Leavening Agents Demonstration

*Learning about chemical reactions*

**Background:** Atoms bond together to form molecules, molecules bond together to form other molecules or compounds. The process of changing one substance into another substance is called a **chemical reaction.** Common chemical reactions are used to create **leavening** in baked goods. This lab will discuss the types of leavening that create **carbon dioxide (CO2).**  Chemical means of producing CO2 take advantage of chemical reactions between **acids** and **bases**, like vinegar and baking soda, to create the CO2 needed to leaven quick breads. **Yeast** uses fermentation to create CO2. The yeast needs to have ideal conditions (temperature, nutrients, and water) in order to grow. For microorganisms “growth” means that the cells are multiplying (“reproducing”), not that the cells are getting larger.

*This demonstration uses 5 water bottles and five 7-inch balloons. The balloons measure the gases created by the chemical reactions in the solutions. Students are to observe the experiments and write their findings, copying the chemical equations on the baking soda portion.*

**Vocabulary:**

*Acids*—Acids are compounds with a pH level lower than 7, they taste “sour,” and

produce carbon dioxide when reacted with carbonates. Some common food

examples are lemons, oranges and vinegar

*Bases*—Bases are compounds with a pH level higher than 7; they give a slippery feel and

a bitter slightly soapy taste in foods. Common examples include baking soda,

toothpaste, bleach, and soap.

*Chemical equation* --Chemistry’s way of writing the process of a chemical reaction using

symbols and formulas.

*Chemical reaction* --When one substance changes into another substance because of

chemical processes creating changes in molecular structures.

*Yeast*—A microorganism often used for fermentation of foods or beverages.

*Fermentation*—a process that uses microorganisms in a food to create another food. For

example, *Lactobacillus bulgaricus* microorganisms put in warm milk eventually

change the milk into yogurt.

**This lesson addresses the following USOE Core Standards:**

**Foods & Nutrition Sciences 1:**

Standard 3 Objective 3a: Identify the role of each ingredient contained in quick breads: flour, liquid, **leavening agents**, fat, salt and sugar.

**Chemistry**

Standard 4, Objective 1: Identify evidence of chemical reactions and demonstrate how chemical equations are used to describe them

**Materials**

5 small water bottles

5 7-inch balloons

Baking soda

Vinegar

Yeast

Sugar

Water

**Instructions** *(With teacher notes):*

1. Prepare and label the water bottles:

-- 1/4 tsp. Baking Soda and 1/3 cup Water (Water in bottle and baking soda in

balloon)

--1/4 tsp Baking Soda and 1/3 cup Vinegar (Vinegar in bottle and baking soda in

balloon)

-- 1/2 tsp Yeast and 1/3 cup Cold Water (Yeast in bottle and water in measuring

cup)

--1/2 tsp Yeast and 1/3 cup Warm (90o F) Water (Yeast in bottle and water in

measuring cup)

--1/2 tsp Yeast, 1 tsp Sugar and 1/3 cup Warm (90o) Water (Yeast and sugar in

bottle and water in measuring cup)

2. Starting with the baking soda and water, go through each of the experiments. Have the students note which reaction occurs the fastest.

* *Baking Soda (sodium bicarbonate: NaHCO3) is a base. When mixed with water (which is neutral) very little carbon dioxide (CO2) is created, unless heat is part of the equation. When mixed with an acid, like vinegar, there is a rapid reaction to the base, creating CO2 and blowing up the balloon. In baked goods, the CO2 is trapped by the structure of the batter or dough, creating the air pockets that leaven the food.*
* *Yeast is a microorganism that creates CO2 by fermentation—CO2 is a by-product of growth. As a living plant, yeast needs food, water and the correct temperature range to grow or reproduce. The cold water is not the optimal temperature for yeast, so it will grow very slowly. The warm water is more conducive to growing the yeast as long as the temperature is right. When combined with sugar, the yeast ferments the sugar, producing ethyl alcohol and CO2. In bread the ethyl alcohol evaporates during the baking and eventually baking temperatures kill the yeast so the fermentation process stops.*

3. Have the students take notes on the different reactions, showing them how to write the baking soda/vinegar in chemical equation form.

