ScienceCube

Measuring the Caloric Content in Food

1. **You can design a device for burning food and calculate the caloric content in the food.**
2. **You can explain various sources of error that can affect the experimental results.**

Fundamental Concept

1. Combustion

Combustion is a phenomenon where a substance burns with heat and light, typically accompanied by flames in the presence of oxygen in the air. It is a process where the chemical energy in a substance is easily converted into thermal energy.

2. Combustion Products

When a substance combusts, it produces different substances than it initially contained, known as combustion products. Based on these combustion products, we can infer the elemental composition of the fuel. If the fuel contains carbon and oxygen atoms, it produces carbon dioxide and water vapor upon combustion.

Ex) $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g) +$ 에너지

3. Caloric Content

The amount of heat is expressed as caloric content. The unit for caloric content is the calorie (1 cal = 4.186051 J). One calorie is the amount of heat required to raise the temperature of water by 1°C. Caloric content can be converted into equivalent quantities like mechanical work and contributes to changes in the internal energy of a material system.

Caloric content (cal) =Heat capacity (Cal/°C) x Temperature change (Δt)

- Heat capacity (Cal/°C): The amount of heat required to raise the temperature of an object by 1°C. It can be calculated as specific heat × mass.
- Specific heat (Cal/g·°C): The amount of heat required to raise the temperature of 1g of a substance by 1°C. It has unique values for different substances.

Career Exploration

'Nutritionist'

Job Overview

A nutritionist plans, prepares, and oversees balanced meals for individuals and groups. The goal of a nutritionist is to promote health and treat diseases. To achieve this, they research and develop nutritional techniques and applications, providing professional nutrition services.

Job Duties

- Food Service Management Nutritionists: Manage group meal services in businesses, schools, hospitals, etc. This includes task management, hygiene management, purchasing management, personnel and labor management, and food management.
- Clinical Nutrition Managers: Work in hospitals following a doctor's instructions to manage patient nutrition.
- Community Nutritionists: Engage in community nutrition improvement projects to prevent disease and promote health.
- Other Duties: Product development, food hygiene inspection and management, research, education, and providing nutritional counseling.

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Required Skills / Abilities

- Numerical Skills: To calculate nutritional values for meal planning.
- Judgment and Application Skills: To choose appropriate foods and create economical meal plans.
- Communication and Interpersonal Skills: Essential for working smoothly with kitchen staff and other personnel.

Education / Qualifications

- Must major in nutrition, food and nutrition, food science, or dietetics at a two-year or four-year university.
- Must obtain a nutritionist certification..

Job Outlook

Although the mandatory employment of nutritionists has increased demand in recent years, the oversupply makes it challenging for new graduates to find employment.

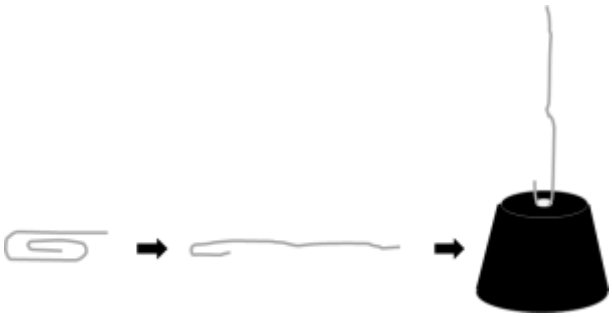
Experiment

Materials Needed

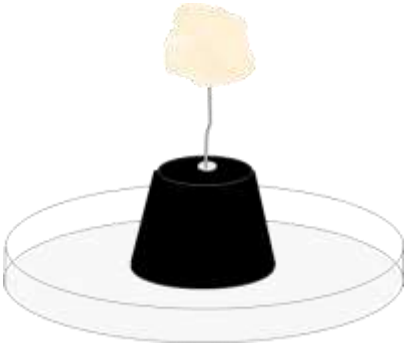
Interface, Science# program, Temperature sensor, Stand, Clamps (2), Igniter, Clip, Petri dish, Rubber stopper, Aluminum can, 200mL graduated cylinder, Electronic scale, Food to be burned (snacks, nuts), Caloric content analysis table for the respective food

Setting Up the Experimental Device

1. Cut the food to similar sizes as much as possible.
2. Insert a straightened clip into the rubber stopper as shown in the figure.



