Food

Burning Calories: How Much Energy is Stored in Different Types of Food?

(http://www.sciencebuddies.com)

Objective

The goal of this experiment is to determine the amount of chemical energy stored in food by burning it and capturing the heat given off in a homemade calorimeter.

Introduction

You know that the energy that keeps your brain and body going comes from the food you eat. Your digestive system and the cells in your body break down the food and gradually oxidize the resulting molecules to release energy that your cells can use and store.

In this project you will learn a method for measuring how much chemical energy is stored in different types of food. You will oxidize the food much more rapidly, by burning it in air. You'll use a homemade *calorimeter* to capture and measure the heat energy released by burning. The basic idea of a calorimeter is to capture the released heat energy with a reservoir of water, which has a high capacity for absorbing heat. The temperature of the water reservoir is measured at the beginning and at the end of the experiment. The increase in the temperature (in °C) times the mass of the water (in g) will give you the amount of energy captured by the calorimeter, in calories. We can write this in the form of an equation:

$$Q_{water} = mc\Delta T$$

where:

- Q_{water} is the heat captured, in calories (cal);
- m is the mass of the water, in grams (g);
- c is the specific heat capacity of water, which is 1 cal/g°C (1 calorie per gram per degree Celsius); and
- ΔT is the change in temperature (the final temperature of the water minus the initial temperature of the water), in degrees Celsius (°C).

Let's work through an example to make sure that the equation is clear. (We'll use made-up numbers for the example. You'll have to try the experiment for yourself to get actual measurements.) So let's say that we start out with 100 g of water in the calorimeter (m = 100 g). The initial temperature of the water is 20°C. After burning up some small piece of food, we measure the water temperature again, and find that the final temperature is 24°C. Now we have all of the information we need to calculate the amount of heat captured by the calorimeter:

$$\begin{aligned} Q_{water} &= mc\Delta T \\ &= 100\ \text{g} \times 1\ \frac{\text{cal}}{\text{g}^\circ\text{C}} \times (24^\circ\text{C} - 20^\circ\text{C}) \\ &= 100\ \not{\text{g}} \times 1\ \frac{\text{cal}}{\not{\text{g}}^\circ\not{\text{C}}} \times (24^\circ\not{\text{C}} - 20^\circ\not{\text{C}}) \\ &= 100 \times 1\ \text{cal} \times 4 \\ &= 400\ \text{cal} \end{aligned}$$

Now you can see why the specific heat capacity of water has such strange units (cal/g°C). Notice that the grams (g) from the mass of the water and the degrees Celsius (°C) from the change in temperature cancel out with the grams (g) and degrees Celsius (°C) in the denominator of the units for specific heat. That way you are left with units of calories (cal), which is what you want.

A Note on Units

A calorie (lowercase "c") is actually defined by the heat capacity of water. One calorie is the amount of energy that will raise the temperature of a gram of water by 1°C. When we talk about food energy, we also use the word "Calorie," (note uppercase "C") but it is a different unit. It is the amount of energy needed to raise the temperature of a kilogram (= 1000 grams) of water by 1°C. So a Calorie is the same as 1000 calories. Or, to put it another way, 1 Calorie = 1 kcal. So in this project, for food Calories we will be careful always to use an uppercase "C".

Eating a balanced diet is fundamental to good health. This project will give you a chance to learn about how much energy your cells can extract from different types of food. It is important to remember though, that energy is only one measure of nutritional value. As you are doing your background research on this project, try to find out about other measures of a balanced diet in addition to food energy.

Terms, Concepts and Questions to Start Background Research

To do this project, you should do research that enables you to understand the following terms and concepts:

- calorie (cal),
- kilocalorie (kcal),
- Calorie,
- calorimeter,
- oxidation,
- Recommended Dietary Allowance.

Questions

- The reference level for a normal diet is 2000 Calories. How many calories is this?
- What are the basic chemical structures of fats, sugars and proteins?
- Do these types of molecules differ in the amount of energy they contain?
- Which of your food items do you think will release the most energy? Why?
- What is meant by a "balanced" diet? Why is it important?

Bibliography

- Gardner, R., 1999. *Science Projects About Kitchen Chemistry.* Berkeley Heights, NJ: Enslow Publishers, 40–42.
- The U.S. Department of Agriculture is a good online source of information about nutrition. The links below are for general information, key nutritional recommendations and special pages with information for kids:
  - http://www.mypyramid.gov/guidelines/index.html,
  - http://www.health.gov/dietaryguidelines/dga2005/recommendations.htm,
  - http://www.mypyramid.gov/kids/index.html.

Materials and Equipment

To do this project, you will need the following materials and equipment:

- Homemade calorimeter, (for diagram and instructions on assembling, see Experimental Procedure, below) requires:
  - two tin cans, one larger than the other,
  - wood dowel, pencil or other rod-shaped support,
  - cork,
  - needle or wire,
  - pliers,
  - old style beer can opener,

    - hammer and nail.
- graduated cylinder,
- water (preferably distilled),
- thermometer (calibrated in °C, range 20–100 or greater),
- safety glasses,
- lighter or matches,
- scale (calibrated in grams, for determining energy content per gram of food),
- food items to test (dry items will obviously work better), for example:
    - roasted cashew nuts, peanuts or other whole nuts,
    - pieces of popcorn,
    - marshmallows,
    - small pieces of bread,
    - dry pet food.

Experimental Procedure

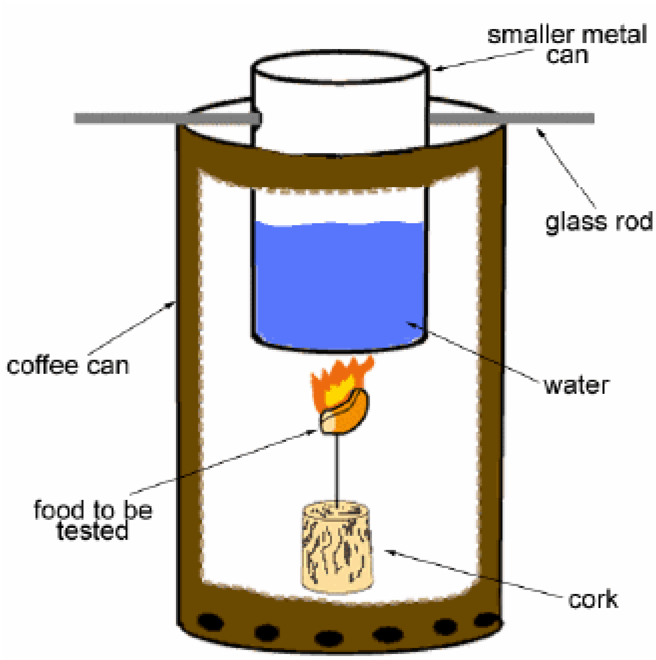


Diagram of Homemade Calorimeter

1. ***Safety note: adult supervision is required! As with any project involving open flame, there is a fire hazard with this project. Make sure you work on a non-flammable surface. Keep long hair tied back. Be careful handling the***

items used in this experiment as they may be hot! Wear safety glasses.

