Calorimetry: Measuring the Energy in Foods

A Carolina Essentials™ Investigation

Student Worksheet

Overview

People who check nutrition labels to make informed decisions about which foods to eat and which to avoid often base those decisions on the number of calories per serving. A calorie, like a joule, is a unit of energy. The International System of Units (SI) unit for energy is the joule; however, the calorie is commonly used for a unit of food energy. A calorie is equal to the amount of energy per unit of mass required to raise the temperature of 1 g of water by 1° C. One calorie is the equivalent of 4.18 joules.

A **calorimeter** is a device designed to measure the energy released or absorbed during a chemical reaction or phase change. Food calorimetry allows us to determine the number of calories per gram of food.

In this activity, you will burn a piece of food and use the released energy to heat a known quantity of water. You will use the temperature change (ΔT) of the water to determine the amount of energy in the food. You will determine the calorie content of 3 different foods to use as evidence to construct a model of energy transfer through the combustion/oxidation of food.

Phenomenon

Observe a burning marshmallow. What changed? Explain the changes.

Essential Question

How are bonds of food molecules broken and new compounds formed, resulting in a net transfer of energy?

Investigation Objectives

1. Use a calorimeter to determine the number of calories in 3 samples of food.

2. Construct a model to illustrate the flow of energy through a calorimetry experiment and relate the model to what happens in cells.

Safety Precautions

Use safety glasses or goggles and be cautious with the matches and burning food samples. Check for food allergies before using food samples. Sensitive individuals should not participate in any activities that may result in exposure. Never eat or drink in the lab.

SAFETY REQUIREMENTS

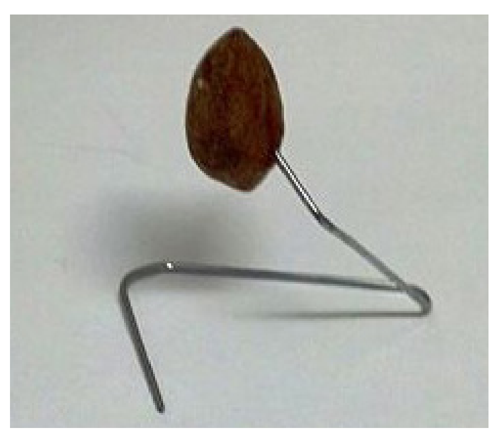
MATERIALS

- Soda can (empty with tab still attached)
- Stirring rod
- Support stand and 2 rings
- Thermometer
- Graduated cylinder, 100 mL
- 2 large paper clips
- 3 food samples with nutrition labels (2 to 3 g each of samples such as nuts, marshmallows, dry crackers, or chips)
- Water
- Matches
- Aluminum foil (10 cm × 10 cm)
- Electronic balance
- Cork stopper (optional)

Procedures

1. Using the graduated cylinder, obtain 50 mL of water and carefully pour it into the soda can.
2. Determine the mass of water and the can. Record the mass of water in the data table (hint: density of water = 1 g/mL).
3. Hold the paper clip horizontally and bend the outer end upwards until it reaches a 90° angle to the rest of the paper clip.
4. Obtain a food sample that weighs 2 or 3 g (Sample #1).
5. Place the food sample on the end of the paper clip that extends upward. The sample should be freestanding, supported by the bottom of the paper clip (see Figure 1). Determine the initial mass of the food sample and paper clip, and record your findings in the data table.

Figure 1.



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6. Place a small piece of aluminum foil underneath the paper clip in a space that has been cleared of all flammables.
7. Insert the stirring rod through the soda can tab and position the can in the ring stand so the stirring rod supports it (see Figure 2).

Figure 2.

8. Adjust the ring stand until the can is approximately 4 cm above the food sample.
9. Suspend the thermometer inside the can. The thermometer bulb should be in the water but not touching the bottom of the can. Unfold the second paper clip and use it as a hook to suspend the thermometer from the top ring.
10. Determine the initial temperature of the water in the can and record this value in the data table.
11. Carefully light a match and use it to light the food sample.
12. Allow the lit sample to heat the water in the can. Gently stir the water periodically with the thermometer (see Figure 3).
13. Monitor the temperature change of the water and record the highest observed temperature in the data table.

Figure 3.

14. Once the food sample has burned, find the mass of the remaining food sample and paper clip. Record this value in the data table.
15. Repeat steps 1 through 14 for each of the remaining food samples.

Disposal

Roll the food scraps, ashes, and paper clips in the aluminum foil and dispose of in the trash. Recycle the can. Wash the thermometer and return all equipment to the designated place.

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Data and Observations

	Sample #1	Sample #2	Sample #3
Mass of Water			
Initial Mass of Food Sample and Paper Clip			
Initial Water Temperature (°C)			
Final Water Temperature (°C)			
Final Mass of Food Sample and Paper Clip After Burning			

Analysis and Discussion

1. Determine the mass of food that actually burned. (Initial Mass of Food Sample and Paper Clip – Final Mass of Food Sample and Paper Clip After Burning) ____________ g

2. Determine the change in temperature of water, ΔT. ____________ °C

3. Calculate the energy (in calories) released by the burning food sample and absorbed by the water.

$$Q = mCp\Delta T$$

Q = heat absorbed by water, m = mass of water in grams,
Cp = 1 cal/g °C, ΔT = change in temperature

Q = ____________ calories

Compare your calculated calories to the food nutrition label. Describe any differences.

4. Food calories, as read off a nutrition label, are actually kilocalories (often denoted as “calories” with a capital C). There are 1,000 calories in a kilocalorie, or food calorie. Determine the number of kilocalories (food calories) released by the burning food sample (1 kilocalorie, or calorie = 1,000 calories).

5. Calculate the energy content of the food in kilocalories/gram.

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6. Using information on the nutrition label of the food sample, calculate the food manufacturer's kilocalories/gram. (Divide calories per serving by the number of grams in a serving.)

7. Compare your experimentally determined energy content (in kilocalories/gram) to the calculated value from the nutrition label. Calculate the percent error for your experiment and discuss possible sources of error.

8. Draw and label a model of energy transfers that take place during this activity. Be as detailed as possible.

9. Explain how the calorimetry model compares to what happens in a cell.