Food Calorimetry

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People who check nutrition labels to make informed decisions about which foods to eat and which to avoid often base those decisions solely 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 mass required to raise the temperature of 1 g of water by 1° C. One calorie is the equivalent of 4.18 joules. 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).

A calorimeter is a piece of equipment 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 a piece of food is burned and the released energy is used to heat a known quantity of water. The temperature change (ΔT) of the water is then used to determine the amount of energy in the food.

National Science Education Standards

This activity is appropriate for high school students and addresses the following National Science Education Standards for grades 9–12.

- Science as Inquiry: Abilities necessary to do scientific inquiry; Use technology and mathematics to improve investigations and communications; Understandings about scientific inquiry
- Physical Science: Structure and properties of matter; Chemical reactions

Safety measures

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 lab.

Materials

For each group

- Soda Can
- Stirring Rod
- Ring Stand and Ring
- Thermometer
- 100-mL Graduated Cylinder
- Large Paper Clip
- 2 Twist Ties
- 3 Food Samples (2 to 3 g each) with Nutrition Labels (samples such as nuts, marshmallows, or soft chips [e.g., cheese puffs])
- Water
- Matches
- Aluminum Foil (small piece)

At least 1 of the following to be shared

- Electronic Balance

Procedure

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 record your finding 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 is at a 90° angle to the rest of the paper clip.
4. Obtain a 2- to 3-g food sample.
5. Place the food sample on the paper clip's upward-extending end. The sample should be freestanding, supported by the bottom of the paper clip (see Fig. 1). Determine the initial mass of the food sample and paper clip, and record your findings in the data table.
6. Place a small piece of aluminum foil underneath the paper clip.
7. Insert the stirring rod through the soda can tab and position the can in the ring stand so the stirring rod supports it.
8. Adjust the position of the ring stand until the can is approximately 4 centimeters above the food sample.
9. Suspend the thermometer inside the can a few centimeters above the can's bottom. Secure with 2 twist ties.

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.
13. Monitor the temperature change of the water and record the highest observed temperature in the data table.
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.

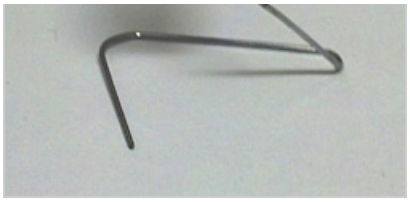

Figure 1 Paper clip with food sample attached.

Data Table

	Sample #1	Sample #2	Sample #3
Mass of water			
Initial mass of food sample and paper clip			
Initial temperature of water (°C)			
Final temperature of water (°C)			
Final mass of paper clip and food after burning			

Calculations

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) _____ 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

4. 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.
6. Using information on the nutrition label of the food sample, calculate the 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.

Extension activities

- Use the nutrition label to determine the amount of fat, protein, and carbohydrates in each food sample. Determine if there is a connection between these values and the energy content of the tested foods.
- Challenge students to develop a more efficient calorimeter and allow students to test their devices.
- Further explore food calorimetry with our Food Calorimeter.