2. Constructing the calorimeter (refer to the diagram above).
    a. Select two cans to build your calorimeter. They should nest inside one another. The smaller can needs to sit high enough so that you can place the cork, needle and food item beneath it.
    b. Remove the top *and* bottom from a coffee (or similar-sized) can, so that you have a cylinder open on both ends.
    c. Use the beer can opener to make holes in the bottom (to allow air to in to sustain the flame).
    d. Punch holes at opposite sides of the smaller can for the support to pass through. The diagram labels the support as a glass rod, but you can use a wood dowel, a pencil, or a metal rod for the support. Your support needs to be longer than the width of your large can.
    e. Use the pliers to grasp the needle (or wire) and push its blunt end into the cork. You will impale the food to be tested on the sharp end of the needle. (If you use wire, you can wrap it around the food item to be tested. Don't use insulated wire!)
    f. The smaller can will hold the water to be heated by burning the food samples. Use the graduated cylinder to measure how much water you use; the can should be about half-full. Put the supporting rod in place through the two holes.
3. Weigh each of the food items to be tested and record the weight.
4. Fill the small can about half-way with a measured amount of distilled water.
5. Measure the initial temperature (T_i) of the water.
6. Impale the food item on the needle (or wrap the wire around it.
7. Have your calorimeter pieces close at hand, and ready for use. For more information on how to properly weigh items see Chemistry Lab Techniques - http://sciencebuddies.com/science-fair-projects/project_ideas/Chem_Lab_Techniques.shtml.
8. Place the cork on a non-flammable surface. Light the food item (the nuts may take awhile to catch fire).
9. When the food catches fire, immediately place the large can around the cork, then carefully place the smaller can in place above the flame.
10. Allow the food item to burn itself out.
11. Carefully remove the small can by holding the ends of the supporting rod, and place it on a flat, heat-proof surface. The can will be hot, so be careful.
12. Carefully stir the water and measure the final temperature (T_f). Make sure the thermometer has reached a steady level before recording the value.
13. When the burnt food item has cooled, carefully remove it from the needle (or wire) and weigh the remains.

14. Repeat these steps for all of the food items. It's a good idea to repeat the measurement with multiple samples of each food item, to insure consistent results.
15. Analyze your data. Calculate the energy released per individual food item (in calories and Calories), and the energy per unit weight of each food item (in calories/gram and Calories/gram). From your individual results, calculate average values for each food type.

Questions

- Which food type released the most energy per gram?
- Can you calculate the average energy (in Calories) for each type of food item you tested?
- Do you think the amount of Calories you measured is likely to be higher or lower than the true value for each food item? Why?

Variations

- Do background research to find out the approximate proportions of the different basic food chemicals (fats, carbohydrates, proteins) in each of the food items you tested. Can you draw any conclusions about the relative amounts of energy available in these different types of chemicals?
- Do background research to find out the chemical composition of candle wax (paraffin). Design an experiment to determine the amount of energy released per gram of candlewax.

Candy Chromatography: What Makes Those Colors?

(from http://www.sciencebuddies.com)

Objective

The goal of this project is to use paper chromatography to see which dyes are used in the coatings of your favorite colored candies.

Introduction

Have you ever had a drop of water spoil your nice print-out from an inkjet printer? Once the water hits the paper, the ink starts to run. The water is absorbed into the fibers of the paper by capillary action. As the water travels through the paper, it picks up ink particles and carries them along. This same process that spoils a perfect print-out can also be put to good use. There's even a name for it: paper chromatography.

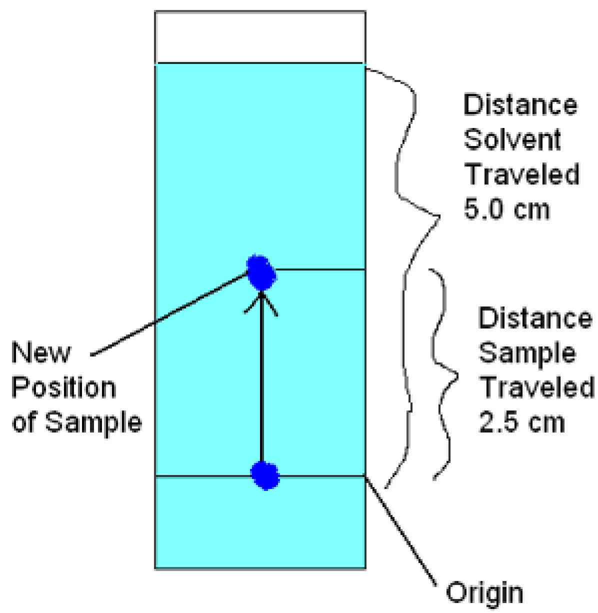
Chromatography is a technique used to separate the various components in a complex mixture or solution. It works because the components of the mixture will differ in how much they "stick" to things: to each other, and to other substances. For example, some of the components of the ink will stick more tightly to the paper fibers. They will spend less time in the water as it moves along the paper fibers, and thus they will not travel very far. Other components of the ink will stick less tightly to the paper fibers. They will spend more time in the water as it moves along the paper fibers, and thus they will travel farther through the paper.

Other materials than paper and water can be used for chromatography, but in each chromatography apparatus there is generally a *stationary phase* and a *mobile phase*. In paper chromatography, the paper is the stationary phase, and water is the mobile phase. Another example of a chromatography systems is a glass column filled with tiny, inert beads (the stationary phase). The mixture to be separated is added to the column, and is then "washed out" with some type of solution (the mobile phase). In this case, the separation is based on molecular size. Smaller molecules will pass through the spaces between the beads more easily, so they will come out of the column more quickly. Larger molecules will take more time to pass between the beads, so they will come out of the column later. You can separate the smaller molecules from the larger molecules by collecting the liquid that comes off such a column in a series of separate containers.

Chromatography can be used to separate (purify) specific components from a complex mixture, based on molecular size or other chemical properties. It can also be used to identify chemicals, for example crime scene samples like blood, drugs, or explosive residue. Highly accurate chromatographic methods are used for process monitoring, for example to assure that a pharmaceutical manufacturing process is producing the desired drug compound in pure form.

With colored mixtures in paper chromatography, you can see the components separate out on the paper.

To measure how far each component travels, we calculate the retention factor (R_f value) of the sample. The R_f value is the ratio between how far the component travels and the distance the solvent travels from a common starting point (the origin). If one of the sample components moves 2.5 cm up the paper and the solvent moves 5.0 cm, then the R_f value is 0.5. You can use R_f values to identify different components as long as the solvent, temperature, pH, and type of paper remain the same. In the image below, the light blue shading represents the solvent and the dark blue spot is the chemical sample.



When measuring the distance the sample traveled, you should measure from the origin (where the middle of the spot originally was) and then to the center of the spot in its new location.

