Baking Powder

Dictionary: bak·ing powder

n.
A mixture of baking soda, starch, and at least one slightly acidic compound such as cream of tartar that works as a leavening agent in baking by releasing carbon dioxide when mixed with a liquid, such as milk or water.

A mixture of powdered compounds added to dough or cake mixture to make it rise in cooking. It is used as a substitute for yeast in bread-making. Baking powders consist of a source of carbon dioxide, such as sodium hydrogencarbonate or ammonium hydrogencarbonate, and an acidic substance such as calcium hydrogenphosphate, potassium hydrogentartrate (cream of tartar), or sodium hydrogenphosphate. In the hot wet mixture, the acid releases bubbles of carbon dioxide gas from the hydrogencarbonate, which make the mixture rise.

How is baking powder made?

Baking powder is a solid mixture that is used as a chemical leavening agent in baked goods. It can be composed of a number of materials, but usually contains baking soda (sodium bicarbonate, $NaHCO_3$), cream of tartar (potassium bitartrate, $C_4H_5KO_6$), and cornstarch. (A base, an acid, and a filler respectively.) Baking powder is made by generating these solids, combining them in unique proportions, and then transferring them to packaging. First developed in the mid 1800s, baking powder formulations have changed little since.

Background

To modify the final characteristics of baked goods, leavening agents such as baking powder or yeast are added to recipes. A leavening agent is a material that releases carbon dioxide (CO_2) under certain conditions. This creates gas bubbles in the dough making it expand. When the product is baked, air pockets are created resulting in food that is light and crispy. Baking powder is generally preferred to yeast because it produces bubbles much faster. Yeast leavened dough takes anywhere from two to three hours to rise. Baking powder dough takes about 15 minutes.

Baking powder is a white solid that typically has three components, including an acid, a base, and a filler. When water is added to the baking powder, the dry base and acid dissolve into a solution. In this form, the compounds react to produce carbon dioxide bubbles, however, the amount of carbon dioxide produced by this reaction varies. Baking powder determines the final texture of the food and can affect the flavor, moisture, and overall palatability.

History

The development of baking powders began with the discovery of carbonate materials. One of the first carbonates was potash (potassium carbonate, K_2CO_3), a material that was extracted from wood ashes. During the eighteenth century, potash production had become a major commercial industry. American colonies exported huge amounts to England where it was used by glass factories and soap manufacturers.

Potash's usefulness to the baking industry was discovered during the 1760s. Prior to this time bakers had to hand knead dough for long periods to get the proper amount of air mixed throughout. For recipes which called for sourdough, pearlash (concentrated potash) was added to offset the sour taste. By chance, bakers found that these types of dough rose quickly. Evidently, the pearlash reacted with the natural acids in the sour-dough to produce carbon dioxide gas. This discovery revolutionized the baking industry.

Over time, wood sources became scarce in England and other sources of carbonates were sought. In 1783 the French Academy of Sciences ran a contest for inventors who could develop a process for converting salt (sodium chloride, NaCI) to soda ash (sodium carbonate, Na_2CO_3). This contest was won by Nicolas LeBlanc in 1791. In his process, salt was reacted with sulfuric acid, coal, and limestone to produce soda ash. The soda ash was tried by bakeries as a leavening agent and found to be equivalent to potash. Baking soda was soon after extracted from soda ash and used to sooth stomach acids. The superior leavening properties of this material were discovered by American bakeries by the 1830s. It released gas quicker and the aftertaste was not as bitter as soda ash.

Another important development in America was the development of potassium bicarbonate ($CHKO_3$) by Natha Read in 1788. He suspended lumps of pearlash over fermenting molasses. This converted the potassium carbonate into potassium bicarbonate. Unfortunately, this process resulted in a less dependable leavening agent when compared to that manufactured in Europe. In 1834, Dr. Austin Church developed a different process for making baking soda from soda ash. This product is still sold today under the Arm & Hammer name.

