3 Energy Content of Food

Purpose

The purpose of the activity is to measure the energy content of different kinds of food by burning the food to warm a known quantity of water. Measure the change in temperature of the water.

Background

When burning food warms a known quantity of water, the amount of thermal energy given off by the food is theoretically equal to the amount of thermal energy gained by the water. The following is an equation that describes this idea:

$$Q = m \times c \times \Delta T$$

where Q is the amount of thermal energy, m is the mass of the water, c is the specific heat of the water, and ΔT is the change in temperature of the water.

The specific heat, c, of water is:

$$c = \frac{1\text{ calorie}}{\text{gram}^{\circ}\text{C}} = \frac{4.186\text{ joule}}{\text{gram}^{\circ}\text{C}}$$

In this activity, burn a sample of food under a container of water to heat the water. Measure the change in temperature of the water as it is heated by the burning food.

Compare the amount of heat given off by one type of food to the amount of heat given off by a different type of food.

Materials

Equipment	
• PASPORT Xplorer GLX	• Large Base and Support Rod
• Fast-Response Temperature Probe (included with Xplorer GLX)	• Food holder (cardboard square, 10 by 10 cm, aluminum foil, paperclips)
• Balance	• Graduated cylinder
• Can, aluminum (about 300 to 500 mL)	

Consumables	
• Food samples	• Matches
• Water (50 mL per food sample)	• Wood splint

Safety Precautions

- Take care when using matches and wooden splints.
- Follow all directions for using the equipment.
- Wear protective gear (e.g., safety goggles, gloves, apron).

Pre-Lab Questions

All human activity requires "burning" food for energy. When samples of different kinds of food are burned, which of the food samples will produce the most energy?

1) Marshmallow? Cashew? Popcorn? Which food sample will produce the most energy?
2) How will you compare one food sample to another?
3) Will the amount of mass of the food sample make a difference?
4) Will the time that the food takes to burn make a difference?

Procedure

Equipment Setup

1) Measure and record the mass of the aluminum can. Pour 50 mL of water into the aluminum can. Measure and record the total mass of the can plus the water.

2) Set up the equipment as shown. Use an unbent paper clip to hang the aluminum can from the rod.

3) Place the end of the Fast-Response Temperature Probe into the water, but don't let the end of the probe rest on the bottom of the can.

4) Use a 10 by 10 cm square of cardboard, a piece of aluminum foil, two large paper clips, and tape to build the food holder as shown (see the Appendix for instructions).


Figure 2: Setup

5) Place the food sample on the paper clips of the food holder. Measure and record the total mass of the food sample and holder.

Xplorer GLX Setup

1) Connect a Fast-Response Temperature Probe (included with the GLX) into Port 1 on the left side of the Xplorer GLX. The Graph Screen will automatically open with Temperature (°C) versus Time (s).

2) Open the GLX setup file labeled **food energy** (check the Appendix at the end of this activity.) The file is set to record at 2 samples per second (2 Hz).


Figure 1: Connect probe to GLX

Optional: To calibrate the Fast-Response Temperature Probe, see the instructions provided by the instructor.

Record Data

Data recording is easier if one person handles the GLX and another person handles the food sample.

1) Set up the GLX to start recording data. When you are ready, press ▶ on the GLX.

2) Light the wooden splint with a match and use the splint to light your food sample. Quickly place the burning food sample directly under the center of the container. Leave the sample under the container until the food sample stops burning.

CAUTION: Keep hair, clothing, and other items away from open flames.

3) Leave the sensor in the water for at least 45 seconds after the food has stopped burning. Gently twirl the can to stir the water. Stop recording data with the GLX when the temperature stops rising.

Do you need to measure the final mass of the remains of the burned food sample?

4) Measure and record the mass of the burned food sample and holder.

5) Repeat the data recording procedure for the other food samples. Empty the can and use 50 mL of fresh water for each food sample.

What measurements do you need to record?

Analyze

Record results in your lab notebook/data table as you complete your analysis.

1) Make a sketch of a graph of one run of data for temperature versus time, including labels for the y- and x-axes..

2) Use your recorded data to find the change in temperature of the water heated by the first food sample.

3) Use your measured data to find the change of mass of the food sample.

4) Repeat the analysis for the other runs of data and record your results in the Data Table.

5) Calculate the heat absorbed by the water, Q, for each food sample. Remember the equation:

$$Q = m \times c \times \Delta T$$

For water, the specific heat "c" is 4.186 J/g°C.

How would you convert the heat absorbed from joules to kilojoules (kJ)?

6) Determine the mass of the food that burned.

7) Calculate the energy content, or ratio of heat (in kilojoules) divided by the mass of burned food (in grams), for each food sample.

8) How do your results compare with others in your class?

