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The Chemistry of Baking Bread

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Introduction

As a second-grade teacher in a self-contained classroom at Edgewood Magnet School in New Haven, I find the neighborhood/ magnet setting a rewarding environment, with students coming to school each day from a variety of home circumstances and with differences in academic levels. Because of these variables, the children have differing levels of background knowledge and life experiences. The classroom is a mixture of varied ethnicities, economic strata and social and emotional strengths and weaknesses. Edgewood provides an arts-integrated curriculum, an educational approach that supports multiple intelligence theory and uses arts education as a means to assist students to improve their academic performance and enrich their lives. Arts-integration curricula use art forms--music, visual art, theater, and dance to teach other core subjects, including math, science, reading, and language arts. This planned unit aligns with the philosophy of the school. The use of scientific inquiry allows all students at all levels to learn in an inherently differentiated environment, learning new concepts and experiencing laboratory and demonstrations as they move through this curriculum unit on chemistry of baking bread. My students will conduct experiments to have practical experience with making bread from “scratch” and enjoying the results!

Rationale

Consumption of food prepared away from home plays an increasingly large role in the American diet. In 1970, 25.9 percent of all food spending was on food away from home; by 2012, that share rose to its highest level of 43.1 percent.[1] Many of my young students are not only unaware of where food comes from, many do not spend time in grocery stores or supermarkets to see and shop for food in its natural, whole-food state. Bread is an interesting case when considering natural foods. My focus for students is to learn that bread is a composition of ingredients and is formed under chemical reactions influenced by those specific ingredients and a heat source.

The New Haven Public School Science Curriculum includes a focus in second grade on Nutrition, specifically the standards for healthy food choices. I plan to launch my curriculum unit by reading *Everybody Bakes*

Bread, a picture book by Norah Dooley that introduces several types of breads, each a typical example or staple from across a number of cultures. This text is part of a series by the same author that exposes primary-level students to the common food that most cultures use in their everyday diets. The companion books include *Everybody Cooks Rice*, *Everybody Brings Noodles*, and *Everybody Serves Soup*. This unit focuses specifically on the story of Carrie, heading out into her multicultural neighborhood to borrow a baking tool. As she travels around and visits the friends and neighbors on her quest, she samples coconut bread from Barbados, chapatis from India, corn bread from South Carolina, pocket bread from Lebanon, challah from the Jewish "old country," pupusa from El Salvador, and braided bread from Italy. At the end of the book, Dooley has included the recipes for each of the breads that Carrie enjoys in her neighbors' homes.

Using the bread recipes as a resource, the students will experiment with various basic ingredients (yeast, baking powder, baking soda, eggs, salt, and sugar) to discover why they are necessary to the success of the product. We will explore the chemical reactions that cause breads to rise or not, research why breads brown in the oven or skillet, and discover what makes bread smell so good while it is cooking.

The Evolution of Bread

Bread is a standard staple of our daily food choices. Children and adults alike recognize the smell of freshly baked bread and understand its function in our diets and find it a satisfying, everyday, familiar food. Bread has evolved because of all the elements that go into its making: the grains, the machines for milling them, the microbes and chemicals that leaven the dough, the ovens that bake the loaves, and the people who make and eat it. The word *dough* comes from an Indo-European root that meant "to form, to build," suggesting the importance of dough's malleability, its clay-like capacity to be shaped by human hands. The word *bread* comes from a Germanic root and originally meant a piece or bit of a *loaf*, a leavened, baked substance. Over time, *loaf* came to mean intact baked mass and *bread* took over *loaf's* original meaning.[2]

Development of Agriculture and Domestication of Grains

Before 10,000 years ago, man lived a nomadic life style as a hunter-gatherer relying on the hunting of wild animals and collecting wild plants for his food. Then, the Neolithic revolution took place where the hunter-gatherer way of life was replaced by an agrarian lifestyle. This was a crucial turning point in human history and had a profound effect on life thereafter. The Neolithic revolution spread through the Middle East and encompasses a region extending from Jordan, Israel, Lebanon, and Syria through southeast Turkey and along the Tigris and Euphrates rivers through Iraq and western Iran. This "cradle of agriculture" was the center of domestication of einkorn and emmer wheat, which were staple crops of early civilization and close relatives of modern day wheat. These cereals were domesticated alongside other important crops including barley, pea, lentil and chickpea, as well as animals such as sheep, goats, cattle and pigs, and they led the way for an agricultural revolution.

