The Energy Stored in Food

Introduction:
All living things require energy (metabolism). Plants produce their own energy (autotrophic) using sunlight in a process called photosynthesis. Humans, as well as other animals, can not photosynthesize and instead must get their energy from the food they eat (heterotrophic).

Energy is stored in chemical bonds and can be released only by breaking those bonds. In this experiment, you will measure the amount of energy available for use in selected food samples. This process of measuring the energy stored/released in food is known as calorimetry.

A calorie is defined as raising 1g of water 1 °C. This means that any food sample’s energy content can be determined by burning it and recording the temperature change. Notice the “calorie” counts listed on food packages are given in kilocalories (kcal also represented Cal) or 1,000 calories. An average person should consume a minimum of 2,100 kilocalories per day, which is equivalent to 8,778 kilojoules. Calories and joules are both units of energy. We will use joules in this lab since it is the accepted SI metric standard.

Prelab:
1. Define the term calorie.
2. Study the diagrams below. The first is of the calorimeter you will assemble and the second is of a commercial calorimeter used in a laboratory. Compare the features of the commercial calorimeter with those of the calorimeter you will construct. What features do both calorimeters have in common? How are these shared features different between the two?
3. How do you think these differences effect the accuracy of the measurements you will make in this lab?
4. Navigate to the following website and complete the Calorimetry weblab. When complete answer Conclusion question 1 at the end of the lab.

When you come to the following class, bring a single food sample to test. Note: dry, easily combustible foods are better candidates for successful labs.

Part 1: Determine the energy content of two food samples.
1. Read all the directions and put on your safety goggles and lab apron
2. Connect the Temperature Probe to LabQuest. Choose New from the File menu. If you have an older sensor that does not auto-ID, manually set up the sensor.
3. On the Meter screen, tap Rate. Change the data-collection rate to 0.2 samples/second and the data collect length to 480 seconds.
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4. Obtain a sample of food and a food holder similar to the one shown in Figure 1. Mount the food onto the food holder so that it can burn without damaging the holder. Determine and record the initial mass of the food sample and food holder in Table 1. **CAUTION: Do not eat or drink in the laboratory.**

5. Set up the apparatus shown in Figure 1 with either a beaker or a test tube.
   a. Determine the mass of an empty beaker/test tube. Record the value in Table 1.
   b. Place 50 mL of cold water into the beaker/test tube.
   c. Determine and record the mass of the beaker/test tube plus the water.
   d. Position the can 2.5 cm (~1 inch) above the food sample.
   e. Use a utility clamp to suspend the temperature probe in the water as shown in Figure 1. The probe should not touch the bottom or side of the can.

6. You are now ready to begin collecting data. Start data collection and light the food sample. Relight sample until it no longer burns.

8. After data collection has stopped, analyze the graph to determine the maximum and minimum temperatures of the water.
   a. Choose Statistics from the Analyze menu.
   b. Record the Maximum (final) and Minimum (starting) temperature values recorded during data collection in your data table.
   c. Select OK.

9. Remove the food holder and determine the final mass of the food and holder. Record the mass in Table 1.

10. Clean off the food holder and empty the can of water.

11. Store the data from the first run by tapping the File Cabinet icon.

12. Repeat Steps 4–10 for the second food sample.

13. A good way to compare the two samples is to view both sets of data on one graph.
   a. To do this, tap Run 2 and select All Runs. Both runs will now be displayed on the same graph.
   b. Examine the data points along the displayed curve. To examine the data pairs on the displayed graph, tap any data point. As you move the examine line right or left, the temperature values of each data point are displayed to the right of the graph.
   c. Use the displayed graph to fill in the tables and answer the questions below.
   d. (optional) Print a copy of your graph per your teacher’s instructions.

14. When finished, discard all burnt matches and food samples as directed by your teacher.

**DATA**

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Measurements</th>
<th>Sample 1</th>
<th>Sample 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food used</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mass of empty can (g)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mass of can plus water (g)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial temperature of water (°C)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final temperature of water (°C)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial mass of food and holder (g)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final mass of food and holder (g)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Calculations</th>
<th>Sample 1</th>
<th>Sample 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass of water (g)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Δt of water (°C)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Δmass of food (g)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy gained by water (J)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy content of food (J/g)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
CALCULATIONS: Record the following calculations in table 2. Show your work in table 3.

1. Determine the mass of the water and record in Table 2.
2. Calculate the change in mass of each food sample.
3. Calculate the changes in the temperature of the water, \( \Delta t \). Record this in Table 2.
4. Calculate the calories per gram of food. Show your calculations.

\[
\text{Energy released by food sample} = \frac{\text{(mass of water) \times (\Delta t \text{ of water})}}{\Delta \text{mass of food}}
\]

5. The label on your food packages report energy in Calories (kcal) meaning 1,000 cal. Convert your answer to part 4 into kilocalories by dividing by 1,000.
6. The SI unit for energy is the joule. Convert the energy you calculated in Step 4 to kilojoules. (1 Calorie = 4.18kJ)

PART 2: Determining the organic compounds in common food items.