During the 1860s, various companies introduced other ingredients in their baking soda formulas and sold them as baking powders. These ingredients behaved in a more controlled way in recipes. Over time, different carbonate and acid mixtures have been sold as baking powders. Today, sodium bicarbonate and tartaric acid mixtures remain the most popular.

Raw Materials

As suggested, the primary components of a baking powder are a dry acid, base, and filler. Each of these materials can have a significant impact on the texture and taste of the finished product.

The most common dry base used in baking powders is baking soda, also called sodium bicarbonate. It is a water soluble white crystalline material, and produces carbon dioxide gas by itself when heated above 122°F (50°C). In addition to its use in baking, it is also used in the production of effervescent salts in medicine to prevent excess stomach acidity and in various types of fire extinguishers.

The type of acid used in a baking powder formula is more varied. The first baking powders used cream of tartar, a powdered acid. It was quick reacting and had to be put in the oven quickly or the gas would be spent. This material was perfect for products like pancakes or muffins. Today, there are four major acids used in commercial baking powders including monocalcium phosphate (CaHO4P), sodium acid pyrophosphate (H2Na207P2) sodium aluminum phosphate (H304P), and sodium aluminum sulfate (NaAl08S2). Monocalcium phosphate is a fast reacting acid which produces a large amount of gas within three minutes of its addition to baking soda. This is about twice the speed of other acids. Sodium acid pyrophosphate is a slower reacting acid and is used in refrigerated biscuit dough recipes. Sodium aluminum phosphate and sodium aluminum sulfate are also slow reacting acids which generate gas when heated. While these compounds are used, most bakers prefer aluminum-free baking powders due to the unpleasant flavor the aluminum can cause in the baked good.

The third major component of baking powders is an inert filler. The most common of these is cornstarch. The cornstarch has three purposes. First, it helps keep the product dry and easily flowing. Without it, containers of baking powder could bind up and form one large mass. Second, it keeps the acids and bases separated and prevents them from reacting during storage. Finally, it adds bulk to the powder to make it easier to measure and standardize.

Design

While a variety of baking powders are available, all of them meet basic standards and generate almost identical amounts of carbon dioxide. The basic difference between all types is the reaction time. There are two categories of baking powders: single acting and double acting.

Single-acting baking powders immediately produce most of their gas when mixed with a liquid. They are classified by the type of acid they utilize. Those that contain cream of tartar and tartaric acid (C4H606) create gas rapidly when mixed with baking soda and a liquid. These batters must be cooked quickly or they will go flat. Slower single-acting baking powders are phosphate baking powders that contain either calcium phosphate (Ca3O8P2) or disodium pyrophosphate (H2Na2O7P2). Aluminum sulfate (AI2012S3) powders react more slowly at room temperature but give a bitter taste to the batter.

Most commercial baking powders are double-acting. These means that initially a small amount of gas is released when it is mixed with a liquid. The primary generation of gas occurs when the batter is heated during cooking. These types of powders allow a batter to be left in an unbaked condition for long periods of time. Often double-acting baking powders have two acids, one which reacts immediately and one that reacts when heated.

A less often used third type of baking powder is baker's ammonia. It results in a light, airy product but can impart an ammonia flavor if not used properly. It is best used in the production of flat cookies, helping to dissipate the ammonia odor during cooking.

The Manufacturing Process

Baking powder is made in a batch process and involves production of the component raw materials, blending, and packaging.

Production of raw materials

- The manufacture of baking powder begins with the production of sodium carbonate. Known as the Solvay ammonia process, it was first developed in 1861. In this process ammonia and carbon dioxide are passed through a saltwater (NaClH2) solution in an absorption tower. This results in a compound called ammonium bicarbonate (CH5NO3) which reacts with the salt to produce crude sodium bicarbonate crystals and ammonium chloride (ClH4N).
- The bicarbonate crystals are filtered out using vacuum filters or centrifuges. They are then washed with water to remove any residual chloride. The resulting solid is then conveyed to the calcining operation. Here, the material is heated and reacted with carbon dioxide to produce sodium carbonate, or soda ash.
- The soda ash is dissolved, carbonated, and cooled which results in crystallized sodium bicarbonate. This solid bicarbonate material is of a purer concentrate than the intermediate bicarbonate formed earlier in the process. It is then laid out on driers to remove most of the moisture. The product is passed through metal screens to produce the desired particle size and filled into drums for storage.
- The solid acid for many baking powders is tartaric acid. This material is made using potassium hydrogen tartrate, which is a waste product from wine making. The potassium hydrogen tartrate is first purified and converted to calcium tartrate. Using sulfuric acid, the calcium tartrate is hydrolyzed to produce calcium sulfate and tartaric acid. These materials are then separated and the resulting tartaric acid is purified and dried.

