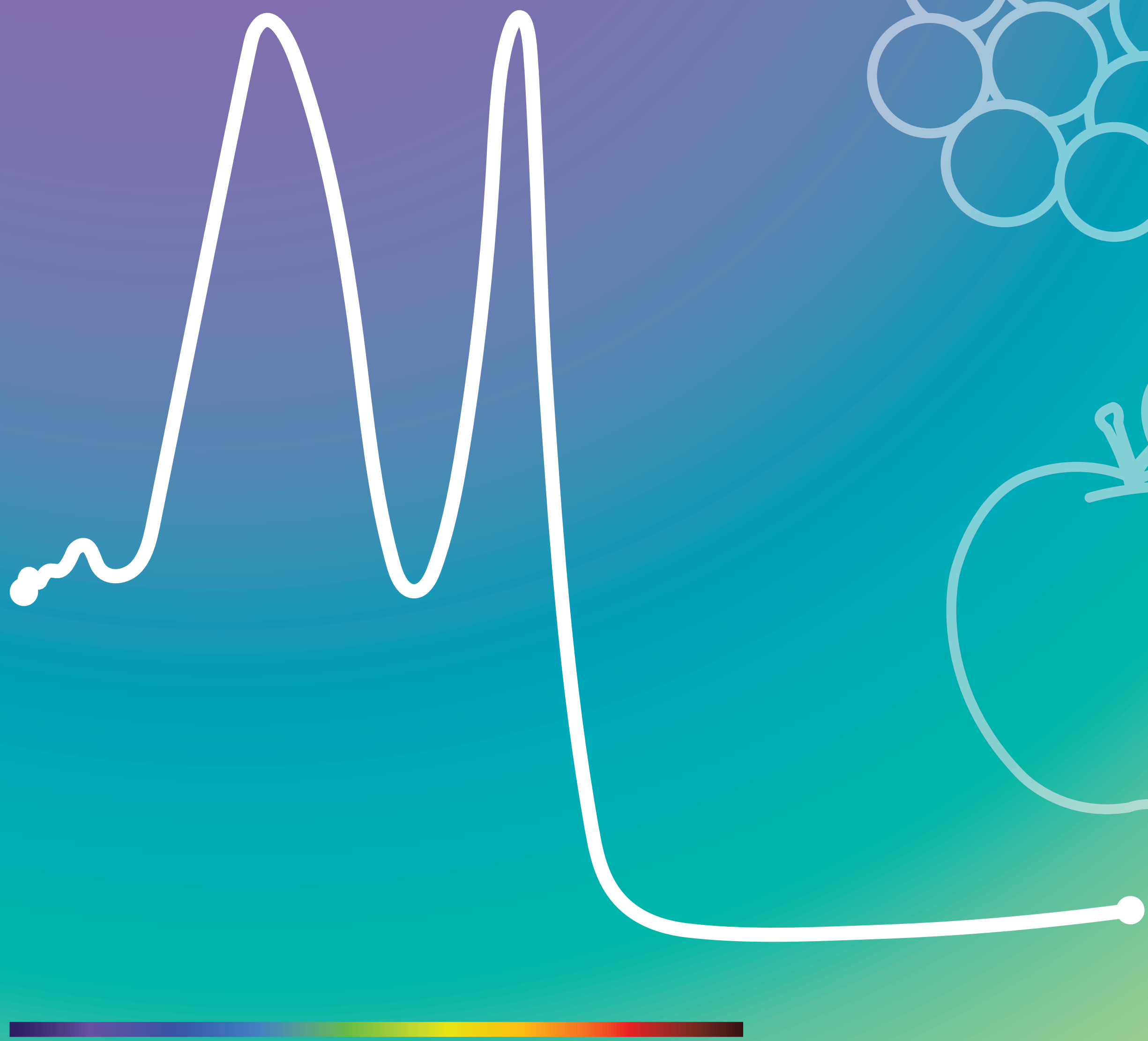
Food Chemistry Experiments



HSB-FOOD

Vernier

Contents

Experiments

Appendices

Topics in Chemistry Courses

		Units and Measurement	States of Matter	Soluitons and Mixtures	Thermochemisty	Atomic Structure	Chemcal Bonding	Equations and Stoichiometry	Acids/Bases/pH	Kinetics	Electrochemistry
1	Food is Fuel	X			X						
2	Cooking Under Pressure	X	X								
3	What’s the Difference Between Baking Soda and Baking Powder?		X					X	X		
4	My Flat Soda Pop	X	X	X							
5	I'm Drinking Acid?!	X						X	X		
6	Electrolytes in Energy Drinks	X		X		X	X				
7	Fermenting Carbohydrates		X							X	
8	True Colors: Separating Food Dyes			X							
9	Quantifying Iron in Cereal	X	X	X				X			
10	Do Vegetables Have Carotenoids?			X							
11	Why Does Your Energy Drink Glow?			X							
12	Vitamin C in Orange Juice			X				X	X		X
13	Using Polarimetry to Identify Sugar and Sweeteners in Beverages							X			
14	Confectionary Chemistry: Measuring Sugar Inversion			X						X	

Equipment Used in Experiments

		Temperature	Gas Pressure	pH	Conductivity	Carbon Dioxide Gas	Ethanol	Spectrometer	ORP	Chemcal Polarimeter
1	Food is Fuel	X								
2	Cooking Under Pressure	X	X							
3	What's the Difference Between Baking Soda and Baking Powder?			X		X				
4	My Flat Soda Pop					X				
5	I'm Drinking Acid?!			X						
6	Electrolytes in Energy Drinks				X					
7	Fermenting Carbohydrates					X	X			
8	True Colors: Separating Food Dyes							X		
9	Quantifying Iron in Cereal							X		
10	Do Vegetables Have Carotenoids?							X		
11	Why Does Your Energy Drink Glow?							X		
12	Vitamin C in Orange Juice								X	
13	Using Polarimetry to Identify Sugar and Sweeteners in Beverages									X
14	Confectionary Chemistry: Measuring Sugar Inversion									X

Food is Fuel

