understanding these variables.

    **$Q = m \times C \times \Delta T$**

    Here are the abbreviations being used:
    Mass of water being heated = m
    Initial temperature of water = T initial
    Final temperature of water = T final
    T initial- T final = $\Delta T$
    Energy in Calories = Q
    Specific heat of water = C
22. **Slides 17-20 (5 minutes):** These slides present the variables, letters, or explanations by themselves. Ask students to connect the variable to the name, the symbol to the variable and the explanation to the symbol so that they understand the parts of the equation. Slide 20 summarizes the information and can be referred to as needed.

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23. **Slides 21-24 (3 minutes)** Go through a sample calculation. This step is helpful for students to see how the variables fit into the equations. It will be useful to emphasize that **ΔT** is two measurements from their equation, the final minus the initial temperature of the water. Explain to students that they will all be using the same value for C, the specific heat of water.
24. **Slide 25 (5 minutes):** Have students calculate the Q value (calories) of their food item with their own data. As an option, you can write the information on the board as groups finish so that the calories found by each group can be compared.

5. Follow-up:

**Slide 26 (5 minutes):** Have students write down their answers to the follow up questions. The first question should be gleaned from calorie measurements from the separate groups. The second question can be understood as a comparison between mass and energy content. The third question asks them to synthesize this information into a real scenario.

1. Which food item contains the most energy? (The item with the highest calories)
2. Which food is most efficient, or has the most energy in the smallest mass? (the almond)
3. Which food would make the best fuel to carry on a long hike? Why? (The almond, it should have the highest energy content in the least amount of mass)

6. Leveling Up:

**Slides 27-28 (3-5 minutes)** As an option, you may further extend student knowledge with two additional questions.

1. How does the energy contained in these food substances get released in your digestive system when you eat food?
2. What does your stomach do to “unlock” these nutrients besides burning them? (You can tell students that there is chemical energy locked in the molecular bonds in food items, and discuss the role of the stomach in digestion).

7. Exit ticket:

How would we measure the calories contained in a food item that does not burn very easily? Answers will vary, but one possibility is weighing the item, drying it out and weighing it again, then using the procedure in this activity to find calories.

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Vocabulary:

**Calorie:** A measurement of the energy contained within a substance.
**Nutrient content:** A description of the level of a specific type of energy contained within a food.
**Carbohydrate:** Sugar molecules that can be used for energy in the body.
**Protein:** Molecules made up of a chain of amino acids that can be used for energy in the body.
**Fat:** Molecules made up of triglycerides that can be used for energy in the body.
**Energy:** The ability to do work.

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## STANDARDS DETAILS (AFNR, FFA, NGSS)

**NGSS**

HS-PS1-2 Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.
MS-PS1-4 Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.

**AFNR Career Ready Practices**

CRP.02: Apply appropriate academic and technical skills. Career-ready individuals readily access and use the knowledge and skills acquired through experience and education to be more productive.
CRP.04: Communicate clearly, effectively, and with reason. Career-ready individuals communicate thoughts, ideas and action plans with clarity, whether using written, verbal and/or visual methods.
CRP.07: Employ valid and reliable research strategies. Career-ready individuals are discerning in accepting and using new information to make decisions, change practices or inform strategies.
CRP.08: Utilize critical thinking to make sense of problems and persevere in solving them. Career-ready individuals readily recognize problems in the workplace, understand the nature of the problem, and devise effective plans to solve the problem.

**FFA Precept**

FFA.PL-A. Action: Assume responsibility and take the necessary steps to achieve the desired results, no matter what the goal or task at hand. -
FFA.PL-E. Awareness: Understand personal vision, mission and goals.
FFA.PL-F. Continuous Improvement: Accept responsibility for learning and personal growth.
FFA.PG-J. Mental Growth: Embrace cognitive and intellectual development relative to reasoning, thinking, and coping.
FFA.CS-M. Communication: Effectively interact with others in personal and professional settings.
FFA.CS-N. Decision Making: Analyze a situation and execute an appropriate course of action.
FFA.CS-O. Flexibility/Adaptability: Be flexible in various situations and adapt to change.

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Author Biographies:

**Matthew Katterman** He is a PhD graduate student at the University of Arizona studying Biosystems Engineering. He is interested in irrigation engineering along with computer modeling of the guayule production system. He also has an intense interest in bioproducts and biofuels production. Matthew is a native of Tucson, Arizona, and received his Bachelor's in Chemistry in 1997 as well as his Masters in Agricultural and Biosystems Engineering in 2004.

**Traci Klein** Traci started her graduate work in Plant Sciences at the University of Arizona and worked as a lab researcher for several years. Traci then began working as a long-term substitute in the Baboquivari School District on the Tohono O'odham nation while taking online education classes. She received her teaching certificate and has been teaching 7th grade science at Valencia Middle School for 6 years. She has also been the MESA (Math Engineering Science Achievement) Club Advisor for 5 years.

**Matt Swanson** is a lifelong Arizona resident and an educator with experience teaching science at the middle school and high school levels. He is now working for the Arizona State 4-H office as a Curriculum Specialist, where he continues to enjoy bringing learning experience to youth. He received both his undergraduate degree in philosophy and his graduate degree in science education at the University of Arizona.

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