



Cookie Lab

PowerPoint Slide/Science Guide

Note to Presenter: This event is a ton of fun to present, but you want to make sure that you feel comfortable with the science because people may have a lot of questions. Below is a breakdown of the basics of cookie science (broken down slide-by-slide to accompany the Powerpoint presentation). If you are interested to learn more, check out *On Food and Cooking: The Science and Lore of the Kitchen* by Harold McGee. The index in the back is quite complete and his explanations are clear enough for a novice, but thorough enough for an expert. Bake on!

1. **Intro Slide**
2. **TED Talk Video** – [Play the video](#). It's 4 ½ minutes long and covers a lot of the basic science needed to understand baking cookies. It's also well animated and engaging.
3. **Cookie Science Powerpoint Slide 1: Protein Coagulation** – Protein coagulation is important to cookies because it helps to turn soft, breakable dough into cookies with some substance and hold.
 - a. Raw eggs are made of mostly water with tightly bound up protein molecules dispersed throughout. Protein molecules are very large when stretched out, but fold up tiny and are held together by bonds between neighboring folds of the chain.
 - b. When the egg is heated, its molecules move around faster and smash into one another. This begins to unfold the protein molecules, allowing them to bond with other protein molecules, forming a 3-dimensional protein network.
 - c. This protein network traps water molecules, turning the egg from a liquid into a moist solid.
4. **Slide 2: Chemical Leavening Agents** –Baking soda and baking powder can both be added to cookie dough to produce carbon dioxide, causing the dough to rise while baking.



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- a. Basic chemistry—Both of these leavening agents produce carbon dioxide via an acid-base reaction.
 - i. Baking Soda – The sole ingredient in baking soda is sodium bicarbonate, NaHCO_3 , a weak base. When exposed to acid in an aqueous solution it reacts to form carbon dioxide, causing dough to rise. Baking soda can be used as the only leavening agent if the dough or batter includes an acid (e.g. sourdough cultures, buttermilk, brown sugar/molasses, or cocoa).
 - ii. Baking Powder –Baking powder is a complete leavening agent, containing both basic baking soda (sodium bicarbonate) and a solid powdered acid. These dry ingredients are mixed with dry starch which acts to absorb environmental moisture, preventing them from reacting until they are dissolved in water (in your batter). Some baking powders include several acids which will react at different temperatures, allowing the dough to continue rising in the oven.
 - b. *Cookie Tip:* Baking soda and baking powder cannot be used interchangeably in the same amounts. It is possible to substitute one for the other, but the proper ratio of acid must be included to react with the base or the unreacted base will adversely affect taste and color of your cookies.
5. **Slide 3: White Sugar vs. Brown Sugar** –In addition to a difference in flavor profile, white and brown sugar will react differently with your chemical leavening agents.
- a. White Sugar –White sugar is produced in a highly industrialized process that separates the sucrose molecules from other components of either sugar cane or sugar beets. Table sugar is 99.85% sucrose with only 0.15% impurities.



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- b. Brown Sugar –Brown sugar is essentially made of refined white sugar coated with a thin layer of molasses. It can also be made by partially refining raw sugar, and not removing the last of the molasses from the crystals. The molasses in brown sugar has some acidic components, making it the major source of acid in cookie dough to react with baking soda.
 - c. *Cookie Tip:* If you use only white sugar in your dough, you will need to use baking powder to allow for proper leavening of your cookies.
6. **Slide 4: Browning Reactions** –Adding heat to your ingredients provides the activation energy for dozens if not hundreds of reactions, including a variety of browning reactions that add color, flavor, and aroma to your cookies.
- a. Maillard Browning –Maillard browning is responsible for the color and aroma of toast, roasted meat, coffee beans, and dark beers. This type of reaction begins at around 250°F and occurs when carbohydrates react with amino acids. Because different foods are made of different carbohydrates and amino acids, they will each produce different products, resulting in different colors and aromas.
 - b. Caramelization –Caramelization is responsible for the color and aroma of caramel and butterscotch. It occurs when sugar (sucrose) breaks down and its constituent pieces rearrange into a huge array of compounds. Caramelization begins above 350°F.
7. **Slide 5: Flour: What’s in it?** –Today most flour is made from wheat, which has a distinctive composition including a relatively high percentage of gluten proteins. This composition has a great impact on the texture of your cookies.
- a. 10% Gluten –Gluten is a network of combined proteins. Proteins are enormous chains of repeating molecular pieces, also known as polymers. Gliadin and gluten are the two main protein



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components of gluten. Neither dissolves in water, but when water is added to their powdered forms, it allows them to stick together and form a stretchy network that helps to give dough structure and traps gas released by vaporizing water and leavening agents.

- b. 70% Starch –Starch molecules are long chain polymers of repeating sugar molecule pieces. In the case of cookies and cakes, starch makes up most of the structure because the gluten network is interrupted by too much water and sugar. During baking these starch granules absorb water and swell up forming walls that trap gas in a similar fashion to gluten.