3. Attach the cut food to one end of the clip and place it on the petri dish.

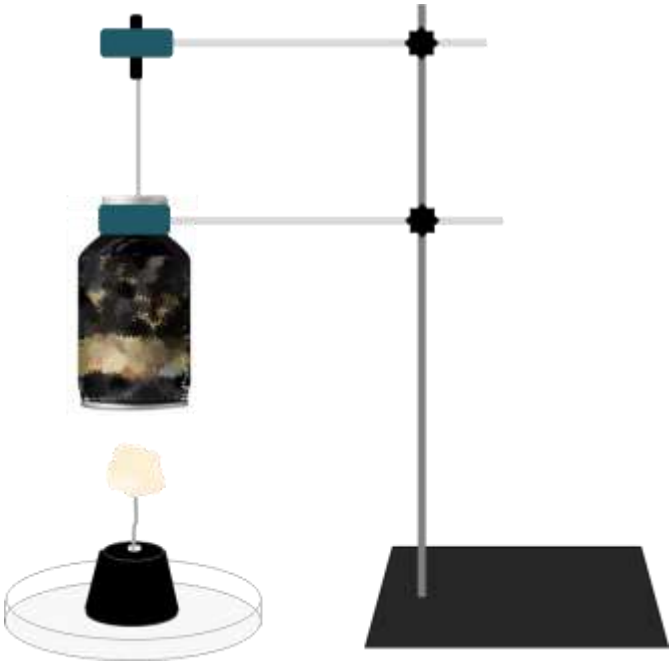


4. Measure and record the mass of the food sample set (food + clip + rubber stopper + petri dish).

5. Peel the outer shell of the aluminum can, measure, and record its mass.
6. Pour 200mL of water into the aluminum can and fix it at an appropriate height on the stand using clamps.

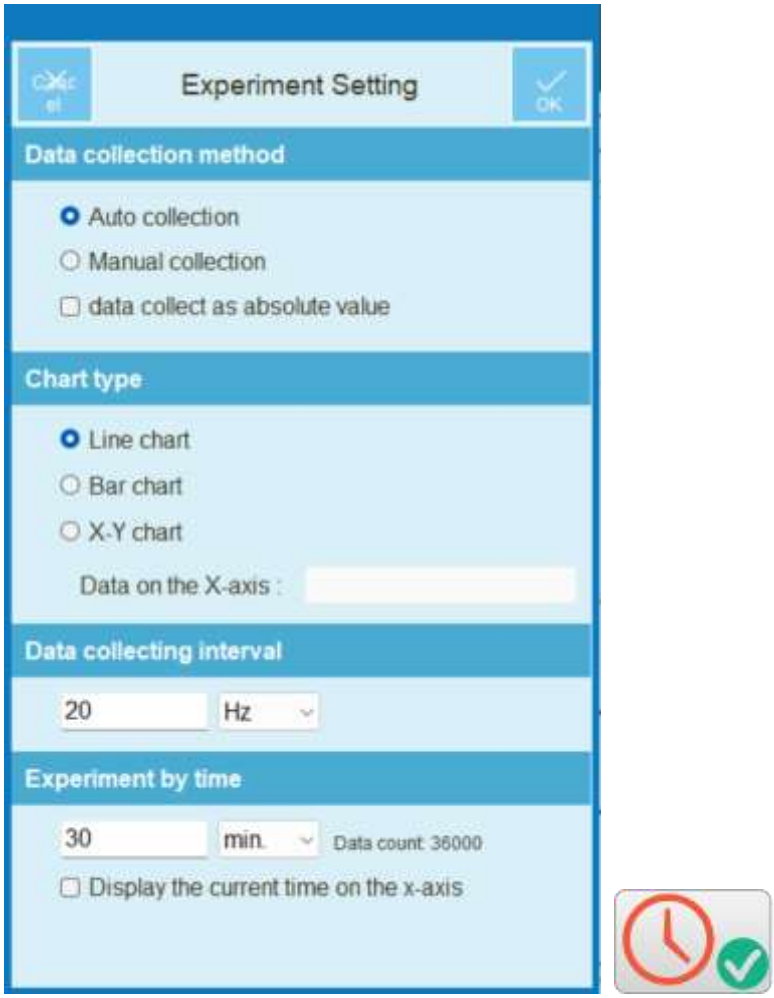
7. Set up the temperature sensor to be submerged in the water, ensuring it does not touch the bottom or walls of the aluminum can.

