Measuring Calories…Calorimetry Lab (Energy Content of Food)

Introduction

All human activity requires "burning" food for energy. How much energy is released when food burns in the body? How is the caloric content of food determined? This lab will involve investigation of the caloric content of different snack foods such as marshmallows and cheese puffs.

Concepts

* Combustion reaction
* Calorimetry
* Nutritional calorie
* Caloric content of foods

Background

What does it mean to say that we "burn" food in our bodies? The digestion and metabolism of food converts the chemical constituents of food to carbon dioxide and water. This is the same overall reaction that occurs when organic molecules—such as carbohydrates, proteins, and fats—are burned in the presence of oxygen. The reaction of an organic compound with oxygen to produce carbon dioxide, water and heat is called a *combustion reaction.* The chemical equation for the most important reaction in our metabolism, the combustion of glucose, is Equation 1.

$$\mathbf{C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + heat} \qquad \textit{Equation 1}$$

Within our bodies, the energy released by the combustion of food molecules is converted to heat energy (to maintain our constant body temperature), mechanical energy (to move our muscles), and electrical energy (for nerve transmission). The total amount of energy released by the digestion and metabolism of a particular food is referred to as its *caloric content* and is expressed in units of nutritional Calories (note the uppercase C). The caloric content of most prepared foods is listed on their nutritional information labels.

Nutritionists and food scientists measure the caloric content of food by burning the food in a special device called a calorimeter. *Calorimetry* is the measurement of the amount of heat energy produced in a reaction. Calorimetry experiments are carried out by measuring the temperature change in water that is in contact with or surrounds the reactants products. (The reactants products together are referred to as the system, the water as the surroundings.)

Further investigation would include information regarding nutritional Calories in relation to chemistry calories. The calorie content (in Cal per gram) of different molecule types found in food such as fats, carbohydrates (sugars) and proteins. On your report, discuss which of these 3 molecule types would be dominant in the food samples you chose based upon the ingredients listed.

Hypothesis

Describe a relationship between marshmallows and cheese puffs based on caloric content. Which snack food do you think has more calories per gram and WHY? You may think about relative fat content vs. sugar (carbohydrate) content if that helps.

Purpose

The purpose of this experiment is to determine the amount of heat released when Cheetos are burned versus marshmallows.

Materials:

Balance	Matches	Calorimeter (Soda Can)	Cheetos/Marshmallows
Paper clip/watchglass	Thermometer	Graduated cylinder, 50-mL	Water

Procedure

1. Obtain a clean, empty soda can. Measure and record the mass.
2. Add about 50 mL of tap water to the can and measure the combined mass of the can and water.
3. Place a food sample on the food holder. Measure and record the combined mass of the food holder and sample. Place the food holder on a ring stand.
4. Bend the top tab on can up and slide a stirring rod through the hole. Suspend the can on a ring stand using a metal ring. Adjust the height of the can so that it is about 2.5 cm above the food holder.
5. Insert a thermometer into the can. Measure and record the initial temperature of the water.
6. Light the food sample and center it under the can. Allow the water to be heated until the food sample stops burning. Record the maximum (final) temperature of the water in the can.
7. Measure and record the final mass of the food holder and sample.
8. Clean the bottom of the can and remove any residue from the food holder. Repeat the procedure with a second food sample.

Calculations and Analysis:

1. Subtract the final mass of the food sample and holder from the initial mass to determine the mass in grams of the food sample that burned in each experiment. **(mass burned = m_i-m_f)**
2. Calculate the change in temperature for each sample. ($\Delta T = T_f - T_i$).
3. Find the accepted specific heat value for water in calories per gram per degree Celsius.
4. Use the heat equation **($Q = ms\Delta T$)** to calculate the heat absorbed by the ***WATER*** in the calorimeter (thus the heat released by the food) for each food sample. Report the results in calories, kilocalories (AKA nutritional Calories). **(1000 cal = 1kcal = 1 nutritional Cal)**
5. Use the results from #4 and #1 to calculate the energy content (fuel value) of the food sample in units of Cal/g. (This just requires taking your Calories produced divided by mass of sample burned).
6. Calculate the Cal/gram for each of your food samples from your experimental data AND calculate the Cal/gram using the nutritional label information recorded from part 1.

Conclusion:

State a claim by accepting or rejecting the hypothesis. In two to three statements, use evidence from the data to support your claim. State your final conclusions on Cal/gram in each food. Justify which snack food has the higher energy content by comparing the nutritional labels of the two foods. Address the major sources of error in this experiment. Elaborate on why a result was off on the high or the low side? Suggest modifications to get better results.

Extension Application Problems: Solve the problems below as an **application** of what was learned in the lab.

1. A candy bar has a total mass of 75.0 grams. In a calorimetry experiment, a 1.0-g sample of this candy bar was burned in a calorimeter surrounded by 1000 g of water. The temperature of the water in contact with the burning candy bar was measured and found to increase from an initial temperature of 21.2°C to a final temperature of 24.3°C.
   a. Calculate the amount of heat in calories released when the 1.0-g sample burned.
   b. Convert the heat in calories to nutritional Calories and then calculate the energy content (fuel value) in Cal/g.
   c. Calculate the total caloric content of the candy bar in Calories.
2. Attach two nutritional labels from one of your favorite snack foods. Report their total caloric content (in Calories) and calculate their fuel value in Cal/g.
3. Many diet crazes come along claiming they have the secret to weight loss. Atkins Diet. Research a popular diet (such as Atkins Diet, South Beach Diet, the Zone Diet, etc) and explain what this diet involves and give two advantages and two disadvantages.

Period: _____ Name: _____ Station: _____

Title:

Hypothesis:

Background:

Procedure: Write down a step-by-step procedure in your own words. Draw pictures to explain the experiment.

Experiment/Observations:

	Cheese Puffs		Marshmallow	
	Trial 1	Trial 2	Trial 1	Trial 2
Mass of empty can (grams)				
Mass of can with water (grams)*				
Initial Mass (m_i) grams				
Final Mass (m_f) grams				
Initial Temp (T_i) °C				
Final Temp (T_f) °C				

*Remember density of water is 1g/mL so keep water at 50.0mL each time for easier calculations.

Food Item	Calories/Serving	Grams/Serving	Amount of Fats	Carbohydrates	Proteins
Cheese Puffs					
Marshmallow					

Calculations and Analysis:

	Cheese Puffs		Marshmallow	
	Trial 1	Trial 2	Trial 1	Trial 2
Mass of water (grams)				
Mass Burned of Food (grams)				
Temperature Change of Water ($\Delta T=T_f-T_i$)				
Heat absorbed by water (calories) **($Q = msΔT$)**				
Heat absorbed in Kcal				

What is the specific heat (symbol s_{water}) of liquid water? _____

Conclusion:

Claim

Evidence

Reasoning

Evidence

Reasoning

Evidence

Reasoning

Error and Modifications

Application: SHOW WORK!