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The Chemistry of Baking Cookies

Use Science to Bake Perfect Chocolate Chip Cookies

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 The perfect chocolate chip cookie is a type of successful science project. Esther Chou / Getty Images

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Baking cookies seems simple, especially if you cook pre-made cookie dough, but it's really a set of chemical reactions. If your cookies never turn out perfect, understanding their chemistry may help improve your technique. Follow this classic chocolate chip cookie recipe and learn about the ingredients and the reactions that occur throughout the mixing and baking process.

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- 3/4 cup brown sugar (caramelized sucrose)
 - 1 cup unsalted butter (a fat)
 - 1 large egg (consists of water, protein, fat, emulsifier, and albumin)
 - 1 teaspoon vanilla extract (for flavor)
 - 2-1/4 cups all-purpose flour (contains gluten)
 - 1 teaspoon baking soda (sodium bicarbonate, NaHCO_3 , which is a weak base)
 - 1/2 teaspoon salt (NaCl)
 - 2 cups semi-sweet chocolate chips

1. You'll get the best results if you use room temperature eggs and butter. This helps the ingredients mix into the recipe more evenly and means your cookie dough will be room temperature and not cool when you put the cookies in the oven. The fat in the recipe affects the texture of the cookies and browns them, which influences flavor as well as color. Substituting a different fat in place of butter affects the flavor of the cookies and also the texture since other fats (lard, vegetable oil, margarine, etc.) have a different melting point from butter. If you use salted butter, it's usually best to reduce the amount of added salt.
2. **Preheat oven to 375 degrees Fahrenheit.** It's important to preheat the oven because if you put the cookies in the oven and the temperature is too low, the dough can spread rather than firm up. This affects the thickness of the cookie, its texture, and how evenly it browns.
3. **Mix together the sugar, brown sugar, butter, vanilla, and eggs.** Mostly, this is to blend the ingredients so the composition of the cookies will be uniform. For the most part, no chemical reaction occurs at this point. Mixing the sugars with the eggs dissolves some of the sugar in the water from the eggs, so the crystals won't be as large in the cookies. Brown sugar adds caramelized sugar flavor to the cookies. While it doesn't matter what color of eggs you use (white or brown), the size matters, just like measuring all of the other ingredients! If you substitute an egg from a different bird than a chicken, the recipe will work, but the flavor will be different. You don't want to over-mix the ingredients because beating eggs for too long affects the protein molecules in the egg white. Real vanilla and imitation vanilla (vanillin)

can sift the ingredients together to make sure they are evenly distributed, but sprinkling the salt and baking soda onto the mixture works too. The flour contains gluten, the protein that holds the cookies together, makes them a bit chewy and gives them their substance. Cake flour, bread flour, and self-rising flour could be substituted for all-purpose flour in a pinch, but aren't ideal. The cake flour might produce fragile cookies with a finer "crumb"; the bread flour contains more gluten and could make the cookies tough or too chewy, and the self-rising flour already contains leavening agents that would make the cookies rise. The baking soda is the ingredient that makes cookies rise. The salt is a flavoring, but also controls the rising of the cookies.

- 5. Stir in the chocolate chips.** This last to ensure the other ingredients are properly mixed and to avoid smashing the chips. The chocolate chips are flavoring. Don't like semi-sweet? Switch it out!
- 6. Drop rounded teaspoons of the dough about two inches apart on an ungreased cookie sheet.** The size of the cookies matters! If you make the cookies too big or put them too close together, the interior of the cookie isn't don't by the time the bottom and edges brown. If the cookies are too small, they may not brown enough by the time the middle is done, giving you rock-hard cookies. There's no need to grease the cookie sheet. While a light spritz of non-stick spray might not hurt, greasing the pan adds fat to the cookies and affects how they brown and their texture.
- 7. Bake the cookies 8 to 10 minutes or until they are light golden brown.** Which rack you put the cookies on depends on your oven. Usually, the center rack is fine, but if your cookies tend to get too dark on the bottom, try moving them up one rack. The heating element in a conventional oven is on the bottom.

Chemistry During Baking

If the ingredients are high quality, measured carefully, and mixed as they should be, chemical magic happens in the oven to make great cookies.

Heating sodium bicarbonate causes it to decompose into water and carbon dioxide:



the bubbles don't get too big. This could lead to weak cookies or to cookies that fall flat when they come out of the oven. The heat works on the butter, egg yolk, and flour to change the shape of the molecules. The gluten in the flour forms a polymer mesh that works with the albumin protein from the egg white and the emulsifier lecithin from the egg yolk to form the dough and support the bubbles. Heat breaks the sucrose into the simple sugars glucose and fructose, giving each cookie a shiny, light brown crust.

When you take the cookies out of the oven, the hot water gases in the cookie contract. The chemical changes that occurred during baking help the cookie keep its shape. This is why undercooked cookies (or other baked goods) fall in the center.

Chemistry After Baking

If the cookies aren't devoured immediately, the chemistry doesn't end with baking. The humidity of the surroundings affects cookies after they have cooled. If the air is very dry, moisture from the cookies escapes, making them hard. In a humid environment, cookies can absorb water vapor, making them soft. After cookies have completely cooled, they can be placed into a cookie jar or other container to keep them fresh and delicious.

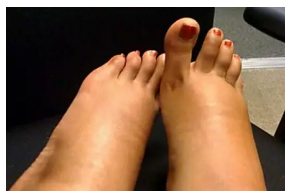
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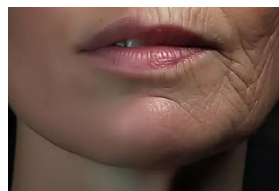
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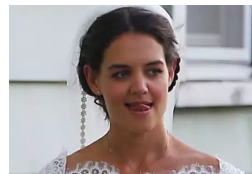
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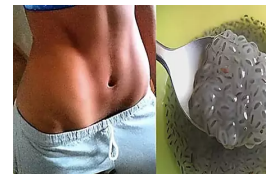
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