This agricultural revolution changed our species and our planet. As groups of hunter-gatherers began domesticating plants and animals, they quit the nomadic life, building villages and towns that endured for thousands of years. A stable food supply enabled population to explode, and small groups turned into territories sprawling across hundreds of miles.

Agriculture originated in a few small hubs around the world, but probably first in the Fertile Crescent, the region that includes parts of modern-day Iraq, Syria, Lebanon, Israel and Jordan. The evidence for full-blown agriculture there — crops, livestock, tools for food preparation, and villages — dates back about 11,000 years.[3]

The early discoveries laid the foundation for the transformation of grains into breads and noodles, pastries and cakes. The first was that in addition to being cooked in porridge, pastes of crushed grain and water could also be turned into an interesting solid by cooking them on hot embers or stones: the result was flatbread. The second was that a paste set aside for a few days would ferment and become inflated with gases; and such a paste made a softer, lighter, more flavorful bread, especially when cooked from all sides at once in an enclosed oven.

Flatbreads were a common feature of the late Stone Age in parts of the world where grains were the chief food in the diet. Some versions of these breads still exist and include Middle Eastern lavash, Greek Pita, Indian roti and chapati, all made mainly from wheat but also other grains, and the Latin American tortilla and North American johnnycake, both made from maize. These breads were likely first cooked alongside an open fire, then on a griddle stone and some of them much later in beehive-shaped ovens.

Bread wheat, the unique species can make large, light loaves, had evolved by 8000 BCE, but the earliest archaeological evidence for leavened breads comes from Egyptian remains of around 4000 BCE. The first raised dough arose spontaneously, since yeast spores are ubiquitous in the air and on grain surfaces, and they readily infect a moist, nutritious grain paste. Bread makers throughout history have harnessed this natural process by leavening new dough with a leftover piece in which yeast is already growing. Grinding equipment progressed from the mortar and pestle to two flat stones and then around 800 BCE in Mesopotamia, to stones that could rotate continuously, by use of animal, wind and water power.

Leavened breads arrived fairly late around the northern rim of the Mediterranean. Bread wheat was not grown in Greece until around 400 BCE. It is documented that Greeks enjoyed breads and cakes flavored with honey, anise, sesame and fruits and that they made both whole grain and partly refined breads. At least from the Greeks on, whiteness in bread was a mark of purity. By the early Roman times, wheat bread was a central feature of life and durum wheat and other bread wheats were imported from northern Africa and other parts of the empire to satisfy the public demand.

During the European Middle Ages, bakers were specialists, producing either common brown or luxurious white bread. In the 17th century, improvements in milling led to wide availability of white bread. In northern areas, rye, barley and oats were more common than wheat and were made into coarse breads. One use of these breads was as a "trencher," a dense, dry, days-old thick slice that served as a plate at medieval meals and was either eaten or given away to the poor. Pastry was often use as a combination cooking and storage container, a protective and edible wrapping for mainly meat dishes.

During the late medieval period and into the Renaissance, there was notable progress in the production of enriched breads. Domestic recipes for bread begin to appear in cookbooks for the middle class and already look similar to our current day versions. Eighteenth century English and American cookbooks contain dozens of recipes for breads, cakes and cookies. In England in the 1800's, most bread was still baked in domestic or village ovens. As the Industrial Revolution spread and more people moved to the cities, bakeries took over an increasing share of bread production and some of them adulterated the flour with whiteners, like alum, and fillers, such as chalk and ground animal bones.

Two trends developed in the 20th century across North America and Europe. One was the decline in the per capita consumption of plain bread. People could afford to eat more meat and high-sugar, high-fat cakes and pastries in the place of regular bread products. The second trend was the industrialization of bread-making. Very little bread is made at home now; most bread is made in large central factories and some still in small local bakeries. Mechanical aids to bread making, such as powered mixers, began to appear around 1900 and by the 1960's; largely automated factories began to produce bread in a fraction of the time. These manufacturing systems replaced the biological dough development, which includes the gradual, hours-long leavening and gluten strengthening of the dough by yeast with almost instantaneous, mechanical and chemical dough development. They are formulated to remain soft and edible for a week or more in plastic bags.

