

NRELEd: Science in the Kitchen

(Recipe adapted from Nestle Toll House Cookies)

Background

What's in the Kitchen?

While many activities take place in the kitchen, cooking and baking are probably the most common. While many use these terms as synonyms, they do mean different things. Cooking is an action that takes place on the stove top. Baking takes place in the oven. Baking is a very strict science because it relies on chemical reactions to complete its process. This makes recipes very important.

Science and math are big part of recipe building. Bakers [test combinations of ingredients](#) until they make the perfect batch of cookies. Once satisfied, they write down their ratio of ingredients they used. This becomes their recipe. Recipes are experiments that can be easily replicated. Other bakers can follow these recipes, make their own adjustments until they are happy with the recipe, and then write down their version. Through this process, families end up with their own “secret” recipes. Ask your family to see if you have any special recipes!

Cookies!

Baking cookies is a really fun way to explore many different [chemical reactions](#). Within 30 minutes, there are acids and bases reacting, proteins denaturing, and sugars caramelizing. A lot is happening!

Toll House Chocolate Chip Cookies

Enjoy making some delicious cookies. What changes will you make? Be sure to submit [pictures](#) of you eating your delicious cookies!*

What you need:

- Baking sheet
- 2 ¼ cups all-purpose flour
- 1 tsp baking soda
- 1 tsp salt
- 1 cup (2 sticks) butter, softened
- ¾ cup granulated sugar
- ¾ cup packed brown sugar
- 1 tsp vanilla extract
- 2 large eggs
- 2 cups semi-sweet chocolate morsels
- What else could you add?

Procedure

1. Preheat the oven to 375° F.
2. Combine flour, baking soda, and salt in small bowl and mix.
3. Combine butter, granulated sugar, brown sugar, and vanilla extract in large bowl. Mix until creamy and smooth.
4. Into the large bowl, add in eggs one at a time, beating the mixture after each addition.
5. Stir the flour mixture into the large bowl. Make sure to get all the ingredients well combined.
6. Stir in the chocolate chips. Stir until chips are evenly distributed in the batter.
7. Measure out dough balls with a 1-inch diameter. Place dough balls on baking sheet.
8. Place the sheet in the oven. Bake for 9-11 minutes.

Do the cookies look the same as when you put them in? What happened? Could you smell the cookies the whole time or only towards the end?

For High Altitude (above 5200 ft): Increase the flour to 2 ½ cups, decrease both sugars to 2/3 cups, and add 2 tbsp of water. Bake for 8-10 minutes.*

**I have made this recipe with and without the high-altitude adjustment. At 5280, they both work fine.*

The Science!

Now you can see, NREL's café is also a laboratory. The staff is always baking and cooking up tasty treats for NRELians to enjoy, including cookies! Learn more about NREL's cafeteria by reading the fun facts.

In cookies, there are several different reactions that take place slowly as the dough increases in temperature. The first change is actually a [physical change](#). First, butter melts. This allows for the cookie to lose its ball shape and flatten out into the cookie shape that we pull out. This happens quickly, as butter melts at a fairly low temperature (90°F; 33°C).

Next, water evaporates. Again, this is actually a physical change, not a reaction. Once the dough reaches 212°F (100°C), the water inside the cookie begins to evaporate. Even though you did not add water, there is water in the ingredients you added to the dough. At altitude, because water boils at a lower temperature (94°C), you may have needed to add a little extra water to keep the water from evaporating too quickly.

Baking Soda reacts with lactic acid from the butter. This is the first chemical reaction that occurs. Baking soda (NaHCO_3) reacts with lactic acid ($\text{C}_3\text{H}_6\text{O}_3$). This reaction produces sodium acetate (very edible), water (H_2O), and carbon dioxide (CO_2). The carbon dioxide helps the cookie rise.

Finally, [Maillard reactions](#) occur. These are the reactions of the sugars caramelizing and occur around 350°F. This is the reaction you can smell as the cookies are finishing up in the oven, and it's how you know your cookies are done!