Blending the powders

- The sodium bicarbonate, tartaric acid, and cornstarch are transferred to a blending area. Compounders pour the appropriate amount of each solid into mixing containers. These mixers have large, stainless steel blades that thoroughly combine the powders into a single, homogeneous blend. This material is then transferred through vacuum tubing to the filling machine.

Filling and packing

- The baking powder is placed in a covered hopper and dispensed into the desired package. Baking powders are packaged in a variety of ways depending on the manufacturer. For home use it is typically sold in a 4 or 10 oz (113 or 264g) can. Restaurants can get baking powder in 5 or 10 lb (2.3 or 4.5 kg) metal cans. Industrial bakeries buy it in 50 or 100 lb (23 or 45 kg) fiber cartons. Filling is typically performed by a rapid, carousel filler which forces a specific amount of baking powder into the package which is then sealed. The sealed containers are placed into cardboard boxes and stacked on pallets. The pallets are transferred to trucks or railroad cars and shipped to local grocery stores or commercial bakeries.

Quality Control

To ensure the quality of each batch of baking powder manufacturers monitor the product at each stage of production. The starting raw materials are subjected to various physical and chemical tests to determine if they meet previously determined specifications. Some of the characteristics

that are tested include pH, appearance, and density. The finished product is also tested. Typically, the particle size is checked as are the micro-biological characteristics of the powder.

The Future

While baking powders have changed little over the last 100 years, manufacturers are always looking for new ways to make a greater profit. The baking powders of the future may be blended with different ingredients to enhance flavor. They may also be specially formulated for specific types of batter to accentuate characteristics such as gas evolution speed, residual flavor, or blending ease. Certainly, in the future manufacturers will find less expensive production methods.

Where to Learn More

Books

Ciullo, Peter. *Baking Soda Bonanza.* New York: Harper Perennial, 1995.

Kirk-Othmer. *Encyclopedia of Chemical Technology.* Vol. 1. New York: John Wiley & Sons, 1992.

Macrae, R. et al. ed. *Encyclopedia of Food Science, Food Technology and Nutrition.* San Diego: Academic Press, 1993.

Periodicals

"Is Your Baking Powder Still Potent?" *Diabetes Forecast* 50, no. 10 (October 1997).

Lutzow, Susan. "Baking-powder Power." *Journal Information Bakery Production and Marketing* (November 1996).

[Article by: Perry Romanowski]

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A mixture that liberates carbon dioxide when moistened and heated. The source of carbon dioxide is sodium bicarbonate, and an acid is required. This may be cream of tartar (in fast-acting baking powders which liberate carbon dioxide in the dough before heating) or calcium acid phosphate, sodium pyrophosphate, or sodium aluminium sulphate (in slow-acting powders, which liberate most of the carbon dioxide during heating).

Legally, baking powder must contain not less than 8% available, and not more than 1.5% residual, carbon dioxide. Golden raising powder (formerly known as egg substitute) is similar, but is coloured yellow, and must contain not less than 6% available, and not more than 1.5% residual, carbon dioxide.