During the 1980's, Europeans and Americans began to eat significantly more bread than they had just the decade before. Traditional breadmaking was experiencing a revival and small bakeries began to produce bread using less refined grains and grain mixtures, build flavor with long, slow fermentation and baking in small batches. A second reason for an increase in bread consumption was the invention of the home bread machine. Home cooks were able to merely put all the ingredients in a single chamber, close the lid, and fill the house with the aroma of fresh-baked bread. Although these two trends account for only a fraction of the production of bread, they do demonstrate that people still enjoy the flavors and textures of freshly made traditional breads. Industrial manufacturers have responded to this revival by making bread products with taste and texture, not just minimum cost and shelf life, in mind.[4]

The Structure of Flour

Flour is made up of small starch granules. Each granule is composed of a mixture of starch molecules. These starch granules contain some proteins which vary based on the source of the starch granules. There are two starch molecules – amylose (a "linear" molecule) and amylopectin (a heavily branched molecule). Both molecules are polysaccharides (long string molecules made up from lots of sugar molecules all strung together). The arrangement of the different molecules and their proportions determine the "type" of flour and how the flour will behave when used in baking.

For bread making, the most important aspect of the flour is the formation of gluten sheets. Gluten consists mainly of protein and includes what may be the largest protein molecules to be found in the natural world. Proteins are long, chain-like molecules built up from smaller molecules called amino acids. Gluten is a complex mixture of certain wheat proteins that cannot dissolve in water, but do form associations with water molecules and each other. When water is added to flour, the proteins on the outside of the starch molecules quickly absorb the moisture and become "sticky." This process is technically called hydration. The hydrated protein molecules begin to stick together and bind the granules together. As the granules are stretched, the proteins change their shape. From this process, gluten is formed.

Gluten is not a protein itself nor does it occur in nature. It is formed when two different protein molecules (gliadin and glutenin) are made to interact with each other by the kneading of the wet dough. Gluten is a highly elastic and plastic material. It will change its shape under pressure yet resists the pressure and moves back toward its original shape when the pressure is removed. Because of this combination of properties, wheat dough can expand to incorporate the carbon dioxide gas produced by the yeast. Its gluten forms sheets that behave like rubber balloons, which fill with the carbon dioxide as the bread leavens and thus causes the bread to rise. To make good bread, you need these gluten sheets to be robust enough not to break as the carbon dioxide is formed and plentiful enough to capture the gas in very small bubbles. Large bubbles would create holes in the final loaf.[5]

How Wheat Becomes Flour

Several kinds of wheat are grown today, each with its own characteristics and uses. Most are species of bread wheat, *Triticum aestivuum*. The most important distinguishing characteristic is the content and quality of gluten proteins. Hard wheat grains constitute about 75% of the American crop. Soft wheats, which make up 20% of the crop have a lower amount of somewhat weaker gluten proteins. North American wheats are named by their growth habit and kernel color. Spring wheats are sown in the spring and harvested in the fall. Winter wheats are sown in late fall, live through the winter as a seedling and are harvested in the summer.

The baking qualities of any flour are determined by the wheat from which it's made and how the wheat is turned into flour. Flour has been made since prehistoric times. The earliest methods used for producing flour all involved grinding grain between stones. These methods included the mortar and pestle (a stone club striking grain held in a stone bowl), the saddlestone (a cylindrical stone rolling against grain held in a stone bowl), and the quern (a horizontal, disk-shaped stone spinning on top of grain held on another horizontal stone). These devices were all operated by hand.

The millstone, a later development, consisted of one vertical, disk-shaped stone rolling on grain sitting on a horizontal, disk-shaped stone. Millstones were first operated by human or animal power. The ancient Romans used waterwheels to power millstones. Windmills were also used to power millstones in Europe by the twelfth century.

The first mills in the North American colonies were powered by either wind or water. During the nineteenth century, numerous improvements were made in mill technology. In 1865, Edmund La Croix introduced the first middlings purifier, a device that included a vibrating screen through which air was blown to remove bran from ground wheat. The resulting product, known as middlings or farina, could be further ground into high-quality flour. This new type of mill used metal rollers, rather than millstones, to grind wheat. Roller mills were less expensive, more efficient, more uniform, and cleaner than millstones. Modern versions of middlings purifiers and roller mills are still used to make flour today.[6]