8. Position the food sample directly under the center of the aluminum can.



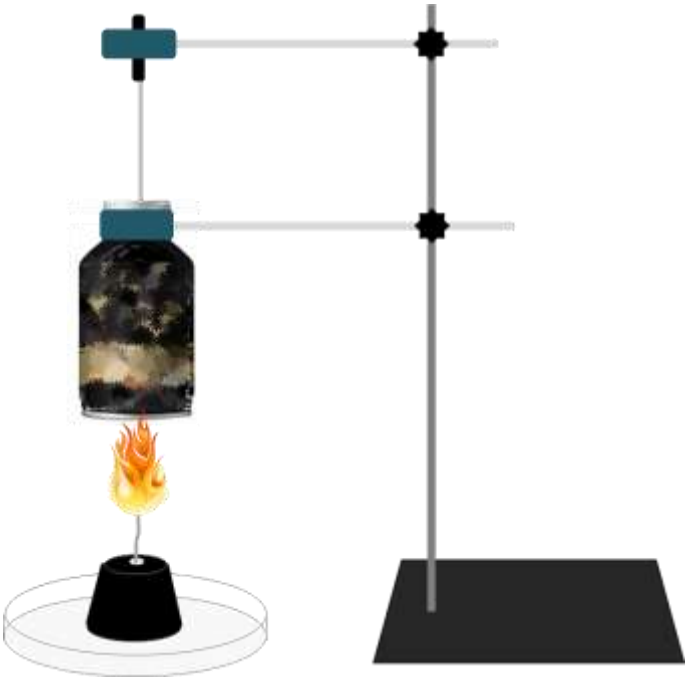
Interface Setup

1. Run the Science# program.
2. Connect the temperature sensor to the interface.
3. Press to set up the experimental environment as shown below or press for automatic setup.



Data Collection

1. Ignite the food sample under the aluminum can using the igniter and immediately place it directly below the center of the aluminum can.
2. Press  to start data collection.



3. Stop data collection when the food sample's flame goes out and the temperature no longer rises.
4. Record the initial and final temperatures of the water.
5. Measure and record the mass of the food sample set after combustion.

6. Remove the soot from the aluminum can with a tissue, refill it with 200mL of fresh water, and repeat the experiment.

Data Analysis

Recording Data

1. Record the name of the food to be experimented on and its caloric content as listed in

the food analysis table..

Category	A	B	C	D
Food Name				
Listed Calories (kcal/g)				

2. Record the results measured from the above experiment in the table below..

Category	A	B	C	D
Mass of Water (g)				
Mass of Aluminum Can (g)				
Initial Temperature of Water (°C)				
Final Temperature of Water (°C)				
Temperature Change of Water Δt (°C)				
Initial Mass of Food Sample Set (g)				
Mass of Food Sample Set after Combustion (g)				
Mass Change of Food Sample (g)				

3. Calculate and record the caloric content of the burned food and the caloric content per gram of food..

▶ Caloric content of the burned food (Cal) = [Heat capacity of water (Cal/°C) + Heat capacity of the can (Cal/°C)] × Temperature change of water (°C)

※ Specific heat of water: 1(Cal/g·°C) , Specific heat of aluminum: 0.215 (Cal/g·°C)

▶ Caloric content per gram of food (Cal/g) = (Caloric content of burned food (Cal)) / (Mass of burned material (g))

Category	A	B	C	D
Caloric Content of Burned Food (Cal)				
Caloric Content per Gram of Food (Cal/g)				

Data Application

1. Among the tested foods, list the names of the foods in the order of lowest caloric content according to the food analysis table and the measured results.

   Order by food analysis table:

   Order by measured results:

2. Do the measured caloric contents of the foods match those listed in the food analysis table? If not, what are the possible reasons for the discrepancies (sources of error)?

3. Explain how to improve the experimental setup to minimize errors.