To calculate the R_f value, we use the equation:

$$R_f = \frac{\text{distance traveled by the sample component}}{\text{distance traveled by the solvent}}$$

In our example, this would be:

$$R_f = \frac{2.5\ cm}{5.0\ cm} = 0.5$$

Note that an R_f value has no units because the units of distance cancel.
In this project, you'll use the R_f value to compare the "unknown" components of colored candy dyes with the "known" components of food coloring dyes. Since there are only a small number of approved food dyes, you should be able to identify the ones used in the candies by comparison to the chromatography results for food coloring.

Terms, Concepts and Questions to Start Background Research

To do this project, you should do research that enables you to understand the following terms and concepts:

- Adhesion, cohesion forces
- Capillary action
- Paper chromatography
- Stationary phase
- Mobile phase
- Hydrophilic
- Hydrophobic
- Retention factor (R_f)
- Solvent
- Solution

Questions

- Why do different compounds travel different distances on the piece of paper?
- How is an Rf value useful?
- What is chromatography used for?

Bibliography

- This website is a good reference for basic chemistry concepts:
  Andrew Rader Studios, 1997–2007. "Chem4Kids," Chem4Kids.com [accessed July 17, 2007] http://www.chem4kids.com.
- Here you'll find an overview of liquids and capillary action:
  Microsoft Corporation, 2003–2007. "Liquids," Microsoft Encarta [accessed July 17, 2007]

http://encarta.msn.com/encnet/refpages/RefArticle.aspx?refid=761571486&sec=18#s18.

- This is a good general reference on chromatography, written by a high school sophomore in an AP Chemistry course:
  VanBlaricum, A., 1997. "Chromatography," [accessed July 17, 2007] http://www.doggedresearch.com/chromo/chromatography.htm.
- This project idea is based on:
  Helmenstine, A.M., 2007. "Candy & Coffee Filter Chromatography," About.com:Chemistry [accessed July 17, 2007] http://chemistry.about.com/od/chemistryexperiments/ht/candychroma.htm.

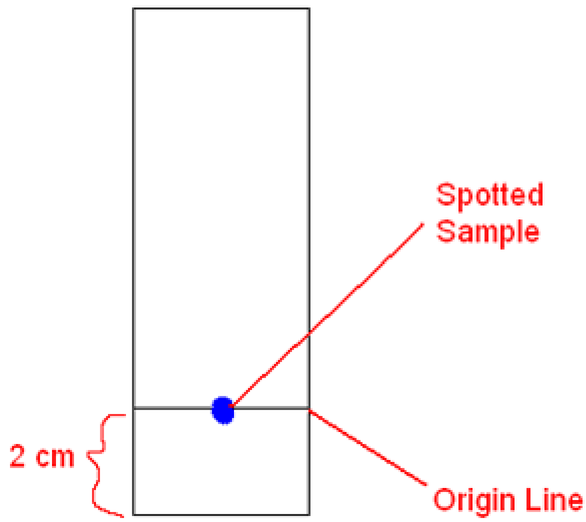
Materials and Equipment

To do this experiment you will need the following materials and equipment:

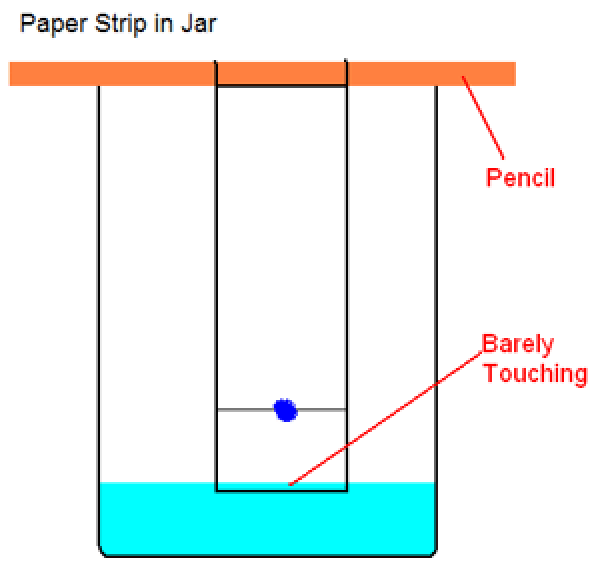
- Candy with a colored coating, like Skittles® or M&Ms®
- At least 30 strips of paper
  - All strips must be exactly the same size.
  - 3 cm × 9 cm is a good size, but you can change this to fit your needs.
  - You can use white cone-type coffee filters cut into strips, or you can use chromatography paper.
- Wide-mouth jar
- Pencil
- Ruler
- Tape
- Salt
- Water
- Toothpicks
- Food coloring (red, green, and blue)

Experimental Procedure

1. Do your background research so that you are knowledgeable about the terms, concepts, and questions, above.
2. Use a pencil to lightly label which candy color or food coloring will be spotted on each paper strip. Tip: do *not* use a pen for writing on the strips: the ink will run when the solvent passes through the strips.
3. Draw a pencil line 2 cm from the edge of each strip of paper.
   a. This will be the origin line.
   b. You will spot the candy color for each strip right on this line, as shown below.



4. Next you need to extract some dye from each candy you wish to test.
    a. Set the candy down on a clean plate in a drop of water.
    b. Leave it for a minute to allow the dye to dissolve.
    c. Remove the candy, then dip a clean toothpick into the now-colored drop of water.
    d. Spot the candy dye solution onto the chromatography paper by touching the toothpick to the chromatography strip, right in the center of the origin line.
    e. Allow the spot to dry, then repeat the spotting at least three more times. You want to make sure to have enough dye on the chromatography paper so that you can see the dye components when they separate out on the paper.
    f. Make five separate strips for each candy you want to test.
5. Repeat step 4 for each color of candy you want to test (at least three different colors).
6. You also need to prepare chromatography strips with food coloring dyes.
    a. These will be your known compounds, with which you will compare the "unknown" candy dyes.
    b. For each food coloring color, use the same procedure as in step 4. You'll use a drop of food coloring as the source for dipping your clean toothpick.
7. Prepare a 1% salt solution for the chromatography solvent.
    a. Add 1/8 teaspoon of salt to 3 cups of water (1 g of salt to 1 L of water).
    b. Shake or stir until the salt is completely dissolved.
8. Pour a small amount of the salt solution into the wide-mouth jar.
    a. You'll tape the strip to a pencil and rest the pencil on top of the jar so that the strip hangs into the jar.
    b. The goal is to have the end of the chromatography strip just touching the surface of the solvent solution, as shown in the drawing below.



9. Let the solvent rise up the strip (by capillary action) until it is almost at the top, then remove the strip from the solvent.
10. Use a pencil to mark how far the solvent rose with a pencil.
11. Allow the strip to dry, then measure the R_f value for each candy color (or food coloring) dye component.
12. Using the five repeated strips for each candy color (or food coloring), calculate the average R_f for each dye component.
13. Compare the R_f values for the candy colors and the food coloring dyes. Can you identify which food coloring dyes match which candy colors?

