Skills Practice Lab

PROBEWARE LAB

# Energy Content of Foods

## Time Required

One lab period (for a two-period lab, have each lab group test all four food samples)

## Skills Acquired

- Collecting data
- Experimenting
- Organizing and analyzing data
- Interpreting
- Drawing real-world conclusions

## The Scientific Method

- **Analyze the Results** In Analysis questions 1–5, students will compile the data from their experiments and make calculations to determine the caloric content of the foods tested.
- **Draw Conclusions** In Conclusions questions 1–4, students will interpret the data and apply it to the objectives of the experiment.

## Teacher's Notes

### MATERIALS AND EQUIPMENT

- The food stand can be made using an extra-large paper clip and a small jar lid, such as a baby-food jar lid. Partially straighten the paper clip, then bend a small loop at one end. This loop will cradle food samples. Bend the other end to a V shape—this will be the base. Glue the paper clip into the lid. An advantage of such a stand is its ability to catch pieces of burned food that fall.
- Small soup cans work well. Remove the paper and label the top. Place two holes, large enough to accommodate a stirring rod, near the top. Some teachers prefer to use aluminum beverage cans instead.
- The temperature calibrations that are stored in the DataMate data-collection program will work fine for this experiment. No calibration is necessary for the temperature probes.
- The Vernier stainless steel temperature probe and CBL temperature probe will plug directly into CH1 on the Vernier LabPro or CBL2 interface. If you are using the Vernier direct-connect temperature probe, you will need a DIN-BTA (formerly CBL-DIN) adapter to convert from the 5-pin Din connector to the BTA connector.

### SAFETY CAUTIONS

- Be sure to remove all sharp edges from cans.
- Because peanuts and cashew nuts release very large amounts of heat as they burn, you may want to have your students use 100 mL portions of cold water when testing these foods.
- Some students may be allergic to peanuts. Before proceeding with this activity, poll your students to determine if anyone in the class is allergic to peanuts. If any are, do not allow any students to perform the part involving peanuts. Have students answer Conclusions question 2 for cashews instead of peanuts.

## Graphing Calculator and Sensors

### TIPS AND TRICKS

- Students should have the DataMate program loaded on their graphing calculators. Refer to Appendix B of Vernier's *Chemistry with Calculators* for instructions.
- Not all models of TI graphing calculators have the same amount of memory. If possible, instruct students to clear all calculator memory before loading the DataMate program.

### TECHNIQUES TO DEMONSTRATE

When viewing graphs on the calculator, students should use the arrow keys to trace the data points on the graph.

If students wish to see the data for both food samples on the same graph, instruct them to store the first data set before beginning the second food sample. From the Main Screen of DataMate, the Store Latest Run feature can be found under the Tools menu. The program will only permit storing up to two runs. If more than one sensor is used at a time, the Store Latest Run feature will not work.

## Experimental Setup

### TIPS AND TRICKS

- Supply students with water that is 15°C to 18°C to achieve best results.
- Perform this experiment in a fume hood or in a well-ventilated classroom.

## Answers

### CONCLUSIONS

**1.** Cashews and peanuts have the highest energy content. Marshmallows and popcorn have the lowest.

**2.** Calories in a 50.0 g package of peanuts:
(12.0 kJ/g)(50.0 g)(1 Cal / 4.18 kJ) = 155 Cal

## Energy Content of Foods *continued*

3. The two foods with a high fat content, cashews and peanuts, have a much higher energy content than those with a high carbohydrate content (nearly double the energy content).
4. On average, peanuts have the highest energy content per gram, followed by cashews.

### EXTENSIONS

1. Nuts of any kind would be a good energy source for the physical demands involved.
2. Answers should discuss the possible loss of heat between the burner and the thermometer and possible improvements to keep that loss to near zero—for instance, insulating the space between the burner and the water to prevent heat loss.
3. The nutrition labels for peanuts and popcorn are accurate. The labels for marshmallows and cashews are not accurate. The marshmallow label indicates a higher Calorie and fat content than is likely. The label for cashews indicates a fat and Calorie content that is too low.