1. For each food sample place 4 test tubes in your test-tube rack. Be sure to compare your samples to a positive test and to a water control. Label each test tube with the food sample.
2. If you are using solid foods, then you will need to use a mortar and pestle to crush your sample and dissolve in water.

Testing for Carbohydrates (SUGAR- simple sugar/ monosaccharide)

1. Use a medicine dropper to put ~10 drops of each food into the test tube with the matching label. Add 10 drops of Benedict's solution to each test tube. CAUTION: Benedict’s solution is poisonous. Do not get any in your mouth and do not swallow any!
2. Use a test-tube holder to carefully place the test tubes in the hot water bath your teacher has prepared. Heat the test tubes for 2 to 3 minutes. CAUTION: Use a test-tube holder to handle hot test tubes. Point the open end of a test tube away from yourself and others.
3. Use a test -tube holder to return the hot test tubes to the test-tube rack. If the substance in your test tube contains sugar, Benedict's solution will change color. See Table 1 below

<table>
<thead>
<tr>
<th>Macromolecule in sample</th>
<th>0 none</th>
<th>+ trace</th>
<th>++ little</th>
<th>+++ some</th>
<th>++++ much</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indicated monosaccharides</td>
<td>blue</td>
<td>blue/green</td>
<td>green</td>
<td>yellow</td>
<td>orange/red</td>
</tr>
<tr>
<td>Indicated polysaccharides</td>
<td>No change</td>
<td>tan</td>
<td>light blue</td>
<td>dark blue</td>
<td>purple/black</td>
</tr>
<tr>
<td>Indicated lipids</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indicated proteins</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. Observe your test tubes (using white paper as a background). Record the amount of sugar present, in your data table.
5. Empty your test tubes, clean them thoroughly, and return them to the test tube rack.

Testing for Carbohydrates (SUGAR- complex sugar/ polysaccharide)

1. Use a medicine dropper to put ~10 drops of each food in the test tube with the matching label. Add 3-4 drops of Lugol's solution (iodine) to each test tube.
2. Starch is one form of carbohydrate. If the substance in your test tube contains starch, it will turn a blue-black color when it mixes with the iodine solution.
3. Observe the contents of your test tubes and Record the amount of starch present (0, +, ++, ++++, ++++) in your data chart. The food which contains the most starch should be recorded as ++++.
4. Empty and wash each test tube and return it to your test tube rack.
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Testing for Lipids
1. Use a medicine dropper to put ~1 drop of each food onto the newsprint.
2. Observe and compare/contrast the translucence of each food substance. Record the information, in order of translucence (0, +, ++, ++++, +++++) in your data chart. The food which contains the most lipids should be recorded as ++++

OR
3. Place a small piece of sample in each clean test tube. Use a clean dropper to add 10 drops of Sudan III solution to each test tube. Mix well, observe and record your results in the DATA TABLE.

Testing for Proteins
1. Use a medicine dropper to put ~10 drops of each food on the test tube with the matching label. Use a medicine dropper to carefully add 10 drops of Biuret reagent to each test tube. CAUTION: Biuret reagent can burn your skin. Wash off spills and splashes immediately with plenty of water while calling to your teacher.
2. Observe the contents of each test tube (using white paper as a background). If the food contains proteins, it will turn a pinkish purple. Record the amount (0, +, ++, ++++, +++++) of protein for each food substance in your data table. The food which contains the most protein should be recorded as ++++
3. Empty the test tubes and clean them thoroughly. Before leaving the laboratory, clean up all materials and wash your hands thoroughly.

Part 3: Calorie content from fast food
Go to your favorite fast food restaurant’s website: ex. http://www.mcdonalds.com Find the nutrition facts. Choose a meal and write the nutrition data each item (like a burger, fries and drink). Record your data in a data table like the one below.

<table>
<thead>
<tr>
<th>Menu Item</th>
<th>Calories</th>
<th>Fat (g)</th>
<th>Sugar (g)</th>
<th>Protein</th>
<th>Sodium</th>
<th>Vitamins (you pick)</th>
</tr>
</thead>
</table>

CONCLUSION QUESTIONS: Answer the following questions in complete sentences:

1. Which macromolecules are most common in foods that come from plants? Animals? Use your prelab, calorimetry, and food nutritional labels to provide support for your answer.
2. Draw a concept map of the energy conversions that took place from it’s original source to the form you measured in lab. Hint: energy is released from chemical bonds, but where did the energy for those bonds come from in the first place?
3. Compare your experimental results from the food samples you tested with those from the food label (may also be found on-line). Suggest why your tests might produce different results and how you could improve your experiment.
4. The average person can live on about 2,100 kcal per day to maintain a healthy body. Compare and contrast the burning of food in a calorimeter to the releasing of energy from food in your body. Use your textbook to examine the structure of ATP to help you with your answer.
5. Most carnivores feed directly on the fatty parts of their prey. List at least three properties of fatty tissues that make them a good food source for such predators.