We consume food to get the energy necessary to run our bodies. Different foods contain different amounts of energy. In the United States, the energy in food is measured in Calories (which are actually kilocalories, indicated by the capital "C"); in other parts of the world, people use kilojoules (kJ).

What is in food that provides the energy? How do you measure the amount of energy in food?

In this activity, you will be using a process called calorimetry to determine the amount of energy in different foods. You will burn measured quantities of different foods. The energy released will be used to increase the temperature of a known mass of water (see Figure 1).

Once you know the change in temperature for the amount of water you used, you can calculate the amount of heat energy that went into the water using a well known equation

$$q = mC_p \Delta T$$

where q is the heat energy, m is the mass of the water, ΔT is the change in temperature, and C_p is the specific heat of water, 4.18 J/g°C. This means that 4.18 joules of energy are required to increase the temperature of each gram of water by 1 degree Celsius.

You will then use the amount of heat produced and the mass of the food burned to determine the energy content, in kilojoules per gram, and energy per serving for each food you test.

OBJECTIVES

- Determine the energy released from various foods as they burn.
- Look for patterns in the amounts of energy released during burning of different foods.

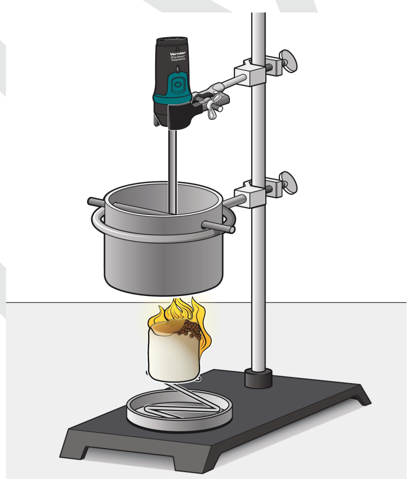


Figure 1

MATERIALS

Chromebook, computer, or mobile device
Graphical Analysis app
Go Direct Temperature
goggles
utility clamp
ring stand and 10 cm (4 inch) ring
2 stirring rods
2 food samples
food holder (medium binder clip and aluminum foil)
wooden splint
100 mL graduated cylinder
small can
cold water
matches
ruler
scissors