Current day milling continues as the process of breaking the wheat kernel down into small particles and sifting the particles to make a flour of desired consistency. Most flours are refined, meaning they have been sieved to remove the germ and bran layers from the particles of protein and starch-rich endosperm. Bran and germ are rich in nutrients and flavor, but go rancid quickly and interfere with the formation of strong gluten. In conventional milling, grooved metal roller shears open the grain, squeeze out the germ and scrape the endosperm away to be ground, sieved and reground until the particles reach the desired size. Stone grinding, which is not as common, crushes the whole grain more thoroughly before sieving so that some of the germ and bran ends up in the refined flours. Breads made with stoned-ground flours tend to have more flavor, but also have a shorter shelf-life.[7]

Types of Wheat Flour

There are many different types of flour available. A general difference between the flours is the type of grain they are milled from. All flours start life as cereal grains; these are then ground down to a fine powder. As we’ve learned, in some flours the outer skin is removed while in others (brown and whole-grain), it is not. Common grains used for flour include wheat, rice, corn (or maize), barley and several types of beans. Although these flours can be used in a variety of recipes, with adjustments, it is wheat flour that is, by far the most common.

There are many strains of wheat and even a single strain will produce different proportions of starch and protein in the grains. These variations occur as a result of the climate and soil conditions where the wheat is grown. Flours are often blended to provide a more consistent product.

Most flours that we buy in the supermarket are labeled based on their intended use. Recipes developed with a particular flour often turn out differently when made with another. For general baking, you need a moderate protein content of around 7–10% by weight. It is generally better to have a flour with a protein content at the lower end of this range for pastry (where the gluten needs to be minimized). For breads, where the generation of gluten is essential, a higher protein content is necessary. In choosing the best flour for the recipe, it helps to know the basics about the wheat from which flour is milled. Soft wheat thrives in temperate, moist climates, like the mid-Atlantic region, while hard wheat flourishes in the Midwest. Soft wheat is milled into pastry flour, while hard wheat becomes bread flour. All-purpose flour is a combination of the two.[8]

All-purpose flour: If a recipe calls simply for "flour," it's calling for all-purpose flour. Milled from a mixture of soft and hard wheat, with a moderate protein content in the 10 to 12 percent range, all-purpose flour is a staple among staples. While not necessarily good for *all* purposes, it is the most versatile of flours.

Cake flour: The flour with the lowest protein content at 5-8%. The relative lack of gluten-forming proteins makes cake flour useful for cakes (of course), but also biscuits, muffins and scones. Cake flour is generally chlorinated, a bleaching process that further weakens the gluten proteins and, just as important, alters the flour's starch to increase its capacity to absorb more liquid and sugar, and creates a moist product.

Bread flour: With a protein content of 12 to 14 percent, bread flour is the strongest of all flours, providing the most structural support. This is especially important in yeasted breads, where a strong gluten network is required to contain the CO_2 gases produced during fermentation. The extra protein doesn't just make for better volume and a chewier consistency; it also results in more browning in the crust. Bread flour can be found in white or whole wheat, bleached or unbleached forms. Unbleached all-purpose flour can generally be substituted for bread flour with good results.

Self-rising flour: As the name suggests, self-rising flours contain baking powder (1½ teaspoons baking powder per cup flour) and, therefore, don’t require added leavening for the making of quickbreads, pancakes, or other chemically raised foods.

Whole wheat flour: During milling, the wheat kernel is separated into its three components: the endosperm, the germ (the embryo) and the bran (the outer coating). In whole-wheat flours, varying amounts of the germ and bran are added back into the flour. Whole-wheat flour tends to be high in protein, but its gluten-forming ability is compromised by the bran and germ and tends to produce heavier, denser baked goods. In most recipes, whole-wheat flour can be substituted for up to half of the all-purpose flour but because wheat germ is high in oils, whole-wheat flour is far more perishable than white.[9]

What is Yeast?

We have been eating raised, or leavened, breads for 6,000 years, but it wasn't until the investigations of Louis Pasteur 150 years ago that we began to understand the process of how bread actually rises. The key is the gas-producing metabolism of a particular class of fungus, the yeasts. The word "yeast" comes from a root word that meant "to seethe, boil, bubble over," the image in which fermentation seems to be a kind of cooking and generating a transformation from within.

The yeasts are a group of microscopic single-celled fungi, and a relative of the mushrooms. There are over 160 species of yeast, each used for different purposes. Yeasts are very small living organisms whose food is mostly sugar and whose waste products, when grown anaerobically, are mostly carbon dioxide (CO_2) and alcohol. The overall equation for the conversion that takes place in yeast cells is:

$$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$$

The yeasts used in baking produce little alcohol. One common yeast used in almost all baking is *Saccharonmyces cerevisiae*, which, in an oxygen-rich environment, converts sugar (mostly glucose) into CO_2 and water.