Chemistry of Ice-Cream Making: Lowering the Freezing Point of Water

(from http://www.sciencebuddies.com)

Objective

The goal of this project is to investigate how dissolving substances in water affects the freezing point of the solution.

Introduction

To make ice cream with an old-fashioned hand-crank machine, you need ice and rock salt to make the cream mixture cold enough to freeze. If you live in a cold climate, you've seen the trucks that salt and sand the streets after a snowfall to prevent ice from building up on the roads. In both of these instances, salt is acting to lower the freezing point of water.

For the ice cream maker, because the rock salt lowers the freezing point of the ice, the temperature of the ice/rock salt mixture can go below the normal freezing point of water. This makes it possible to freeze the ice cream mixture in the inner container of the ice cream machine. For the salt spread on streets in wintertime, the lowered freezing point means that snow and ice can melt even when the weather is below the normal freezing point of water. Both the ice cream maker and road salt are examples of freezing point depression.

Other substances that dissolve in water also lower the freezing point of the solution. In this project, you'll investigate how the freezing point of a diluted solution changes with the amount of solute added.

Terms, Concepts and Questions to Start Background Research

To do this project, you should do research that enables you to understand the following terms and concepts:

- Colligative properties
- Molecular weight
- Moles
- Molality

- Freezing point depression

Questions

- When sodium chloride dissolves in water, how many solute molecules result from each molecule of solid dissolved?
- When sucrose dissolves in water, how many solute molecules result from each molecule of solid dissolved?

Bibliography

- For more information on colligative properties, see:
  - Eli, Todd & Keith, date unknown. "Colligative Properties," Chemworld, ThinkQuest Library, Oracle Education Foundation [accessed March 28, 2007] http://library.thinkquest.org/C006669/data/Chem/colligative/colligative.html?tqskip1=1.
  - Nave, C.R., 2006. "Colligative Properties of Solutions," HyperPhysics, Department of Physics and Astronomy, Georgia State University [accessed March 28, 2007] http://hyperphysics.phy-astr.gsu.edu/hbase/chemical/collig.html.
- For information on Avogadro's number and molecular weight, see:
  - Lachish, U., 2000. "Avogadro's Number, Atomic and Molecular Weight," [accessed March 28, 2007] http://urila.tripod.com/mole.htm.
  - Furtsch, T.A., date unknown. "Avogadro's Number," Tennessee Technological University [accessed March 28, 2007] http://gemini.tntech.edu/~tfurtsch/scihist/avogadro.htm.
- To try a simulated experiment on freezing point depression or boiling point elevation, see (Flash animation, requires browser plug-in):
  Greenbowe, T.J., 2005. "Boiling-Point Elevation and Freezing-Point Depression," Department of Chemistry, Iowa State University [accessed March 28, 2007] http://www.chem.iastate.edu/group/Greenbowe/sections/projectfolder/flashfiles/propOfSoln/colligative.html.

Materials and Equipment

To do this experiment you will need the following materials and equipment:

- Thermometer capable of reading at least −10°C
- Large styrofoam cup (12 oz. or more, or 400 mL Pyrex® beaker)
- 100 ml graduated cylinder

- Gram balance (accurate to 0.1 gram)
- Test tubes
- Salt
- Sugar
- Water
- Ice
- Spoon

Experimental Procedure

Preparation of Ice Bath

1. Fill the styrofoam cup (or beaker) 3/4 full with ice.
2. Cover the ice with 1/4 to 1/2 inches of table salt.
3. Stir this ice-salt mixture with a spoon and make sure the temperature drops to at least −10°C.
4. You will be using this ice bath to freeze many samples of test solutions. During the course of your experiments, you may need to pour off melted water from the ice bath and to replenish the ice and salt. Wait until the temperature drops to at least −10°C before continuing.
5. Always carefully rinse and dry the thermometer before using it to measure the freezing point of your test solutions. You don't want the thermometer to carry salt water into your test solutions!

Determination of Freezing Points of Solutions

1. You will measure the freezing point for seven different liquids:
    a. Pure water
    b. NaCl in water (three different concentrations)
    c. Sucrose in water (three different concentrations)
2. Preparing NaCl solutions (label each solution clearly):
    a. Prepare solution #1 of NaCl by adding 5.8 g of NaCl to 100 mL of water. Mix until all crystals dissolve.
    b. Prepare solution #2 of NaCl by adding 4.35 g of NaCl to 100 mL of water. Mix until all crystals dissolve.
    c. Prepare solution #3 of NaCl by adding 2.9 g of NaCl to 100 mL of water. Mix until all crystals dissolve.
3. Preparing sucrose solutions (label each solution clearly):
    a. Prepare solution #1 of sucrose by adding 34 g of sucrose to 100 mL of water. Mix until all crystals dissolve.

   b. Prepare solution #2 of sucrose by adding 25.5 g of sucrose to 100 mL of water. Mix until all crystals dissolve. Prepare solution #3 of sucrose by adding 17 g of sucrose to 100 mL of water. Mix until all crystals dissolve.
4. Fill a test tube half-way with the liquid to be tested, and place it in the cup with the ice and salt.
   a. The liquid in the test tube should be below the level of the ice and salt in the cup.
   b. Do not allow any ice or salt from the cup to get into the test tube.
5. Stir the solution in the test tube gently with a thermometer while keeping track of the temperature.
6. When the first ice crystals appear on the inside wall of the test tube, record the temperature. This is the freezing point of the liquid.
7. Repeat steps 4 and 5 with each of the three liquids. To assure yourself that your results are consistent, you should do at least three separate freezing-point determinations for each liquid.
8. Calculate the molalities of the NaCl and sucrose solutions.
   a. Molality is defined as the number of moles of a substance, divided by the weight (in kg) of the solvent.
   b. The number of moles of a substance is defined as the weight of the substance (in g) divided by the gram molecular weight of the substance.
   c. The gram molecular weight of NaCl is 58.443.
   d. The gram molecular weight of sucrose is 342.3.
   e. 100 ml of water weighs 0.1 kg.
9. Make a table of your results, like the following:

solution	g substance	molecular weight substance	amount water (kg)	molality	freezing point (T_f, °C)	ΔT
NaCl #1	5.8	58.443	0.1	1	?	?
NaCl #2	4.35	58.443	0.1	0.74	?	?
etc.						

10. Calculate the freezing point depression, ΔT, by subtracting the freezing point of the test solution from your measured freezing point for the plain water solution.
11. For each of your NaCl and sucrose solutions, graph the average amount of freezing point depression (ΔT, y-axis) vs. molality.

Variations

- Can you explain your results using the equation:

$$\Delta T = K_f \cdot m \cdot i$$

- where *i* is the number of particles produced in solution per molecule of the solid, and K_f for water = 1.86°C/m.

Determining Iodide Content of Salt

(from http://www.sciencebuddies.com)

Objective

The goal of this project is to test different types of salt to see if they contain iodine, an essential micronutrient.

