

The Stoichiometry of Cooking:

Lisa Morine

Teacher's Guide

Goals

- To understand the meaning of stoichiometry
- To relate chemistry to the everyday phenomena of cooking so that new concepts are assimilated

The Activity

In this activity, the importance of stoichiometry is emphasized by teaching the effect of changes in ingredients on a final product. Baking is fun, and when kids are having fun, they're more open to learning new ideas. The analogy to stoichiometry deals with relative amounts of ingredients, with measurement of weights and volumes, and with the analysis of the chemistry which is involved in baking.

Materials for Each Group

- Plastic ware for weighing, measuring, and mixing
- Tray with six muffin tins
- 6 small cake trays
- 240 g (1 cup) sifted flour
- 180 g (3/4 cup) sugar
- 10 g (2 teaspoons) baking powder
- 60 ml (1/4 cup) shortening
- 1.25 g (1/4 teaspoon) salt
- 120 ml (1/2 cup) milk
- 2.5 ml (1/2 teaspoon) vanilla
- 2 eggs
- Favorite frosting

Note: if you have a big oven, you can double the amount of batter being made.

In Addition

- Baking oven
- A new (chemical free) semi-analytical balance
- 10 g (2 teaspoons) baking soda (for one group)
- 180 ml (3/4 cup) shortening (for one group)
- 60 ml (1/4 cup) butter (for one group)

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SAFETY

Never eat in the laboratory! If you want to eat the cakes, make them in the kitchen (out of the lab), in chemical-free vessels.

Use a new balance or a kitchen balance instead.

Lecture Notes

What is the definition of stoichiometry? Stoichiometry is using molar mass to calculate the gram amount of reactants needed in order for a product to form.

How important is it to add the correct amount of reactant in order for a reaction to occur? In today's class we are going to bake cupcakes and you're going to see the chemical reactions. More than one chemical reaction is going on when you're baking a cake.

Try to predict what may happen if you vary the amount of reactants that you put in the cake.

This relates to chemistry, because if you don't add the correct amount of chemical reactants before the reaction, the product might come out different, or the reaction might not occur.

Look at the different cake batters and how they are different. The "mole" of the reactant, in the batter of one group, will be different than the "mole" of a reactant in another.

Easy Cupcakes

The ingredients and instructions for baking cupcakes are listed below, taken from:

<http://www.funology.com/inthekitchen/kit062.cfm>

What you will need:

- 240 g (1 cup) sifted flour
- 180 g (3/4 cup) sugar
- 10 g (2 teaspoons) baking powder
- 60 ml (1/4 cup) shortening
- 5 g (1/4 teaspoon) salt
- 120 ml (1/2 cup) milk
- 2.5 ml (1/2 teaspoon) vanilla
- 2 eggs
- Favorite frosting

Recipe:

1. Preheat the oven to 350 degrees Fahrenheit.
2. Sift all dry ingredients and set aside.
3. Measure all liquid ingredients, and combine in a separate container.
4. Combine dry and wet ingredients in a large mixing bowl.
5. Blend for 1/2 minute on low speed, scraping the sides of the bowl constantly.
6. Beat an additional three minutes on high speed, again scraping the bowl occasionally.
7. Place cupcake papers in muffin tins, and pour the batter into the cups, filling them halfway up to the top.

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- Bake for 20-25 minutes.
- Cover with favorite frosting after it cools.

Instructions

Divide class into groups of no more than five students.

Assign the variations in the recipe such that every group will have a different recipe (see table below). When finished mixing, put one of each groups' batter in a muffin tray and bake them (you can bake the rest of the batter in the other cake trays).

Group	Variation
I	none
II	use 5 g (1 teaspoon) baking powder instead of two
III	use 10 g (2 teaspoons) baking soda instead of baking powder
IV	use no leavening agent
V	use no eggs
VI	use 180 ml (3/4 cup) shortening instead of 60 ml (1/4 cup)
VII	replace 60 ml (1/4 cup) shortening with 60 ml (1/4 cup) butter

Observe your cupcakes, taste them and conduct a class discussion.

Comment

A useful site for unit conversion in the kitchen is <http://www.hungrymonster.com/calculators.cfm>.

Teaching Tips From Ms. Morine

You have to be familiar with their prior knowledge and practical experience in the past, and find a way to connect it to the chemistry. It's a leap: it's a reasoning that they have to go through.

They have to realize that they are weighing a mass. It's flour, but they are weighing a mass. They are adding it to the batter and a chemical reaction occur while baking.

When you are doing an activity like this, you can't forget that it's fun. And whenever something is fun, they tend to be more open to new information. They are just having a good time.

When you mention moles they do not get freaked out or stressed. You can't overestimate how important it is to have fun while you are learning.

Song

*"A mole is a unit, or have you heard
Containing six times ten to the twenty-third
It's the six with 23 zeroes at the end
Much too big a number to comprehend"*

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It's a leap of thought, to get down to the molecular level and say, well, if I had varied the gram amount or if I had varied the chemical substance then my outcome would have been different. I like starting the process in reasoning, and the subject with an activity like this, and not as a worksheet with lots of calculations.

They had to look at moisture, texture, consistency and height, because leavening agents produce the CO_2 bubbles which cause the cake to rise. This was one of the reactions that they could qualitatively observe more closely.

I included pH in this exercise because I wanted them to think about the chemical composition of the food, not only that it is cake or batter but that it has a lot of chemistry in it. It has atoms, it has molecules, it's a mixture... when you get to pH, you consider the acidity or basicity of the substance; you consider the molecules in its basicity.

I am happy with the results. I love that students have fun. It might look like things are going crazy in here, when we are doing those hands-on experiments. But in reality I can tell they are learning and tonight they will go out, and it's going to be a thing that they remember, about the time they were talking about moles and baking a cake.

References: Links

http://www.uen.org/utahlink/lp_res/nutri375.html

An extensive site from the University of Utah on food science.

<http://www.hungrymonster.com/calculators.cfm>

A unit converter for the kitchen. Will convert SI and English units. Convenient for anyone adapting a recipe for class use.

References: Readings

JCE Editorial Staff (2000) "Flat as a Pancake? Exploring Rising in Baked Goods," *Journal of Chemical Education*, Vol. 77, No. 10, pp: 1264A-1264B and supplements1-3.

McCamish, M. (1987) "The Rise of Self-Rising Flour: A Recipe for Success," *Journal of Chemical Education*, Vol. 64, p: 710.