Data Table

Item	Sample 1 ________	Sample 2 ________	Sample 3 ________	Sample 4 ________
Mass of empty container	g	g	g	g
Mass of container + water	g	g	g	g
Mass of water	g	g	g	g
Initial mass of sample + holder	g	g	g	g
Final mass of sample + holder	g	g	g	g
Change of mass, food sample	g	g	g	g
Initial temperature	°C	°C	°C	°C
Final temperature	°C	°C	°C	°C
Temperature change, ΔT	°C	°C	°C	°C
Heat, Q	kj	kj	kj	kj
Energy content (heat/mass)	kj/g	kj/g	kj/g	kj/g

Class Results Table: Average Energy Content for each food type:

Food Type	________	________	________	________
Energy content	kj/g	kj/g	kj/g	kj/g

Analysis and Synthesis Questions

1) Which food had the highest energy content?

2) Which food had the lowest energy content?

3) Food energy is expressed in a unit called a Calorie. There are 4.18 kilojoules (or 4180 joules) in one Calorie. Based on the class average for peanuts, calculate the number of Calories in a 50-gram package of peanuts.

$$\text{Calories} = \frac{\_\_\_\_\_\_\_\text{kJ}}{\text{g}}\left(\frac{\text{Calorie}}{4.18\text{kJ}}\right)\left(\frac{50\text{g}}{\text{pkg}}\right)$$

4) Two of the foods in the activity have a high fat content (peanuts and cashews) and two have a high carbohydrate content (marshmallows and popcorn). From your results, what can you conclude about the relative energy content of fats and carbohydrates?

5) What advice would you give to a sports team about the energy content of these foods?

6) Do you think that all of the energy released by the burning food sample was absorbed by the water?

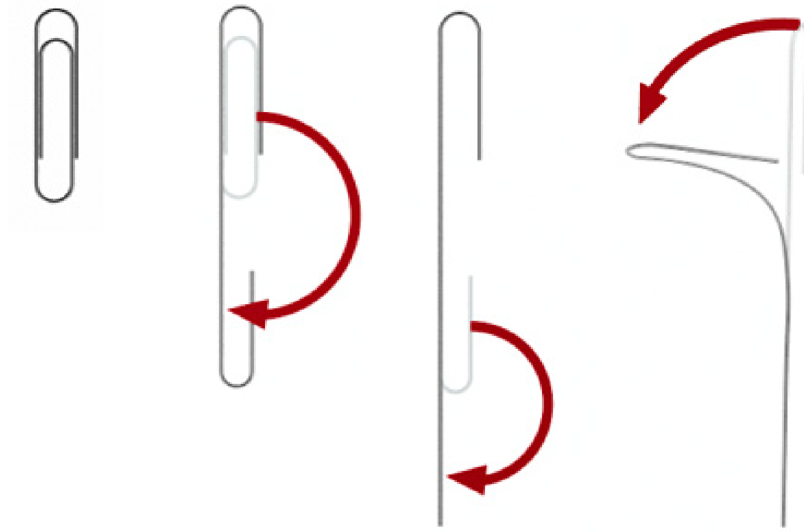
7) Why or why not?

8) What are some things you would do to change the procedure in this activity?

Appendix: Building a Food Holder

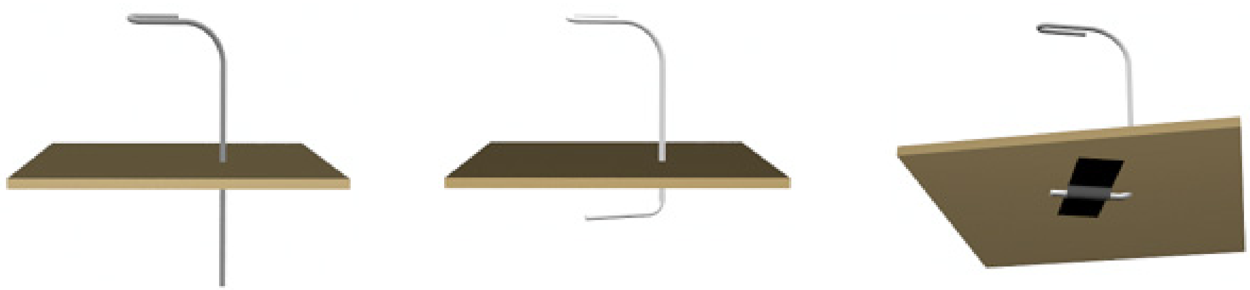
Cover the cardboard square with aluminum foil.

(1) Start with a large paperclip. (2) Unfold the paperclip as shown. (3) Straighten one end of the paperclip. (4) Bend over the curved end of the paperclip to about ninety degrees.



(5) Push the straightened end of the paperclip through the cardboard square near the center of the square. (6) Bend over the straightened end to about ninety degrees. (7) Use tape to fasten the bent part of the paperclip to the bottom of the cardboard square.

Repeat the process with a second paperclip. Push the second straightened paperclip through the cardboard square at a spot about 2 or 3 cm from the first paperclip



After you tape the second paperclip to the bottom of the cardboard, bend the tops of the two paperclips so they hook together and form a platform to hold the food sample.

Opening a GLX File

To open a specific GLX file, go to the Home Screen (press). In the Home Screen, press to open the Data Files screen. Use the cursor keys to navigate to the file you want. Press to open the file.