Introduction

"Iodine is an element that is critical for normal function of the thyroid gland, which is a key regulator of the body's basic metabolic rate. Iodine is a micronutrient, meaning we require only small amounts of it. For example, adults need about 150 micrograms of iodine in the form of iodide ion per day. However, an insufficient supply of iodide via diet and drinking water causes the non-cancerous enlargement of the thyroid gland known as goiter. Prolonged lack of iodide can lead to loss of thyroid function and the birth defect known as cretinism, which has been recognized since the Middle Ages. Iodide ion, in the form of potassium iodide, may be added to table salt to produce "iodized salt" in order to easily provide the population with a sufficient dietary supply of this essential nutrient. One difficulty with this is that iodide ion is easily oxidized to iodine by atmospheric oxygen" (Wright, 2007). The chemical equation below shows the oxidation of iodide to iodine:

$$4H^{+}(aq) + 4I^{-}(aq) + O_2(g) \rightarrow 2I_2(aq) + 2H_2O(l)$$

"An accumulation of iodine in a box of table salt would result in the salt's becoming yellow to red in color and the development of a very noticeable bad taste. To avoid this problem, a reducing agent, typically dextrose ($C_6H_{12}O_6$) is added to reduce back to colorless iodide any iodine that may be formed" (Wright, 2007). The chemical equation below shows the reduction of iodine to iodide by dextrose:

$$C_6H_{12}O_6(aq) + I_2(aq) + H_2O(l) \rightarrow C_6H_{12}O_7(aq) + 2HI(aq)$$

In this project, you will test various samples of salt to determine whether they contain this essential micronutrient. In the test, hydrogen peroxide (H_2O_2) reacts with iodide ion present in the salt sample:

$$2H^{+}(aq) + 2I^{-}(aq) + H_2O_2(aq) \rightarrow I_2(aq) + 2H_2O(l)$$

Starch is also added to the testing mixture, so that any iodine produced will form a blue starch-iodine complex. You will use the colored starch-iodine complex as an indicator, identifying the presence (or absence) of iodine in various types of salt.

Terms, Concepts and Questions to Start Background Research

To do this project, you should do research that enables you to understand the following terms and concepts:

- Oxidation
- Reduction
- Iodine
- Iodide ion
- Hydrogen peroxide
- Vinegar
- Dextrose
- Soluble starch

Questions

- Look at the ingredients list on a container of plain (non-iodized) salt. What other ingredients are included besides salt? What do these ingredients have to do with the Morton Salt® slogan "When it rains, it pours?"
- Compare the ingredients on a container of plain table salt to the ingredients in iodized table salt. Which ingredients are included only in iodized table salt? What is the purpose of the ingredients found only in iodized salt?
- What is the purpose of the hydrogen peroxide in the test for iodide?
- What is the purpose of the vinegar in the test for iodide?
- Assuming iodized table salt contains 0.006% iodide by mass, how much iodized salt would a person need to consume each day in order to get the recommended 150 micrograms of iodide?
- Seawater contains approximately 32 g of total dissolved salts per liter, including about 60 micrograms of iodide. Why is it undesirable to evaporate seawater completely to dryness and use the salt to supply our daily 150 micrograms of iodide?

Bibliography

- This project is from Classroom Activity #92, from the *Journal of Chemical Education*, and was written by Stephen W. Wright of Pfizer Global Research and Development:
  Wright, S.W., 2007. "Testing for Iodide in Table Salt," *Journal of Chemical Education* 84 (No. 10, October): 1616A–1617A.
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Materials and Equipment

To do this experiment you will need the following materials and equipment:

- Distilled water
  - Tip: using tap water can produce erratic results.
- Iodine antiseptic solution
  - Use either tincture of iodine or povidone-iodine solution, found in the first aid section of grocery stores and drugstores.
- 3% hydrogen peroxide (H_2O_2) solution
- White vinegar
- Laundry starch solution (e.g. Linit® brand laundry starch)
- Plastic measuring spoons (or graduated cylinders)
- 7 disposable plastic cups (10 ounce or larger)
  - Tip: In order to see the iodine-starch reaction, the cups should be clear plastic or colored plastic with white interior.
- Disposable plastic spoons
- Different types of salt, for example:
  - Plain (non-iodized) table salt
  - Iodized table salt
  - Pickling salt
  - Rock salt (filter any dirt from the solution before testing)
  - Kosher salt
  - "Lite" salt
  - Sea salt
  - Tip: some nations permit the use of potassium iodate (KIO_3) as an iodine supplement in iodized salt. The advantage of potassium iodate over iodide is that the iodate ion is indefinitely stable in air. The procedure used in this project will not detect iodine added as potassium iodate. The U.S. Food and

Drug Administration (FDA) has not approved the use of potassium iodate as a food additive in the U.S.

Experimental Procedure

1. Do your background research so that you are knowledgeable about the terms, concepts, and questions, above.

Positive Control: Iodine-Starch Reaction

2. Pour 1/2 cup (120 mL) of distilled water in 10 ounce (or larger) plastic cup.
3. Add 1/2 teaspoon (2.5 mL) of starch solution.
4. Add several drops of iodine antiseptic solution and stir well with a clean, disposable plastic spoon.
5. What do you observe?

Testing Various Types of Salt for the Presence of Iodide

6. Place 4 tablespoons (about 80 g) of salt in a 10 ounce or larger plastic cup.
7. Add 1 cup (240 mL) of distilled water and stir well for about a minute with a clean, disposable plastic spoon. Not all of the salt will dissolve, but any iodide present in the salt will dissolve.
8. Add 1 tablespoon (15 mL) of white vinegar.
9. Add 1 tablespoon (15 mL) of 3% hydrogen peroxide (H_2O_2).
10. Add 1/2 teaspoon (2.5 mL) starch solution.
11. Stir the mixture well with the disposable plastic spoon, and then let it stand for a few minutes. Does a color form?
12. Repeat steps 6–11 using different types of salt. Which types have detectable amounts of iodide?

Variations

- The effect of pH on the rate of the reaction may be shown by setting up a mixture with iodized salt in which the vinegar is omitted. The starch-iodine color develops very slowly, or not at all, and can require 12–24 hours or more.
- The effect of added reducing agents upon the rate of the oxidation reaction may be shown by adding 1–2 teaspoons of corn syrup to the iodized salt solution. Corn syrup is primarily a solution of dextrose (glucose) and fructose in water. The starch-iodine color develops more slowly in this case.

Great Globs of Gluten! Which Wheat Flour Has The Most?

(from http://www.sciencbuddies.com)

Objective

To determine the relative differences in gluten content between different types of flour.

