

Project 1: Measuring the heat content of foods

In this exercise, you will measure the heat content of a food, and determine if the energy content on the nutritional label is accurate.

The device you will be using to measure the heat content is the bomb calorimeter; its instructions for use are on a separate handout.

Basically, what you will be doing is placing the food inside the bomb calorimeter and burning it completely; in theory, all of the energy stored in the covalent chemical bonds in food will be released as heat (except for the small bit that is used to make the bonds in carbon dioxide and water). This heat will all go to warming the water outside of the bomb calorimeter. By measuring the temperature change in that water, you should be able to calculate the original amount of heat released, and therefore the heat content of the food.

The equation that governs the energy calculation is:

$$E = - m c \Delta T$$

where E is energy released by a process or reaction, m is the mass of the material absorbing the released energy and ΔT is the change in temperature of the material absorbing the released energy. c is a constant called the “specific heat” or “heat capacity” and is different for different materials. For instance, for water, $c = 1.000 \text{ cal/g}^\circ\text{C}$ (note the weird units!).

You will be using the equation above in a slightly modified form:

$$H = \frac{(w \times \Delta T) + e}{m}$$

where H is the heat content in cal/g, w is the heat capacity of the water and steel of the bomb calorimeter and has the value $2434 \text{ cal/}^\circ\text{C}$, ΔT is the change in temperature of the water (which you will monitor on the computer), e is a correction factor that accounts for energy used to heat the unburned wire and m is the mass of the sample in grams.

Procedure:

Because there are only two calorimeters for use by the class and because there are many jobs to do, form groups of five or six students. **Do not attempt any of the steps in the operating instructions unless under the direct supervision of the instructor or the lab technician;** accidents with the calorimeter can be quite dangerous. Choose *two* people to record the data on the Project 1 data sheet.

Only one project report needs to be turned in by each team; make sure all team members' names are on it.

Bring a piece of *dry food* and its **nutritional content label** on the day of the project. Wait until your team's turn and proceed with the operation of the calorimeter. Record the data, perform the calculations, and answer the analysis questions.

Analysis:

1. Was the label accurate? Explain, especially since the FDA requires food companies to be accurate to the tens digit in the calorie content. A useful number to cite in your explanation is the % difference between your value and the nutritional label value.

2. If there was a significant error, give a reason why your number might have been off (in other words, what might your group have done that caused an error?).

3. Why did you need the extreme precision of a 1L volumetric flask to make sure that there were exactly 2L of water in the steel bucket? In other words, how come the volume of water had to be 2.0000 L and not 2.0 L if you'd used a beaker?

4. After the combustion, why did you look inside the little cup for soot?

5. Would this experiment work with a piece of carrot? Give a reason or two why a carrot might be more difficult than the food you used.

Project 1 data sheet*Before the experiment:*

Name or description of food _____

Energy content according to label (units?) _____

Serving size (units?) _____

Conversion factors: 1 food calorie = 1000 cal 1 ounce = 28.35 g

Energy content of food (cal/g) _____

During the experiment:

m = sample size (g) _____

 T_{initial} (°C) _____ T_{final} (°C) _____ ΔT (°C) _____

length of unburned wire (cm) _____

e (= length of unburned wire \times 2.3 cal/cm) _____

H (energy content of food (cal/g)) _____