**MARSHMALLOWS (Corrected)**

| **Nutrition Facts** | |
|---|---|
| Serving Size 1 ounce | |
| Servings Per Container 6 | |
| **Amount per serving** | |
| **Calories** 90 | Calories from Fat 0 |
| | **% Daily Value** |
| **Total Fat** 0g | ***%** |
| Saturated Fat 0g | ***%** |
| **Cholesterol** 0mg | ***%** |
| **Sodium** 13mg | ***%** |
| **Total Carbohydrate** 23g | **8%** |
| Dietary Fiber 0g | ***%** |
| Sugars 5.9g | |
| **Protein** 0.1g | |
| ***Less than 1% of US RDA** | |

**PEANUTS (oil roasted w/salt)**

| **Nutrition Facts** | |
|---|---|
| Serving Size 1 ounce | |
| Servings Per Container 16 | |
| **Amount per serving** | |
| **Calories** 165 | Calories from Fat 125 |
| | **% Daily Value** |
| **Total Fat** 14g | **70%** |
| Saturated Fat 1.9g | **35%** |
| **Cholesterol** 0mg | **0%** |
| **Sodium** 122mg | **18%** |
| **Total Carbohydrate** 6g | **6%** |
| Dietary Fiber 3g | **4%** |
| Sugars 3g | |
| **Protein** 8g | |

## nergy Content of Foods *continued*

### CASHEWS (oil roasted w/salt) (Corrected)

| Nutrition Facts | |
|---|---|
| Serving Size 1 ounce | |
| Servings Per Container 16 | |
| **Amount per serving** | |
| **Calories** 163 | Calories from Fat 26 |
| | **% Daily Value** |
| **Total Fat** 13.7g | **69%** |
| Saturated Fat 2.7g | **48%** |
| **Cholesterol** 0mg | **0%** |
| **Sodium** 177mg | **26%** |
| **Total Carbohydrate** 8g | **10%** |
| Dietary Fiber 1g | **1%** |
| Sugars 7g | |
| **Protein** 5g | |

### POPCORN (air-popped, no salt)

| Nutrition Facts | |
|---|---|
| Serving Size 1 cup | |
| Servings Per Container 8 | |
| **Amount per serving** | |
| **Calories** 30 | Calories from Fat 0 |
| | **% Daily Value** |
| **Total Fat** 0.3g | ***%** |
| Saturated Fat 0g | ***%** |
| **Cholesterol** 0mg | **0%** |
| **Sodium** 0mg | ***%** |
| **Total Carbohydrate** 6g | **2%** |
| Dietary Fiber 1g | **4%** |
| Sugars 2g | |
| **Protein** 0g | |
| ***Less than 1% of US RDA** | |

## DATA TABLES WITH SAMPLE DATA

### DATA TABLE 1

| **Food sample 1:** | | | |
|---|---|---|---|
| Initial mass of food sample and holder: | 14.04 g | | |
| Mass of empty can: | 41.31 g | Mass of can and water: | 90.69 g |

### DATA TABLE 2

| **Food sample 1:** | | | | | |
|---|---|---|---|---|---|
| $T_1$: | 15.4°C | $T_2$: | 52.9°C | final mass of sample and holder: | 13.36 |

### DATA TABLE 3

| **Food sample 1:** | | | |
|---|---|---|---|
| Mass of water heated: | 49.38 g | Temperature change, $\Delta T$: | 37.5 °C |
| Mass of food burned: | 0.68 g | Heat, $q$: | 7.74 kJ |
| *Energy content of food sample*: | | | 11.4 kJ/g |

### CLASS AVERAGES

| Marshmallows | Peanuts | Cashews | Popcorn |
|---|---|---|---|
| 5.2 kJ/g | 11.8 kJ/g | 11.5 kJ/g | 6.7 kJ/g |

Name _____ Class _____ Date _____

Skills Practice Lab

**PROBEWARE LAB**

# Energy Content of Foods

You are a lab technician working for NASA. Recently you were given the job of deciding what type of foods should be included in the next space mission. Four food types have been selected as possible snacks for the astronauts. You need to determine which of these four food choices has the highest energy content while adding the least amount of mass to the mission.