Introduction

Breads, bagels, pastas, cakes, cookies, crackers, muffins, pastries, pies, and pizza crusts. Are you hungry yet? What do all these foods have in common? Traditionally, they are all made from **wheat flour,** the fine powder made from grinding and sifting **kernels** of wheat, which are the edible part, or **fruit,** of the wheat plant. Wheat is one of a small number of **cereal grains** that comes from the 8,000 species of plants in the **grass family.** It first grew wild on the high plains of the Near East, and then about 12,000 to 14,000 years ago, people first began to **cultivate** it. Today, it is the second most cultivated cereal grain in the world (corn is first, and rice is third).

Figure 1. This drawing shows wheat, from the grass family of plants.

Why is wheat flour so popular? Well, when you mix most other flours (like those made with the cereal grains mentioned above) with water, what you get is a ball of paste that sort of sits there. Mix wheat flour with water, though, and gradually, under repeated pressure, it transforms into something quite lively. It is both **plastic** (can change its shape), and **elastic** (bounces back and returns to its original shape). These unique qualities allow wheat dough to trap gas inside and expand, kind of like a balloon, but not to the point of breaking. The gas comes from tiny plants called **yeast,** which give off **carbon dioxide.** The gas can also come from the combination of **acids** and **bases** in the dough. This expansion of the dough helps breads and other baked goods rise and become light and fluffy.

The plasticity and elasticity are made possible by the presence of an amazing **composite** of **proteins** within the wheat kernel, called **gluten.** These proteins in gluten are long chains of **amino acids,** some of the longest in the world, in fact, with chains around 1,000 amino acids long! The two major proteins in gluten are called **gliadins** and **glutenins.** The gliadins (think of the word "glide") give the gluten its plasticity because they act kind of like ball bearings or a lubricant. They allow the other major protein, the chains of glutenins, to slide past each other without forming **bonds.** You can think of the glutenin molecules as long spring-like chains. As the dough is worked and kneaded, these glutenin molecules can link up with each other, end to end, to form super-long, spring-like chains. This makes a tight, coiled mesh, or net, called "the gluten," to trap the gas in, and this gives the dough its elasticity. All those springs want to "spring back" when they are stretched!

Gluten is also available in a few other cereal grains, notably rye and barley, but in lesser quantities than in wheat. Wheat flours also vary in the amount of gluten they contain. **Hard wheat** is high in gluten and is good for baking things that need toughness and strength, like yeasty breads, bagels, and puff pastries. **Soft wheat** is low in gluten (high in **starch**) and is better for baked goods that need to be tender, like pancakes, cookies, and pastries.

Besides the type of flour that a baker chooses, he or she can also control the gluten strength by manipulating the dough, or by adding other substances to the dough. For example:

- Kneading or stirring the dough strengthens and organizes the gluten mesh.
- Adding salt also greatly strengthens the gluten mesh.
- Adding sugar limits the development of gluten.
- Adding acids weakens the gluten mesh.
- Adding fats weakens the gluten.

Legend has it that gluten was first discovered in the 7th century by Chinese Buddhist monks who were looking for a substitute for meat in vegetarian cooking. When a ball of wheat dough is placed in a bowl of cold water and then **kneaded,** the starch in the dough gradually falls away and dissolves in the water, leaving behind a stringy, **insoluble** ball, most of which is gluten. The Chinese people call it "the muscle of flour." This high-protein mass can then be cut into pieces and fried, steamed, or baked. It has a chewy, meat-like texture. Even today, on a commercial scale, this cold-water rinse-and-knead method is the process by which gluten is commonly extracted from wheat flour. It is also the gooey, sticky process you will use to find out which types of wheat flour contain the most and the least gluten. You'll discover that gluten comes from the Latin word for *glue* for good reason!

Terms, Concepts and Questions to Start Background Research

- Wheat
- Flour
- Kernel
- Fruit (of a wheat plant)
- Cereal grain
- Grass family
- Cultivate
- Plastic
- Elastic
- Yeast
- Carbon dioxide
- Acid
- Base
- Composite
- Protein
- Gluten
- Amino acid
- Gliadin
- Glutenin
- Bond
- Hard wheat
- Soft wheat
- Starch
- Knead
- Insoluble

Questions

- What are the properties of gluten, and what proteins within gluten are responsible for those properties?
- How can a baker control the strength of gluten?
- What are the different types of flour and what kinds of baked goods are they best for?

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- McGee, Harold. *On Food and Cooking.* New York, NY: Scribner, 2004.

This source describes the physical properties of gluten, where it is found, how it is used, and the health concerns associated with it:

- Wikipedia Contributors. (2008, September 14). Gluten. *Wikipedia: The Free Encyclopedia.* Retrieved September 24, 2008, from http://en.wikipedia.org/w/index.php?title=Gluten&oldid=238290563

This source describes the many types of flours, and their relative gluten content:

- Wikipedia Contributors. (2008, September 23). Flour. *Wikipedia: The Free Encyclopedia.* Retrieved September 24, 2008, from http://en.wikipedia.org/w/index.php?title=Flour&oldid=240468848

Materials and Equipment

- Flours, made from wheat, such as whole wheat bread flour, pastry flour, cake flour, or all-purpose flour (3 different types)
- Small mixing bowls (3)
- Sticky notes
- Measuring cup, 1-cup size
- Fork
- Cutting board or work surface
- Clock or watch
- Strainer
- Ruler
- Lab notebook

Experimental Procedure

1. Select three different types of wheat flour and with the measuring cup, measure out 1 cup of each type of flour into small mixing bowls, as shown in Figure 2. Examine the flours and note any differences in color and feel. Write down your observations in your lab notebook.

2. If you have trouble telling the flours apart, then label your bowls with sticky notes to identify what type of flour is inside.

Figure 2. This photo shows three examples of different types of wheat flour.

3. Select one bowl to begin with, and slowly add 1/2 cup to 3/4 cup of tap water to the bowl, while carefully stirring with a fork, as shown below. It will seem difficult to stir at first, but will gradually begin to come together to form a rough ball.

Figure 3. This photo shows the gradual addition of water to the flour, while stirring with a fork to form a rough ball.

4. Sprinkle a spoonful of flour (of the type you are working with) onto a work surface, and onto your hands as well, so that both are lightly dusted with flour. Place the ball of flour onto your work surface and knead it for approximately 5-7 minutes, until it becomes smooth and elastic. Use a clock or watch to keep track of the approximate time you spent kneading. Note the amount of time you spent

kneading in your lab notebook so you can knead for the same amount of time in later trials. If you are unfamiliar with kneading, this is the process of pressing down on the dough ball with your palms, and then pulling it back up again and rotating it slightly with your fingertips. This cycle is repeated over and over again.

Figure 4. These photos show the pushing and pulling process of kneading.

5. Repeat steps 3–4 for your other two bowls of flour. Be sure to knead all the flours for the same amount of time. At the end of the kneading process, you should have three smooth-looking elastic balls of dough.
6. Place your three balls of dough back in their small bowls and let them rest and relax for about 10 minutes.

Figure 5. This photo shows how the balls of dough will look after kneading.