Forms of Baker's Yeast

Commercial yeast is sold to home and restaurant cooks in three common forms, each with a different genetic strain of *S. cerevisiae* with different traits. These forms are as follows:

Cake or compressed yeast is a moist block of fresh yeast cells, direct from the fermentation vat. Its cells are alive, and produce more leavening gas than the other forms. Cake yeast is perishable, must be refrigerated, and has a brief shelf life, about one to two weeks. As soon as sugar is added to the block of yeast, it will almost immediately begin fermenting the sugar and will produce some water so turning the whole block into a bubbling liquid. This mixture can be added to any recipe requiring yeast.

Active dried yeast, which was introduced in the 1920's, has been removed from the fermentation tank and dried into granules with a protective coating of the yeast. The cells are dormant and can be stored at room temperature for months. The cells can be reactivated by soaking them in warm water, 105-110°F/41-43°C and then add some sugar and leave them until a vigorous fermentation has started before mixing it into the dough. At cooler temperatures, the yeast cells recover poorly and the results will be less than optimal.

Instant dry yeast, an innovation of the 1970's, is dried more quickly than active dry yeast, in the form of small porous rods that take up water more rapidly than granules. Instant yeast does not need to be prehydrated before mixing with other dough ingredients, and produce carbon dioxide more vigorously than active dry yeast.[10]

Chemical Leaveners

Yeast cells produce carbon dioxide slowly, over the course of an hour or more, so the material surrounding them must be elastic enough to contain it for that much time. Weak doughs and runny batters can’t hold enough gas bubbles for more than a few minutes and are, therefore, usually raised with chemical leavenings. These ingredients are concentrated and small differences in the amount added can cause large variations in the quality of the finished product. Too little leavening will leave it flat and dense, while too much will cause the batter to overexpand and collapse.

A new method of leavening appeared in the first American cookbook, Amelia Simmons’ 1796 *American Cookery*. Four recipes, two for cookies and two for gingerbread, include the ingredient “pearlash,” made by soaking the ash produced when plant materials are burned, draining off the liquid, and drying it down to the substances dissolved in it. Pearlash is mostly alkaline potassium carbonate, which reacts with acids in doughs to generate carbon dioxide gas. It was the precursor to baking soda and baking powders, which arrived between 1830 and 1850.

Baking soda (sodium bicarbonate, $NaHCO_3$) is a white, powdery alkaline substance. When baking soda is mixed with acidic ingredients, it reacts and creates bubbles of carbon dioxide (the same gas that yeast would produce.) For instance, yogurt, sour milk, buttermilk and molasses contain acid (lactic acid) that the baking soda can react with. These bubbles are trapped inside a batter and help the baked good to rise. As noted before, the biological way of raising a baked good is by using yeast, and kneading the dough until a gluten develops strong enough to trap indefinitely the carbon dioxide exhaled by the yeast. Chemical leaveners such as baking powder and baking soda are obviously faster than all the kneading; which is why these baked goods are often called "quick breads." Sodium bicarbonate is inexpensive to produce, tasteless, non-toxic and easily purified in production. It comes from soda ash. The soda ash itself can come from a rock named "trona", which is mined, or be made via a method called the "Solvay" process, which involves introducing carbon dioxide and ammonia into a solution of sodium chloride.[11]

Baking powder is a leavener that consists of a combination of baking soda, cream of tartar (tartaric acid), and a moisture absorber (like cornstarch). It has the action of yeast but it acts much more quickly because it has its own acid. It is used in batters where there is no other acid naturally present.

The first modern version of baking powder was discovered and manufactured by Alfred Bird (1811-1878), British chemist and founder of Bird and Sons Ltd. His improved version of baking powder was created so he could make yeast-free bread for his wife, Elizabeth, who had allergies to eggs and yeast.[12]

Baking powder acts immediately upon addition of water; therefore, a filler (usually cornstarch) is added to absorb the moisture and prevent premature activity. As soon as the powder gets wet, the two chemicals begin to dissolve and react with each other to produce carbon dioxide. In most cases, we don’t want the baking powder to release all its gas as soon as we mix the batter, before it is baked enough to trap the CO_2 bubbles in place. “Double-acting” baking powder releases only a portion of its gas when it gets wet and releases the rest after the oven has reached a high temperature. Two different chemicals in the powder are responsible for the two separate reactions.

