Calorimetry: The Energy of Food

Objective:

We will determine the energy content of various foods and explore the prospect of algae as a nutritional food option

Introduction:

Calorimetry is a measure of heat exchanged between a system and its surrounding in order to determine the change in energy of a system. Calorimetry experiments can be used to measure heat of dissolution, heat of fusion, heat of reaction, and more. In terms of food science, calorimetry can be utilized to measure the number of calories in a food or the amount of energy required to burn the food.

According to the first law of thermodynamics, heat that is gained by one body must be lost by another body. Although temperature and heat are not exactly the same thing, temperature is an indicator of heat. As the temperature of a system increases, the molecules within the system will move faster, thus increasing the heat energy.

When a food is burned under a calorimeter, its energy content can be determined because the energy will be transferred to the water in the calorimeter, following the first law of thermodynamics.

The following the formula can be used to calculate energy:

$$\mathbf{Q = mc\,\Delta T}$$

Q is the energy (calories), m is the mass in grams, c is specific heat, and ΔT is the change in temperature. In this laboratory, we will be calculating the energy gained by the water so we will use the mass and specific heat of water. The specific heat for water is 1 calorie/gram °C.

Algae as a global food source

According to World Hunger Programme, about 795 million people in the world do not have the proper nutrition to live a healthy and active lifestyle. This is about 1/9 of the world's population. Studies have shown that the best diet for malnutrition recovery consists of high protein and high fat intake. Algae is a food source that contains high protein and fat and therefore has a lot of potential as a future global food source.

Materials:

- ☐ Empty and cleaned soda can
- ☐ Ring stand with clamps
- ☐ Water
- ☐ Cork
- ☐ Needle
- ☐ Mass scale
- ☐ Thermometer
- ☐ Safety Equipment: Goggles, Heat resistant gloves
- ☐ Several small food samples

Safety Considerations:

- ☐ This experiment will utilize an open flame. Make sure that all hair and jewelry are securely tied back. Wear heat resistant gloves when working near the flame and always make sure there is an adult present.
- ☐ Do not eat any of the food samples.

Procedure:

1) Record the mass of the empty, clean soda can.
2) Fill the can calorimeter about ¾ full with water and measure the initial water temperature. Also measure the mass of the can and the water.
3) Secure the can calorimeter onto ring stand and adjust height accordingly.
4) Stick the needle into the piece of cork and secure a food sample onto the other end of the needle. Measure the initial mass of the food and the holder (needle and cork). Place the food and holder beneath the can calorimeter.
5) With a match, carefully light the food sample on fire.
6) Let the food burn completely.
7) Measure the final water temperature and record.
8) Measure the final mass of the food and holder and record.
9) Carefully empty water from can and discard any remaining food.
10) Repeat these steps for each food sample.

Results and Discussion:

	Food Sample 1:	Food Sample 2:
Mass of empty soda can (g)		
Mass of can with water (g)		
Initial mass of food and holder (g)		
Final mass of food and holder (g)		
Initial water temperature (°C)		
Final water temperature (°C)		

Calculations

For each food sample, calculate the following:

- Mass of water
- Change in water temperature
- Heat energy gained by the water ($Q=mc\Delta T$)
- Mass of food burned
- Energy content per gram of food

	How to calculate	Food Sample 1:	Food Sample 2:
Mass of water (g)	= Mass of can with water - Mass of empty can		
ΔT of water (°C)	= Final water temperature - Initial water temperature		
Heat energy gained by water (cal)	= Mass of water * 1 cal/gram°C * ΔT of water		
Mass of food burned (g)	= Initial mass of food and holder - Final mass of food and holder		
Energy content per gram of food (cal/gram)	=Heat energy gained by water / Mass of food burned (g)		

Discussion:

1) What food had highest energy content? The lowest? Explain how you determined this.

2) Peanut butter typically contains about 4 grams of protein per teaspoon, and a teaspoon of peanut butter weighs about 32 grams. Microalgae is composed of about 55% protein. How much peanut butter, by mass, would a protein bar have to contain to have the same amount of protein as a protein bar containing 10 grams of algae.

3) In terms of the food industry, what are the benefits of algae?