7. Now it's time to find out how much gluten is inside those balls of dough. If you thought kneading was icky and gooey, brace yourself for the next step! Place your strainer in the sink. Some strainers are "stand-alone," meaning they have legs to support them inside the sink, while others need to be placed over a bowl or propped against the edge of the sink. Either way, make sure your strainer is over a sink where the faucet can reach it.

8. Take one of the balls of dough to the sink and cup it in your hands over the strainer. Let cold water run on it as you gently pull and stretch it apart, as shown below. The water will wash away the water-soluble parts, like the carbohydrates, but will leave behind the insoluble protein, the gluten, that you developed while you were kneading. The starch that is being washed away will look like a milky liquid. Continue rinsing your ball of dough until very little milky liquid is coming out and only a sticky, stringy ball remains.

Figure 6. These photos show how to rinse off the ball of dough inside a strainer.

9. Rinse off your strainer to remove any debris, and repeat step 8 for the other two balls of dough. At the end of the rinsing process, you should have three balls of gluten.
10. Measure the diameter of each ball of gluten with a ruler. Record your measurements in a data table, like the one below, in your lab notebook.

Figure 7. This photo shows the measurement of the diameter of one ball of gluten.

11. Repeat steps 1–10 two more times so that you have a total of three trials for the three different types of flour.
12. Average the diameters of your balls of gluten for each type of flour and record the averages in your data table. Which type of flour produced the smallest diameter gluten ball, on average? Which produced the largest? Does this make sense based on the type of foods that each flour is used to create?

Gluten Ball Diameter Data Table

Flour Type	Pastry Flour (example)	All-purpose Flour (example)	Whole Wheat Flour (example)
Trial 1: Gluten Ball Diameter (cm)			
Trial 2: Gluten Ball Diameter (cm)			
Trial 3: Gluten Ball Diameter (cm)			
Average Gluten Ball Diameter (cm)			

Variations

- Use a kitchen scale to evaluate the gluten balls, based on weight, rather than diameter.
- Choose one type of flour and create three equally sized balls of dough from it with different degrees of kneading: no kneading, 5 minutes of kneading, and 10 minutes of kneading. Rinse the three balls of dough and evaluate the gluten balls that are created, either by weight or by diameter.
- Select one type of flour and make doughs with different additives, such as salt, sugar, or oil. Compare the development of gluten within these doughs.

Have Your Chips Lost Their Chomp? Understanding How Food Becomes Rancid

(from http://www.sciencebuddies.com)

Objective

To determine what factors cause potato chips to spoil and go rancid.

Introduction

Have you ever snuck a bite of food you've rediscovered from under your bed or between the couch cushions? Be careful, because food isn't good forever! When food spoils and goes bad, it's often described as **rancid.** Not only can eating rancid food taste bad, but a certain kind of rancidity can actually cause you to get sick, which is why people have developed many ways to prevent foods from spoiling, including smoking, salting, and fermentation. In modern times, we most often preserve foods by canning and refrigerating them. But why does food become rancid in the first place?

Fats or oils (also generally called *fats*) are added to foods, like crackers, cookies, and cakes, to improve the taste and feel (texture) of foods. Foods become rancid when there is a chemical change to the fats in the food. There are three types of rancidity: hydrolytic, oxidative, and ketonic. **Hydrolytic rancidity** (pronounced HY-droh-LIH-tik, derived from the Greek work for water, *hydra*) happens when there is water involved. Oils that are used for deep-frying become rancid faster because placing wet food in the heated frying oil introduces water. **Oxidative rancidity** occurs when the food (fat) is exposed to the oxygen in air. Oxidative rancidity happens in two steps. The first step is slow and happens when the fat in the food is exposed to several factors, including light, high temperatures, and salt. The second step is permanent and happens when oxygen interacts with the fat to create unstable **molecules,** which affect the taste. **Ketonic rancidity** (kee-TAH-nik) occurs when **molds** (a microscopic life form) weaken the fats.

In this cooking and food science fair project, you will investigate oxidative rancidity. Oxidative rancidity makes food taste bad, but it will not make you sick. You will expose potato chips and raisins to air and to light for increasing amounts of time and see if and when the chips and raisins become rancid. Time to get chomping—but don't eat all your specimens before the project is over!

Terms, Concepts and Questions to Start Background Research

- Rancid
- Fats
- Hydrolytic rancidity
- Oxidative rancidity
- Molecule
- Ketonic rancidity
- Mold

Questions

- What are fats? Are fats good for you?
- How does the process of oxidative rancidity occur?
- How do food manufacturers prevent foods from going rancid?

Bibliography

This reference discusses rancidity:

- Lowe, B. (1937). *Experimental Cookery from the Chemical and Physical Standpoint.* Retrieved March 31, 2009, from http://chestofbooks.com/food/science/Experimental-Cookery/Rancidity.html

This reference discusses the importance of and facts about food safety:

- North Carolina Department of Agriculture and Consumer Services. (n.d.). *Kids World–Food Safety.* Retrieved May 11, 2009, from http://www.agr.state.nc.us/cyber/kidswrld/foodsafe/index.htm

For help creating graphs, try this website:

- National Center for Education Statistics. (n.d.). *Create a Graph.* Retrieved March 31, 2009, from http://nces.ed.gov/nceskids/CreateAGraph/default.aspx

Materials and Equipment

- Canning jars, 1-quart (qt.) size, clean and with the rings and lids (12)
- Aluminum foil (1 roll)
- Scotch® tape
- Potato chips with fat (3 large or family-size bags)
- Measuring cup, $\frac{1}{4}$-cup
- Raisins, (3 15-ounce [oz.] boxes)
- Permanent marker
- Masking tape
- Volunteers (2, in addition to you)

- *Note:* The volunteers should be around the same age that you are and should be able to come over every 2 days for 2 weeks *or* you could take samples to school every 2 days for them to taste and rate.

- Lab notebook
- Optional: Graph paper

Experimental Procedure

Note: Oxidative rancidity makes food taste bad, but it will not make you sick.

1. Cover the sides and the bottom of two of the canning jars with aluminum foil so that when the lid is screwed on, no light will enter the jars. You can use Scotch tape to securely attach the foil to the jars.
2. Open the bags of potato chips and the boxes of raisins. Fill one of the foil-covered jars almost full with potato chips. Place ¼ cup of raisins in the other foil-covered jar. Label the jars with masking tape and a permanent marker, with the type of food and trial #, such as *Potato Chips: Trial 1.* Screw the lids tightly onto the jars so that no air can enter the jars.
3. Now fill one of the uncovered jars almost full with potato chips and another uncovered jar with ¼ cup of raisins. Label these jars the same was as you did in step 2. Screw lids tightly onto both jars.
4. Repeat steps 2–3 two additional times, labeling four jars for trial 2 and four jars for trial 3. You should now have 12 jars. Six jars should have potato chips in them and the other six should have raisins in them. Three of the potato chip jars should be covered with aluminum foil, as should be three of the raisin jars.
5. Place the jars labeled for trial 1 on a windowsill or other well-lit spot. Make sure that the jars will not be disturbed wherever they are located. Note down the location of these four jars in your lab notebook, as well as the time and date when you placed the jars on the windowsill. Find two other windowsills or well-lit spots in your house. Put the four jars from trial 2 at one of the locations, and the four jars from trial 3 at the other location. Note down all locations, dates, and times in your lab notebook.
6. Keep the jars on the windowsills or well-lit spots for 2 weeks, but on the first day and every two days after that, open each jar so you and your two volunteers can sample the potato chips and the raisins. Each volunteer should only sample one piece of each. When you are finished, remember to tightly screw on the correct lid again. Try to pick the same time of day so roughly the same amount of time has passed between observations. In your lab notebook, describe the taste and

whether or not the taste has changed, using the following rating system (try not to focus on the *texture*—just the *taste*):