Your team will test two of the food types using a method known as calorimetry. During this process, you will burn a food sample positioned below a can containing a given amount of cold water. The water temperature will be monitored during the experiment using a temperature probe. By calculating the temperature change of the water, you will determine how much energy was released when the food sample burned.

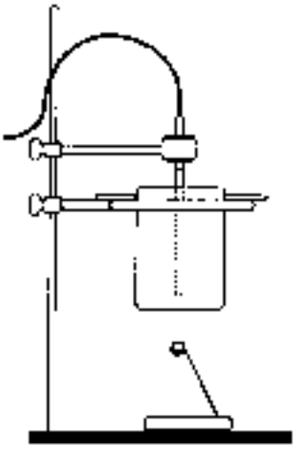

**FIGURE 1**

## OBJECTIVES

- **Measure** temperature changes.
- **Calculate** energy changes using specific heat.
- **Infer** the energy content of food.
- **Relate** energy content to types of food.
- **Evaluate** whether the nutrition labels are accurate.

## MATERIALS

- can, small
- food samples (2)
- matches
- water, cold
- wooden splint

Name _____ Class _____ Date _____



### EQUIPMENT

- food holder (see **Figure 1**)
- graduated cylinder, 100 mL
- LabPro or CBL2 interface
- stirring rods (2)
- ring stand and 4-inch ring
- TI graphing calculator
- utility clamp and slit stopper
- Vernier temperature probe

### SAFETY

- Wear safety goggles when working around chemicals, acids, bases, flames, or heating devices. Contents under pressure may become projectiles and cause serious injury.
- Secure loose clothing, and remove dangling jewelry. Do not wear open-toed shoes or sandals in the lab.
- Wear an apron or lab coat to protect your clothing when working with chemicals.
- In order to avoid burns, wear heat-resistant gloves whenever instructed to do so.
- If you are unsure of whether an object is hot, do not touch it.
- Avoid wearing hair spray or hair gel on lab days.
- Whenever possible, use an electric hot plate as a heat source instead of an open flame.
- Never return unused chemicals to the original container; follow instructions for proper disposal.

## Procedure

### EQUIPMENT PREPARATION

1. Obtain and wear goggles.
2. Plug the temperature probe into Channel 1 of the LabPro or CBL 2 interface. Use the link cable to connect the TI graphing calculator to the interface. Firmly press in the cable ends.
3. Turn on the calculator, and start the DATAMATE program. Press CLEAR to reset the program.
4. Set up the calculator and interface for the temperature probe.
   a. Select SETUP from the main screen.
   b. If the calculator displays a temperature probe in CH 1, proceed directly to Step 5. If it does not, continue with this step to set up your sensor manually.
   c. Press ENTER to select CH 1.
   d. Select TEMPERATURE from the SELECT SENSOR menu.
   e. Select the temperature probe you are using (in °C) from the TEMPERATURE menu.

Name _____ Class _____ Date _____

## Energy Content of Foods *continued*

**5.** Set up the data-collection mode.

**a.** To select MODE, press ▲ once and press ENTER.

**b.** Select TIME GRAPH from the SELECT MODE menu.

**c.** Select CHANGE TIME SETTINGS from the TIME GRAPH SETTINGS menu.

**d.** Enter "6" as the time between samples in seconds.

**e.** Enter "100" as the number of samples. The length of the data collection will be 10 minutes.

**f.** Select OK to return to the setup screen.

**g.** Select OK again to return to the main screen.

**6.** Obtain a piece of one of the two foods assigned to you and a food holder like the one shown in **Figure 1.** Find and record the initial mass of the food sample and food holder. **CAUTION:** *Do not eat or drink in the laboratory.*

**7.** Determine and record the mass of an empty can. Obtain cold water from your teacher, and add 50 mL of it to the can. Determine and record the mass of the can and water.