Food Lover's Companion:

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A leavener containing a combination of baking soda, an acid (such as cream of tartar) and a moisture-absorber (such as cornstarch). When mixed with liquid, baking powder releases carbon dioxide gas bubbles that cause a bread or cake to rise. There are three basic kinds of baking powder. The most common is **double-acting,** which releases some gas when it becomes wet and the rest when exposed to oven heat. **Single-acting tartrate** and **phosphate baking powders** (hard to find in most American markets because of the popularity of double-acting baking powder) release their gases as soon as they're moistened. Because it's perishable, baking powder should be kept in a cool, dry place. Always check the date on the bottom of a baking-powder can before purchasing it. To test if a baking powder still packs a punch, combine 1 teaspoon of it with 1/3 cup hot water. If it bubbles enthusiastically, it's fine.

The Nutritional Value for: baking powder

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Description	Quantity	Energy (calories)	Carbs (grams)	Protein (grams)	Cholesterol (milligrams)	Weight (grams)	Fat (grams)	Saturated Fat (grams)
low sodium	1 tsp	5	1	0	0	4.3	0	0
sas, ca po4	1 tsp	5	1	0	0	3	0	0

sas,capo4+caso4	1 tsp	5	1	0	0	2.9	0	0
straight phosphate	1 tsp	5	1	0	0	3.8	0	0

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Baking powder

Baking powder is a dry chemical raising agent used to increase the volume and lighten the texture of baked goods such as muffins, cakes, scones and North American biscuits. Baking powder works by releasing carbon dioxide gas into a batter or dough through an acid-base reaction, causing bubbles in the wet mixture to expand and thus leavening the mixture. It is used instead of yeast for end-products where fermentation flavors would be undesirable[1] or where the batter lacks the elastic structure to hold gas bubbles for more than a few minutes.[2] Because carbon dioxide is released at a faster rate through the acid-base reaction than through fermentation, breads made by chemical leavening are called quick breads.

Most commercially-available baking powders are made up of an alkaline component (typically baking soda), one or more acid salts, and an inert starch (cornstarch in most cases, though potato starch may also be used). Baking soda is the source of the carbon dioxide,[3] and the acid-base

reaction is more accurately described as an acid-activated decomposition of baking soda, which can be generically represented as[4]

$$NaHCO_3 + H^+ \rightarrow Na^+ + CO_2 + H_2O$$

The inert starch serves several functions in baking powder. Primarily it is used to absorb moisture, and thus prolong shelf life by keeping the powder's alkaline and acidic components from reacting prematurely. A dry powder also flows and mixes more easily. Finally, the added bulk allows for more accurate measurements.[5]

The acid in a baking powder can be either fast-acting or slow-acting.[6] A fast-acting acid reacts in a wet mixture with baking soda at room temperature, and a slow-acting acid will not react until heated in an oven. Baking powders that contain both fast- and slow-acting acids are *double acting*; those that contain only one acid are *single acting*. By providing a second rise in the oven, double-acting baking powders increase the reliability of baked goods by rendering the time elapsed between mixing and baking less critical, and this is the type most widely available to consumers today. Common low-temperature acid salts include cream of tartar and monocalcium phosphate (also called calcium acid phosphate). High-temperature acid salts include sodium aluminum sulfate, sodium aluminum phosphate, and sodium acid pyrophosphate[7].

History

Early chemical leavening was accomplished by activating baking soda in the presence of liquid(s) and an acid such as sour milk, vinegar, lemon juice, or cream of tartar.[8] These acidulants all react with baking soda quickly, meaning that retention of gas bubbles was dependent on batter viscosity and that it was critical for the batter to be baked before the gas escaped. The development of baking powder created a system where the gas-producing reactions could be delayed until needed.[9]

While various baking powders were sold in the first half of the 19th century, our modern variants were discovered by Alfred Bird in 1843. August Oetker, a German pharmacist, made baking powder very popular when he began selling his mixture to housewives. The recipe he created in 1891 is still sold as *Backin* in Germany. Oetker started the mass production of baking powder in 1898 and patented his technique in 1903.