- 5 - The potato chip/raisin tasted great, I really liked it.
- 4 - The potato chip/raisin tasted good.
- 3 - The potato chip/raisin tasted okay.
- 2 - The potato chip/raisin didn't taste good.
- 1 - The potato chip/raisin tasted awful, I wish I had never eaten it.

7. Record your data in a table, like the one shown below. Construct a table like this in your lab notebook for each volunteer.

Volunteer 1's Data Table

Jar and Food	Location	Day 1 Taste Rating	Day 3 Taste Rating	Day 5 Taste Rating	Day 7 Taste Rating	Day 9 Taste Rating	Day 11 Taste Rating	Day 13 Taste Rating	Day 15 Taste Rating
Foil-covered Jar with Potato Chips									
Uncovered Jar with Potato Chips									
Foil-covered Jar with Raisins									
Uncovered Jar with Raisins									

8. Now it is time to analyze the data. Make a plot for each volunteer for each location. If you need help making plots, or would like to do your plots online, try using the following website: http://nces.ed.gov/nceskids/CreateAGraph/default.aspx. You can also make your plots by hand. You will have three sets of plots for each volunteer. One plot for each location. Label the y-axis *Rating* and label the x-axis *Time after placing in light.* You will plot all four jar and food data sets on the same plot.

9. What do your results show? Did both raisins and potato chips become rancid? What did you discover as one of the key differences between raisins and potato chips? What is the difference in the amount of fat, protein, and carbohydrates (*Hint:* You can look on the boxes of each to find this information)?

Variations

- Are the textures—the crispness of the potato chips and chewiness of the raisins—affected in this science fair project? Do you see a visual difference in the chips and raisins between the beginning and the end of the science fair project?
- What is the effect of water on the potato chips and raisins? Investigate hydrolytic rancidity.
- What is the effect of temperature on the potato chips and raisins? Do the foods stay fresher if they are kept at cooler temperatures?
- Does age of the taster affect when things start to taste rancid? Will a younger person notice when food becomes rancid before an older person? Gather a group of 10 people, separate them by age, and perform the experiment.
- Does *gender* affect when things start to taste rancid? Gather a group of 10 people, separate them by gender, and do the experiment.

What Factors Affect the Yield and Composition of Meat After Cooking?

(from All Science Fair Projects/ http://www.all-science-fair-projects.com/project488_39.html)

Purpose

To determine factors that affect the yield and composition of meat after cooking.

Materials

Ground beef
Rice
Broiler pan
Aluminum foil

Procedures

I. Ground Beef Fat Level And Doneness

A. Procedure

1. Shape 120 grams of ground beef into a round patty 1.0 cm. thick. (This is a rather thin patty.)
2. Cover part of a broiler pan with aluminum foil and poke holes in the foil to let the fat drip through.
3. Turn on the broiler in the oven and place the broiler pan in the oven so the top of the meat is about 9 cm. from the coil. (This will probably be the second rack slot down.) Leave the door of the oven part way open.
4. Cook the patty until either medium or well-done.

    - Medium-done - broil until the center of the patty is a pinkish-brown color (about 10 min. - 5 min. on each side.)
    - Well-done - broil until the center of the patty has no evidence of pink (about 16 min. - 8 min. on each side)

5. Weigh the cooked patty immediately after cooking, place on a plate and cut in half.
6. Calculate yield percent as follows:

(cooked weight/starting weight) x 100

7. Report yield and observe color and firmness. Tasting is not necessary and not advisable for the medium-done patties.

B. Treatments

1. Regular ground beef
2. Low fat ground beef

Regular - Medium	**Regular - Well Done**	**Low fat - Medium**	**Low fat - Well Done**
Yield Percent:	Yield Percent:	Yield Percent:	Yield Percent:
Color:	Color:	Color:	Color:

II. Evaluation of wild rice addition to regular ground beef

A. Procedure

1. Make a round 120 gram patty about 1.5 cm. in thickness.
2. Weigh a piece of heavy-duty aluminum foil large enough for the patty and with enough foil left around the edges to fold up to make a pan for the patty. The edges of the pan should not be higher than the patty; preferably, a little lower than the patty.
3. Put the patties (in the foil pans) on a baking sheet. Insert a thermometer into the patty from the side so the end is in the center of the patty.
4. Bake the patties at 325°F to an internal temperature of 80°C (176°F). When patty is done lisft with tongs and let drip 20 seconds before weighing.
5. Record for each patty: weight of cooked patty, weight of drippings, and % of yield.

B. Treatments

1. Ground beef
2. 1 part (30 g) cooked wild rice to 3 parts (90 g) beef

Ground Beef	**Ground Beef + Wild Rice**
Weight of Cooked Patty: Your Group: Class:	Weight of Cooked Patty: Your Group: Class:
Weight of Drippings: Your Group: Class:	Weight of Drippings: Your Group: Class:
% of Yield: Your Group: Class:	% of Yield: Your Group: Class:
Tenderness:	Tenderness:

Mother Knows Best: A Study of the Health Benefits of Spicy Cooking

(from All Science Fair Projects/http://www.all-science-fair-projects.com/project931_107.html

Problem

Do spices have the ability to kill food-spoilage microorganisms. And if they do, which spices are most effective and by how much?

Materials

- Agar plates
- *E. coli* sample
- Sterile swabs
- Spices (cinnamon, garlic, mustard, black pepper, coriander, lemon juice, chili powder, etc.)

Procedure

1. Carefully streak *E. coli* on agar plates.

2. Turn them upside down and apply 1/4 tsp. of spice on the lid.

3. Seal the plates and incubate them at 27° Celsius for 4 days.

4. Analyze results.

Beleaguered Beef: Guess What's Coming to Dinner?

(from All Science Fair Projects/http://www.all-science-fair-projects.com/project933_107.html)

Problem

The objective was to determine whether or not there is a difference between naturally grown ground beef and standard ground beef in terms of antibiotic additives.

Materials

- Agar plates
- Different brands of ground beef (natural and standard)
- Swab

Procedure

1. Swab five agar dishes with the juice from standard and natural ground beef.

2. Have an agar plate that can be used as a variable.

3. Incubated all six agar plates over a period of five days.

4. Analyze plates for results.