Lab: Limiting Reactants in Brownies

**FOR THE TEACHER**

**Summary**
In this lesson, students will investigate the idea of limiting reactant using a brownie recipe.

**Grade Level**
High school

**Objectives**
By the end of this lesson, students should be able to
- Understand the idea of limiting reactant using a brownie recipe.
- Be able to extend the idea of limiting reactant from a real-life scenario to a chemical equation.

**Chemistry Topics**
This lesson supports students’ understanding of
- Limiting reactant

**Time**
**Teacher Preparation:** 30 minutes  
**Lesson:** 45 minutes

**Materials**
- Kitchen equipped with measuring cups, measuring spoons, pot holders, mixer/whisk, oven, and 8x8” pan  
- Paper towels or plates and a knife to cut brownies up for class taste testing

**Safety**
- Do not work in the kitchen without adult supervision. Wash your hands with soap and water before beginning the investigation. Ovens and pan are hot, so use pot holders when removing pans from oven. Let the brownies cool before you cover the pan with foil or saran wrap. Only add the ingredients listed above. Your group will be the first to taste the brownies. If you won’t taste your own brownies, your group will receive no grade.
- Food should never be consumed in a lab setting, so the taste test should be conducted in a classroom.

**Teacher Notes**
- Each group should have one ingredient adjusted by a portion that will change the outcome in a noticeable way. For example, one group should only use one egg, or ½ cup sugar, or no baking powder. Only one variable from the recipe should be changed for each group. Students compare results by noting color, texture, and height. All groups should use an 8 x 8 inch pan.

**FOR THE STUDENT**
Lesson

Background
Have you made a dip for a party and found that you were low on one ingredient you needed? Could you still make the dip? How much dip could you make? The same situation exists for chemical reactions. How do you determine how much product will come out of a chemical process? First, you have to know the balanced equation for the reaction. Then, you need to know how much of each reactant you have. Next, you need to determine which reactant is the limiting quantity by considering the molar ratios of the reactants. Finally, you use the quantity of the limiting reactant to determine how much product you can make.

When you use recipes in the kitchen, the same process takes place. Nothing made in a chemistry lab can be eaten, so you will do this investigation at home. You will be given a list of ingredients. By comparing this list to the standard recipe, you will determine which ingredient is present in a different amount. You will calculate the quantities of materials you need based on the concept of limiting reactants and then bake a batch of brownies according to the new recipe. It is important that you keep careful records of your procedure and the amounts of your materials.

Prelab Questions
1. Will the results always be identical if you mix the same ingredients in exactly the same proportions every time?
2. What is the importance of having a procedure and following it precisely?
3. How does the quantity of a chemical reaction determine the outcome of an experiment in the kitchen? in the chemistry lab?
4. What safety precautions should you observe in the kitchen?
5. If 16.5 grams of aluminum react with 39.2 grams of chlorine gas, aluminum chloride is formed. \[ \text{Al} + \text{Cl}_2 \rightarrow \text{AlCl}_3 \]
a. Calculate the mass of aluminum chloride produced.
b. Which reactant is the limiting reactant?

Problem
How can the concept of limiting reagents be applied to cooking with a recipe?

Materials
Kitchen equipped with measuring cups, measuring spoons, pot holders, mixer/whisk, oven, and 8x8” pan.

Ingredients for Brownie Recipe. (Your teacher will reduce the amount of one of these ingredients for you.)

\[
\begin{align*}
\frac{1}{3} \text{ cup shortening} & \quad 2 \text{ squares of unsweetened chocolate (2 oz)} \\
1 \text{ cup sugar} & \quad 2 \text{ eggs} \\
1 \text{ teaspoon vanilla} & \quad \frac{3}{4} \text{ cup flour} \\
\frac{1}{2} \text{ teaspoon baking powder} & \quad \frac{1}{2} \text{ teaspoon salt}
\end{align*}
\]

Safety
Do not work in the kitchen without adult supervision. Wash your hands with soap and water before beginning the investigation. Ovens and pan are hot, so use pot
holders when removing pans from oven. Let the brownies cool before you cover the pan with foil or saran wrap. Only add the ingredients listed above. Your group will be the first to taste the brownies. If you won’t taste your own brownies, your group will receive no grade.

**Procedure**

**PART A: AT HOME**
1. Record the amounts of each ingredient you will use in your recipe in data table 1.
2. Gather the ingredients and other materials you will need. Explain to your family what you are doing and how this investigation relates to what you are studying in chemistry.
3. Mix the ingredients, making careful notes of measurements, the order of adding the ingredients, and other factors that you think could affect the results. If you have a thermometer in your oven, record the actual temperature of the oven.
4. Bake at 350 °F for 25-30 minutes. Record the actual time of baking. **CAUTION:** Use pot holders to remove the pan from the oven.
5. Let the pan cool completely. Cover pan with foil or plastic wrap so the brownies don’t dry out. Clean up the kitchen completely before leaving.

**PART B: IN CLASS**
6. Before school, bring your experimental brownies to the room. You can bring something to drink to class when taste testing the brownies. Make sure your name is on the pan.
7. The teacher will cut the brownies into 1-inch squares for everyone to taste test.
8. Make observations of each group’s brownies including taste, texture, and anything else you think is notable.

**Data**

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Amount</th>
<th>Order of Mixing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shortening</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sugar</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vanilla</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baking Powder</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unsweetened Chocolate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eggs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flour</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Salt</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature</td>
<td>N/A</td>
<td></td>
</tr>
</tbody>
</table>
**Observations**
Taste brownies made by other groups. Write down your observations about each batch.

**Analysis**
1. Interview the classmate(s) who made what you consider the best brownies. Identify what factor(s) may have contributed to the success of the recipe.
2. Were the brownies all the same texture? If not, what affected the texture?
3. Were the brownies all the same height? If not, what affected the size?
4. Were the brownies all the same color? If not, what affected the color?
5. What procedure do you think made the best brownies?
6. What effect did the lack of a written procedure have?
7. Why are the ratios of ingredients important in a brownie recipe?
8. Can the amount of the ingredients in a brownie recipe vary without ruining the product? If so, which ingredient do you think you could use more or less of?
9. On the basis of your observations, if you wanted low-calories brownies with good texture, what changes would you try?