PROCEDURE

1. Obtain and wear goggles.
2. Launch Graphical Analysis. Connect the Go Direct Temperature Probe to your Chromebook, computer, or mobile device.
3. Click or tap Mode to open Data Collection Settings. Change Rate to **1** samples/s and End Collection to **600** s. Click or tap Done.
4. Stand a binder clip up on its back with the metal clips together pointing upward (see Figure 2). The food sample will be placed between the metal clips.

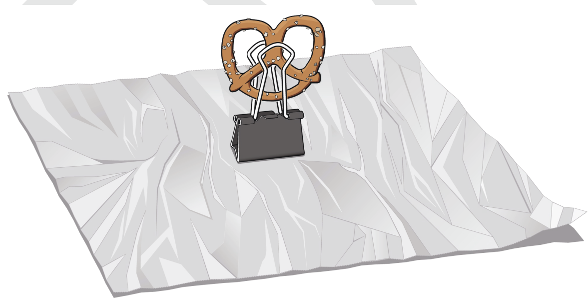


Figure 2

5. Cut a piece of aluminum foil to roughly a 15 × 15 cm square.
6. Determine and record the combined mass of one piece food assigned to you, your binder clip food holder, and your piece of aluminum foil. **Caution**: *Do not eat or drink in the laboratory*.
7. Determine and record the mass of an empty can. Add about 50 mL of cold water to the can. Obtain the cold water from your teacher. There should be no ice in the water. Determine and record the mass of the can and water.

8. Set up the apparatus as shown in Figure 1. Use a ring and stirring rod to suspend the can about 2.5 cm (1 inch) above the food sample. Use a utility clamp to suspend the temperature probe in the water. The probe should not touch the bottom or sides of the can. The temperature probe must be in the water for at least 30 seconds before you do Step 9.

9. Click or tap Collect to start data collection. Light a wooden splint on fire and reach under the food sample to ignite the food. Allow the water to be heated until the food sample stops burning. **Caution**: *Keep hair and clothing away from open flames*.

10. Use a stirring rod to stir the water in the can. Continue stirring the water until the temperature stops rising. Data collection will stop after 10 minutes, or you can stop data collection *before* 10 minutes has elapsed if the maximum temperature has been reached.

11. Click or tap the graph, determine and record the minimum and maximum temperature of the water in the can.

12. Determine and record the combined mass of the food sample, binder clip food holder, and aluminum foil after burning.

13. Repeat Steps 4–12 for the second food sample. The binder clip food holder can be reused. Use a new 50 mL portion of cold water. **Note**: The previous data set is automatically saved.

14. When you are done, place burned food, used matches, and partially-burned wooden splints in the container provided by the teacher. Recycle the can as instructed.

DATA AND CALCULATIONS

Food type/name		
Initial mass of food, food holder, and aluminum foil	g	g
Final mass of food, food holder, and aluminum foil	g	g
Mass of empty can	g	g
Mass of can and water	g	g
Minimum temperature, t_{min}	°C	°C
Maximum temperature, t_{max}	°C	°C

Mass of water heated	g	g
Temperature change, ΔT	°C	°C
Mass of food burned	g	g

Heat absorbed by water, q	kJ	kJ
Energy content	kJ/g	kJ/g

PROCESSING THE DATA

1. Find the mass of water heated for each sample. Record the answer in the table.
2. Calculate the change in temperature of the water, ΔT, for each sample.
3. Calculate the heat absorbed by the water, q, using the equation