Following the American Civil War Joseph and Cornelius Hoagland developed a baking powder with the help of an employee, and their formula became known as Royal Baking Powder. The small company eventually moved to New York in the 1890s and became the largest manufacturer of baking powder.[*citation needed*]

Eben Norton Horsford, a student of Justus von Liebig, who began his studies on baking powder in 1856, eventually developed a variety he named in honor of Count Rumford. By the mid-1860s

"Horsford's Yeast Powder" was on the market as an already-mixed leavening agent, distinct from separate packages of calcium acid phosphate and sodium bicarbonate. This was packaged in bottles, but Horsford was interested in using metal cans for packing; this meant the mixture had to be more moisture resistant. This was accomplished by the addition of corn starch, and in 1869 Rumford began the manufacture of what can truly be considered baking powder.[10]

During World War II, Byron H. Smith, an inventor in Bangor, Maine, created a substitute product for American housewives, who were unable to obtain baking powder, cream of tartar or baking soda due to war food shortages. Named "Bakewell", a mixture of sodium pyrophosphate and corn starch, the product is still part of regional culinary history. When combined with baking soda, it is essentially the same as any single-acting baking powder, the only difference being that the acid is sodium pyrophosphate.

In 2006 the development of Rumford Baking Powder was designated an ACS National Historical Chemical Landmark in recognition of its significance for making baking easier, quicker, and more reliable."[11]

Use

Generally (in countries where the cup is used as a standard measure in cookery) one teaspoon (5ml) of baking powder is used to raise a mixture of one cup (200-250ml) of flour, one cup of liquid, and one egg. However, if the mixture is acidic, baking powder's additional acids will remain unconsumed in the chemical reaction and often lend an unpleasant chemical taste to food. High acidity can be caused by ingredients like buttermilk, lemon, yoghurt, citrus, or honey. When excessive acidity is present, some of the baking powder is replaced with baking soda. For example, one cup of flour, one egg, and one cup of buttermilk requires only ½ teaspoon of baking powder—the remaining leavening is caused by buttermilk acids reacting with ¼ teaspoon of baking soda.[*citation needed*]

The opposite is sometimes true, too. In baking powders that contain sodium acid pyrophosphate, excess alkaline substances can sometimes deprotonate the acid in two steps instead of the one that normally occurs, resulting in an offensive bitter taste to baked goods. Calcium compounds and aluminum compounds do not have that problem, though, since calcium compounds deprotonates twice are insoluble, and aluminum compounds do not deprotonate in that fashion.

Moisture and heat can cause baking powder to lose its effectiveness over time, and commercial varieties have a somewhat arbitrary expiration date printed on the container. Regardless of the expiration date, the effectiveness can be tested by placing a teaspoon of the powder into a small container of hot water. If it fizzes energetically, it's still active and usable.[12]

Substituting in recipes

Baking powder is generally just baking soda mixed with an acid, and a number of kitchen acids may be mixed with baking soda to simulate commercial blends of baking powder. Vinegar (dilute acetic acid), especially white vinegar, is also a common acidifier in baking; for example,

many heirloom chocolate cake recipes call for a tablespoon or two of vinegar.[13] Where a recipe already uses buttermilk or yogurt, baking soda can be used without cream of tartar (or with less). Alternatively, lemon juice can be substituted for some of the liquid in the recipe, to provide the required acidity to activate the baking soda. In China, a small amount of powdered coal may be added to baking soda to simulate baking powder.[14]

In times past, when chemically manufactured baking soda was not available, ash water was used instead, especially in confectionery. Wood ash is also weakly alkaline. To prepare ash water, one used a fistful of ash from the fireplace in a big pot of water. Ash from solid woods, such as the olive tree, is preferred, whereas resinous woods, like pine, cannot be used. The ash water is given a boil, then left overnight to settle. The water is then filtered through a cloth and is ready to use. Many traditional recipes call for ash water instead of baking soda, because of some unique qualities: for example, ash water dripped on hot vegetable oils congeals into a gel-like mixture.[*citation needed*]

Usage of Aluminum compounds

Baking powders are available both with and without aluminum compounds.[15] Some people prefer not to use baking powder with aluminum because they believe it gives food a vaguely metallic taste, and because of a possible link between aluminum consumption and Alzheimer's disease (see *Aluminum*).[16]