* *Discuss the different types of leavening agents: air, steam, and CO2. Air leavens when beaten into a food—like a soufflé or a cake. Steam leavens popovers and creates flakes in pie crusts. Most foods use more than one type of leavening. The most common form of chemical leavening is CO2 created by (a) baking soda combined with an acid such as vinegar or (b) baking powders made of baking soda, a powdered acid and a cornstarch filler that absorbs moisture to keep the powders from reacting before being added to a liquid batter.*
* *Baking Powder contains baking soda, dry acids and starch as a filler. The starch absorbs moisture in the air to prevent the baking soda and dry acids from reacting to each other. When liquid is added to the baking powder, the chemical reactions relating to the base and the powdered acids start, which creates the CO2 leavening action.* *Double-acting baking powder contains two different acids, one that reacts with cold liquid and one that reacts with heat. This creates two-stage leavening: first in the batter and then later in the oven.*
* *Discuss the optimal conditions to activate yeast. Yeast, the microorganism Saccharomyces cerevisiae, is a biological form of leavening that creates CO2 by fermentation. All microorganisms need food, water and the right temperature range in order to grow. When the yeast in warm (82-100o F) water feeds on sugar, the sugar is broken down into ethyl alcohol and CO2 .*
* *Simple chemical equations are formed by taking the symbol of the elements or compounds present at the start of a reaction separated by a plus sign. A yield arrow pointing to the elements or compounds produced represents change. Any catalyst to the reaction, like heat, would go above the arrow in the equation. After the arrow are the symbols of the elements or compounds that have been produced. Both sides of the equation should have the same number of elements.*
* *For example: C12H22O11 + H2O SUCRASE> C6H12O6 + C6H12O6*

*(Sucrose)+(water) → (Glucose) + (Fructose) The sucrose enzyme in the yeast cells provides the catalyst to change table sugar into glucose and fructose which ferment more readily.*

* NaHCO3 (Sodium bicarbonate, or baking soda) + C2H4O2 (Acetic Acid, or vinegar) → NaC2H3O2 (Sodium acetate) + H2O (water) + CO2 (Carbon dioxide)
* *Baking soda is a base, vinegar is an acid.*

**Discussion Points/Questions:**

1. What is blowing up the balloons?

*CO2 created by the chemical reactions within the bottles.*

1. Which bottle had the fastest chemical reaction?

*The baking soda and vinegar should have reacted fastest.*

1. How does Baking Powder work?

*Baking Powder contains baking soda, dry acids and starch as a filler. The starch absorbs moisture in the air to prevent the baking soda and dry acids from reacting to each other. When liquid is added to the baking powder, the chemical reactions relating to the base and the powdered acids start, which creates the CO2 leavening action.*

1. What is “double-acting” baking powder?

*Double-acting baking powder contains two different acids, one that reacts with cold liquid and one that reacts with heat. This creates two-stage leavening: first in the batter and then later in the oven.*

1. What are the optimal conditions for yeast to grow?

*Yeast is a living organism (a fungus that leavens) and needs water, air and nutrients—sugars--to grow. Temperature is also a vital component: Yeast ferments best between 82-105o F.*

*The bottle with just warm water and yeast did not grow because there was nothing for the yeast to feed on. Also, when the water cools, it creates a vacuum in the bottle, meaning there is no air for the yeast to breathe.*

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which reaction occurs the fastest.

3. Take notes on the different reactions, remembering to write the baking soda

reaction in the chemical equation form shown by the teacher.

**Discussion Points/Questions:**

1. What is blowing up the balloons?

2. Which bottle had the fastest reaction?

3. How does baking powder work?

4. What is “double-acting” baking powder?

5. What are the optimal conditions for yeast to grow?