**8.** Set up the apparatus as shown in **Figure 1.** Use a ring and stirring rod to suspend the can about 2.5 cm (1 in.) above the food sample. Use a utility clamp to suspend the temperature probe in the water. The probe should not touch the bottom of the can. Remember that the temperature probe must be in the water for at least 30 seconds before you complete Step 9.

### DATA TABLE 1

| | | | |
|---|---|---|---|
| **Food sample 1:** | | | |
| Initial mass of food sample and holder: | | | |
| Mass of empty can: | | Mass of can and water: | |
| **Food sample 2:** | | | |
| Initial mass of food sample and holder: | | | |
| Mass of empty can: | | Mass of can and water: | |

### DATA COLLECTION

**9.** Select START to begin collecting data. Record the initial temperature of the water, $T_1$, in Data Table 2 (round to the nearest 0.1°C). **Note:** You can monitor temperature in the upper-right corner of the real-time graph displayed on the calculator screen. Remove the food sample from under the can, and use a wooden splint to light it. Quickly place the burning food sample directly under the center of the can. Allow the water to be heated until the food sample stops burning.

**10.** Continue stirring the water until the temperature stops rising. Record this maximum temperature, $T_2$. Data collection will stop after 10 minutes (or press the STO► key to stop *before* 10 minutes have elapsed).

**11.** Determine and record the final mass of the food sample and food holder.

Name _____ Class _____ Date _____



**12.** To confirm the initial ($T_1$) and final ($T_2$) values you recorded earlier, examine the data points along the curve on the displayed graph. As you move the cursor right or left, the time (X) and temperature (Y) values of each data point are displayed below the graph.

**13.** Press ENTER to return to the main screen. Select START to repeat the data collection for the second food sample. Use a new 50 mL portion of cold water. Repeat Steps 6–12.

**14.** When you are done, place burned food, used matches, and partially burned wooden splints in the container provided by the teacher.

**DATA TABLE 2**

| | | | | | |
|---|---|---|---|---|---|
| **Food sample 1:** | | | | | |
| $T_1$: | | $T_2$: | | Final mass of sample and holder: | |
| **Food sample 2:** | | | | | |
| $T_1$: | | $T_2$: | | Final mass of sample and holder: | |

## Analysis

**1. Organizing data** Find the mass of water heated for each sample. _____

_____

**2. Organizing data** Find the change in temperature of the water, $\Delta T$, for each sample. _____

_____

**3. Organizing data** Find the mass (in g) of each food sample burned. _____

_____

**4. Analyzing Results** Calculate the heat absorbed by the water, $q$, using the equation

$$q = C_p m \Delta T$$

where $q$ is heat, $C_p$ is the specific heat, m is the mass of water, and $\Delta T$ is the change in temperature. For water, $C_p$ is 4.18 J/g°C. Convert your final answer to units of kJ. _____

_____

_____

Name _____ Class _____ Date _____

## Energy Content of Foods *continued*

**5. Analyzing Results** Use the results of the previous two steps to calculate the energy content (in kJ/g) of each food sample. _____

_____

_____

### DATA TABLE 3

| | | | |
|---|---|---|---|
| **Food sample 1:** | | | |
| Mass of water heated: | g | Temperature change, $\Delta T$: | °C |
| Mass of food burned: | g | Heat, $q$: | kJ |
| *Energy content of food sample*: | | | kJ/g |
| **Food sample 2:** | | | |
| Mass of water heated: | g | Temperature change, $\Delta T$: | °C |
| Mass of food burned: | g | Heat, $q$: | kJ |
| *Energy content of food sample*: | | | kJ/g |

# Conclusions

**1. Evaluating results** Record your results and the results of other groups in the Class Results Table below. Which food had the highest energy content? Which had the lowest energy content? _____

