

The Many Lives (and Uses) of Baking Soda

Baking soda, aka sodium bicarbonate (NaHCO_3), has been used as a leavening agent for baked goods for a very long time. When heated, or mixed with acid, baking soda forms carbon dioxide gas. It is frequently used alone, but more often in the form of baking powder by combining with certain acids, such as monocalcium phosphate. It is also common practice to use baking soda and baking powder together in the same recipe when acidic ingredients are involved, such as buttermilk. Without the addition of baking soda, the acid in buttermilk would quickly neutralize the baking powder, which is designed to release much of its gas slowly in the oven.

All of this is well known to cooks. But baking soda has many other applications in the kitchen that are less well known. These applications are based on the fact that sodium bicarbonate is a mild alkali. Most food ingredients are neutral or acidic. Other than baking soda, the only other commonly used food ingredient that is alkaline is egg whites.

For many years baking soda has been used to hasten the cooking of vegetables. It does this because the added alkali greatly accelerates the break down of pectin, which strengthens plant cell walls and holds the cells together. Nowadays cooks prefer their vegetables firm so baking soda is not used very much for this purpose. But there are times when a pinch of alkaline baking soda makes cooking easier. Take the example of “No-Fuss Creamy Polenta”, published in *Cook’s Illustrated* (March & April, 2010, page 18-19). The addition of a small amount (literally just a pinch) of baking soda to the water used to cook the coarse-ground cornmeal softens the cell walls of the cornmeal and dramatically reduces both the cooking time and amount of stirring. It takes just a pinch because once the alkaline baking soda initiates the break down of pectin the reaction proceeds on its own.

In another application, increasing the amount of baking soda in a recipe for “Crisp Gingersnap Cookies” (*Cook’s Illustrated*, November & December 2011, pages 22-23) helps to develop desirable fissures in the cookies, as well as produce drier cookies with increased browning and flavor. In this case the baking soda weakens the development of gluten creating a more porous structure. More alkaline dough also promotes cookie spread as well as browning and flavor by the Maillard reaction.

Use of a small amount of baking soda also makes it possible to make “Great Home Fries” (*Cook’s Illustrated*, January & February, 2012, pages 12-13). By briefly cooking (just one minute) the potato cubes in water with a little baking soda the exteriors of the potatoes become mushy, releasing the starch molecule known as amylose, which helps to make a crispy brown crust when the potatoes are roasted in the oven. Meanwhile the interiors remain firm and moist so they cook up creamy and tender. In this case the baking soda hastened the break down of potato cell walls enabling the release of amylose.

As a final example, baking soda helps to tenderize meat. The tenderness of pork is dependent on the pH of the meat (more about pH below). Up to a point, the higher the pH of the meat the more tender it will be. By soaking the pork in a dilute solution of baking soda (1 teaspoon) dissolved in water (1/2 cup) for only 15 minutes, the meat in a recipe for “Sichuan Stir-Fried Pork in Garlic Sauce” (*Cook’s Illustrated*, March & April

2012, pages 10-11) cooked up to be juicy and supple. Increasing the pH of meat makes it less acidic and helps it to retain more moisture, which helps meat remain tender.

To understand how these reactions occur let's look more closely at the chemistry of baking soda. When something is alkaline it means a solution of this substance in water has a pH greater than 7, which is neutral. A solution with a pH below 7 is acidic. The pH scale (0-14) is a measure of the concentration of hydrogen (H^+) and hydroxide (OH^-) ions in solution. When dissolved in water acids produce an excess of hydrogen ions, which combine with water to form hydronium ions (H_3O^+), while alkalis produce an excess of hydroxide ions. At neutral pH 7 the two are equal. A 5% solution of baking soda in water exhibits a pH of about 8 measured by a pH meter. A solution with pH 8 is considered a mild alkali, as the pH is not much higher than a neutral pH of 7.

Most cooks have heard enough about acids, alkalis (also called bases), and the pH scale that they understand this. But what many cooks don't realize is that baking soda is not very stable. As mentioned in the first paragraph, baking soda decomposes with heat to release carbon dioxide gas and water. The other product that is formed by this reaction is called sodium carbonate (see chemical equation). Sodium carbonate is a much stronger alkali. A 5% solution of sodium carbonate has a pH of more than 11. This means there are about 1000 times more hydroxide ions in the solution of sodium carbonate than there are in the solution of baking soda!



But how readily does this decomposition occur? At America's Test Kitchen I measured the pH of a 5% solution of baking soda in water, and found it to have a pH of 8. I then gently boiled the solution, keeping the volume constant, while removing small aliquots for testing. After cooling, the pH of the samples was measured with a pH meter. The pH had increased to about 9.7 after heating for about 30 minutes, confirming that much of the sodium bicarbonate had broken down to sodium carbonate, water, and carbon dioxide, which escaped from the boiling water. It is also possible to do the same reaction in the oven. Heating baking soda at 250 degrees F for about one hour produces sodium carbonate. As both are white powders there appears to be no change. But by measuring the pH of solutions of both baking soda and the reaction product we can quickly confirm the reaction has taken place.

This raises the interesting question of how important this conversion is when cooking and baking with a pinch of added baking soda. Is the effect really due to sodium bicarbonate or sodium carbonate? Should we even care?