   $$q = mC_p\Delta T$$

   where q is heat, C_p is the specific heat capacity of water, m is the mass of water, and ΔT is the change in temperature. For water, C_p is 4.18 J/g°C. Change your final answer to kJ.
4. Calculate the mass (in g) of each food sample burned.
5. Use the results of Steps 3 and 4 to calculate the energy content (in kJ/g) of each food sample. Look at the units (kJ/g) for a hint of how to do this calculation.
6. Which food generated the most heat when it was burned?
7. Which food has the highest energy content?
8. Food energy is often expressed in a unit called a Calorie in the United States. Note that the first letter is capitalized. This indicates that food calories are actually kilocalories. There are 4.18 kJ in one Calorie.
   a. Convert your value for energy content from kJ/g to Calories/g.
   b. Calculate the number of Calories in a 50 g package of one of the foods you tested.
9. Your teacher will supply you with the actual values of energy for each food you tested. Calculate the percent error in your determination of energy content for each food sample you tested.
10. Why do you suppose there is a difference between your data and the actual amount of energy in the foods? How might you change the experiment to improve your results?
11. Chips are typically fried in oil and have high fat content as well as high carbohydrate content. Pretzels are high in carbohydrate content but contain little or no fat. From your results, what generalization can you make about the relative energy content of fats and carbohydrates?

Experiment **10**

Do Vegetables Have Carotenoids?

Carotenoids are fat-soluble pigments found in plants. We can't synthesize carotenoids in our bodies; they can only be acquired from fruits and vegetables in our diet. In addition to being potent antioxidants, some carotenoids also contribute to dietary vitamin A. Vitamin A is essential for normal growth and development, immune system function, and vision.

Carotenoids are divided into two groups: xanthophylls and carotenes. Xanthophylls contain oxygen; carotenes are hydrocarbons and contain no oxygen. The most common carotenoids include lycopene and a vitamin A precursor called β-carotene. These pigments absorb light between 400 nm and 550 nm and appear red, orange, or yellow to the eye. Carotenoids can also be found in spinach, but the characteristic carotenoid color is masked by the presence of chlorophyll. By extracting the pigments and analyzing the solution by spectroscopy, the different colors can be distinguished.

In this experiment, you will create solutions from carrots, spinach, and tomatoes. You will then use a spectrophotometer to analyze the resultant solutions to determine if carotenoids are present.

OBJECTIVES

- Extract carotenoids from carrots, spinach, and tomatoes.
- Observe the absorbance spectra for each of the solutions.

MATERIALS

Chromebook, computer, or mobile device
Spectral Analysis app
Go Direct SpectroVis Plus
goggles
cuvette
distilled water
wash bottle
carrots
spinach
tomato paste
funnel
filter paper
ring stand and ring
three 250 mL Erlenmeyer flasks
70% isopropanol
beral pipets
plastic spoon
three 250 mL beakers
50 mL graduated cylinder
lint-free tissues
balance

PROCEDURE

Part I Extract carotenoids

1. Put on safety goggles.
2. Weigh out ~5 g of carrots and transfer to a 250 mL beaker.
3. Measure 30 mL of isopropanol using a 50 mL graduated cylinder.
4. Pour the solvent into your beaker containing the carrots.
5. Using a plastic spoon, gently mash the carrots into a slurry.

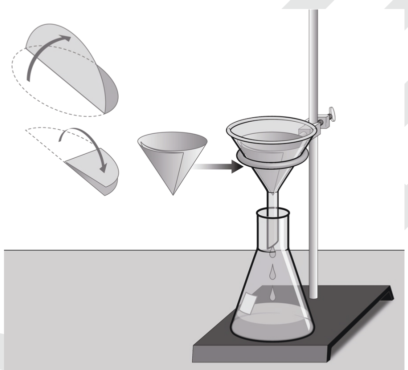


Figure 1

6. Set up a gravity filtration apparatus, see Figure 1.
   a. Gravity filter the contents in the flask into a clean 250 mL flask. Pour only the liquid and not the solid into the funnel.
   b. Label the flask.
   c. Save the solution for Part II.
7. Weigh out ~5 g of spinach and transfer to a clean 250 mL beaker. **Note**: Make sure to use a clean plastic spoon.
8. Repeat Steps 3–6.
9. Weigh out ~5 g of tomato paste and transfer to a clean 250 mL beaker. **Note**: Make sure to use a clean plastic spoon.
10. Repeat Steps 3–6.