_____

### CLASS RESULTS TABLE

| Marshmallows | Peanuts | Cashews | Popcorn |
|---|---|---|---|
| kJ/g | kJ/g | kJ/g | kJ/g |
| kJ/g | kJ/g | kJ/g | kJ/g |
| kJ/g | kJ/g | kJ/g | kJ/g |
| kJ/g | kJ/g | kJ/g | kJ/g |
| kJ/g | kJ/g | kJ/g | kJ/g |
| **Average for each food type:** | | | |
| kJ/g | kJ/g | kJ/g | kJ/g |

**2. Evaluating results** Food energy is often expressed in a unit called a Calorie (or dietary calorie). There are 4.18 kJ in one Calorie. Based on the class average for popcorn, calculate the number of Calories in a 50.0 g package of popcorn. _____

_____

Name _____ Class _____ Date _____

## Energy Content of Foods *continued*

3. **Evaluating results** Two of the foods in the experiment have a high fat content (peanuts and cashews), and two have a high carbohydrate content (marshmallows and popcorn). From your results, what generalization can you make about the relative energy content of fats and carbohydrates? _____

4. **Evaluating results** Based on the data you and your classmates collected, which of the four foods tested would you suggest to send on the NASA space mission?

## Extensions

1. **Applying results** If you were packing for a mountain hike, what kind of snacks would you bring along? Why? _____

2. **Critiquing methods** Was all of the heat given off by the burning food sample transferred to the water in the can? How could this experiment be improved to account for all the heat given off when the food sample was burned?

3. **Applying results** Listed on the following page are possible nutrition labels for each of the food samples that you tested. Based on the data you and your classmates obtained in this lab, determine which of these labels is accurate and which is not. If you find a label to be incorrect, explain your reasoning.

Name _____ Class _____ Date _____

## Energy Content of Foods *continued*

### MARSHMALLOWS

| Nutrition Facts | |
|---|---|
| Serving Size 1 ounce | |
| Servings Per Container 6 | |
| **Amount per serving** | |
| **Calories** 260 | Calories from Fat 160 |
| | **% Daily Value** |
| **Total Fat** 18g | **13%** |
| Saturated Fat 5g | **27%** |
| **Cholesterol** 0mg | **0%** |
| **Sodium** 260mg | **11%** |
| **Total Carbohydrate** 23g | **8%** |
| Dietary Fiber 1g | **11%** |
| Sugars 18g | |
| **Protein** 1g | |

### PEANUTS

| Nutrition Facts | |
|---|---|
| Serving Size 1 ounce | |
| Servings Per Container 16 | |
| **Amount per serving** | |
| **Calories** 165 | Calories from Fat 125 |
| | **% Daily Value** |
| **Total Fat** 14g | **20%** |
| Saturated Fat 1.9g | **10%** |
| **Cholesterol** 0mg | **0%** |
| **Sodium** 122mg | **5%** |
| **Total Carbohydrate** 5g | **2%** |
| Dietary Fiber 1g | **4%** |
| Sugars 2g | |
| **Protein** 8g | |

### CASHEWS

| Nutrition Facts | |
|---|---|
| Serving Size 1 ounce | |
| Servings Per Container 16 | |
| **Amount per serving** | |
| **Calories** 80 | Calories from Fat 26 |
| | **% Daily Value** |
| **Total Fat** 3g | **4%** |
| Saturated Fat 0.5g | **3%** |
| **Cholesterol** 0mg | **0%** |
| **Sodium** 177mg | **7%** |
| **Total Carbohydrate** 8g | **3%** |
| Dietary Fiber 2g | **8%** |
| Sugars 2g | |
| **Protein** 5g | |

### POPCORN

| Nutrition Facts | |
|---|---|
| Serving Size 1 cup | |
| Servings Per Container 8 | |
| **Amount per serving** | |
| **Calories** 30 | Calories from Fat 0 |
| | **% Daily Value** |
| **Total Fat** 0.3g | ***%** |
| Saturated Fat 0g | ***%** |
| **Cholesterol** 0mg | **0%** |
| **Sodium** 0mg | ***%** |
| **Total Carbohydrate** 6g | **2%** |
| Dietary Fiber 1g | **4%** |
| Sugars 2g | |
| **Protein** 0g | |
| ***Less than 1% of US RDA** | |