Part II Measure absorbance spectra

11. Prepare a blank by filling a cuvette 3/4 full with distilled water. To correctly use a cuvette, remember:
    - All cuvettes should be wiped clean and dry on the outside with a tissue.
    - Handle cuvettes only by the top edge of the ribbed sides.
    - All solutions should be free of bubbles.
    - Always position the cuvette so the light passes through the clear sides.

12. Launch Spectral Analysis. Connect Go Direct SpectroVis Plus to your Chromebook, computer, or mobile device. Click or tap Absorbance *vs*. Wavelength.

13. To calibrate the spectrometer, place the blank cuvette of water in the spectrometer and select Finish Calibration. **Note**: If necessary, wait for the spectrometer to warm up before selecting Finish Calibration.

14. Prepare a sample by filling a cuvette 3/4 full with the carrot solution.

15. Collect spectrum data.
    a. Remove the blank cuvette, and place the cuvette containing the sample into the cuvette slot. Make sure to align the cuvette correctly.
    b. Click or tap Collect. The absorbance *vs*. wavelength spectrum will be displayed. Click or tap Stop. **Note**: If the absorbance is higher than 1.0, the sample is too concentrated. Dilute with isopropanol and repeat until the absorbance is below 1.0.
    c. To rename the data set, click or tap the y-axis label, Absorbance. For Data Set 1, click or tap Data Set Options, ⋯, and then select Rename Data Set.
    d. Enter **Carrot** as the name, and click or tap Rename.

16. Repeat Steps 14–15 for the spinach and tomato solutions.

17. Save the file if directed by your instructor.

18. Dispose of all solutions properly.

DATA TABLE

	Peak wavelengths (nm)
Carrot	
Spinach	
Tomato	

DATA ANALYSIS

1. How do the visible light absorbance spectra of various vegetable solutions compare?

2. Describe the visible light absorbance spectrum of the spinach extract, identifying the absorbance peaks and other distinguishing features.

3. A student measures the absorbance spectrum of a sample of food and records a maximum wavelength of 625 nm. Does this food contain carotenoids? Explain your answer.

4. List some additional fruits and/or vegetables that contain carotenoids.

EXTENSION

Materials

- goggles
- 50 mL graduated cylinder, glass
- rubber stopper
- chromatography paper
- fresh spinach leaves
- coin
- pencil
- scissors
- chromatography solvent

Procedure

1. Obtain and wear goggles! **Caution**: *The solvent in this experiment is flammable and poisonous. Be sure there are no open flames in the lab during this experiment. Avoid inhaling fumes. Wear goggles at all times. Notify your instructor immediately if an accident occurs.*
2. Obtain a 50 mL graduated cylinder with 5 mL of chromatography solvent in the bottom.
3. Cut the chromatography paper so that it is long enough to reach the solvent. **Important**: Handle the chromatography paper by the edges only; you do not want to get dirt or oil from your hand on the paper.
4. Draw a pencil line 2.0 cm above the end of the paper.
5. To use a coin to extract the pigments from the spinach leaf, place a small section of the leaf on top of the pencil line and use the ribbed edge of the coin to push the plant cells into the chromatography paper. Repeat the procedure ~10 times.
6. Place the chromatography paper in the cylinder so the end just touches the solvent. Make sure the pigment is not in the solvent.
7. Stopper the cylinder and wait until the solvent is approximately 1 cm from the top of the paper.
8. Remove the stopper and chromatography paper. Mark the solvent front before it evaporates.
9. Allow the paper to dry. Mark the bottom of each pigment band.
10. Identify each of the bands and label them on the chromatography paper.
    - β-carotene: yellow to yellow orange
    - Xanthophyll: yellow
    - chlorophyll *a*: bright green to blue green
    - chlorophyll *b*: yellow green to olive green
11. Discard the solvent as directed by your instructor.