Recipes sometimes call for both baking soda and baking powder. In this case, the bread, cake or cookie batter is actually being leavened by the baking powder, which contains exactly the right proportions of bicarbonate and acid to react completely with each other. But if there is another acid ingredient present, such as buttermilk, some extra bicarbonate in the form of baking soda is used to neutralize the excess acid.[13]

Maillard Reactions

The cooked color and flavor of bread crusts, chocolate, coffee beans, dark beers, and roasted meat are the result of a set of reactions named after its discoverer. Louis Camille Maillard (1878-1936) found that when small amounts of sugars or starches are heated in the presence of proteins or amino acids, a set of high-temperature chemical reactions takes place. This is the first of a series of complex reactions that lead to brown polymers and many highly flavored, as-yet uncharacterized chemicals. These complex reactions are still not fully understood. What we do know is that the Maillard reactions are responsible for the good flavor of heat-browned, carbohydrate- and protein-containing foods, such as grilled and roasted meats, onions and, of course, breads.[14]

Breads

Yeast

There are four steps to making yeast bread. First mix together the flour, water, yeast and salt; then knead the mixture to develop the gluten network; give the yeast time to produce carbon dioxide and fill the dough with gas cells; and finally, bake the dough to set its structure and generate flavor. Italian bread yeast bread will be this unit’s example of a type of yeast bread, with the students discovering that the bread needs to be kneaded!

Quick Breads

Quick breads are appropriately named in two ways: they are quick to prepare, being leavened with rapid acting chemicals and mixed briefly to minimize gluten development; and they should be quickly eaten because they stale rapidly. A cornbread recipe from South Carolina will provide one example of how quick breads really are quick. What happens if the quick bread is not mixed briefly but instead, overmixed?

Unleavened

Breads that are made without yeast or any other chemical rising agent are considered unleavened. This unit will use Indian chapatis to demonstrate this category of breads, the example used in the mentor text, *Everybody Bakes Bread*.

Teaching Strategies

Experiential Learning: The major strategy for this unit is to engage the students in hands-on learning. I want them to be actively participating as inquisitive scientists. The cooking activities are designed to be exploratory for the students so they are engaged in the enjoyment of the process as well as the products, the breads we bake.

Differentiated Instruction: The students will use a variety of approaches, working sometimes individually and sometimes in small groups, determined by the complexity of the activity. Because these are young children with variance in levels and background, guidance and pacing is adjusted to ensure that all students are engaged and active throughout the learning experiences. Students will have opportunities work with a variety of peers as they explore chemical reactions as we bake a variety of breads.

Cooperative Learning: The students will be given opportunities to work as cooperative groups to complete assignments and activities. This strategy will allow students to work collaboratively taking on various roles necessary to complete the experiments and journal work, with a focus on success for all. A culminating activity will be the "publication" of our classroom recipe book of breads from our families and cultures to share with all our families and with students throughout the school.

Classroom Activities

Activity One: Introduce the Unit with the Mentor Text

To introduce the unit on the chemistry of bread baking, students will learn about this common food enjoyed across many cultures and how each region or family makes their own versions. This unit is designed to be taught in conjunction with our district's nutrition curriculum with a focus on how people in different cultures use different food sources to meet their nutritional needs.

Materials: *Everybody Bakes Bread*, t-chart on chart paper with question, chart to track content from text (examples below), student science journals

Prepare T-Chart

How is bread made?
What We Know What We Have Learned

Prepare text content chart

Everybody Bakes Bread
Carrie's friends and neighbors Country, Region or Culture Type of Bread

Begin by asking students the question posted on the chart, "How bread is made?" Record any answers and ideas on the left side titled "What We Know." Read aloud *Everybody Bakes Bread* by Norah Dooley. The story follows the main character, Carrie, through her multicultural neighborhood.

On the 2nd chart, track Carrie's visits with her friends and neighbors and the types of breads that she samples: coconut bread from Barbados, chapatis from India, corn bread from South Carolina, pocket bread from Lebanon, challah from the Jewish culture, pupusa from El Salvador, and braided bread from Italy. The recipes for each of the breads are located at the end of the book.

Return to the t-chart of responses and on the right-side section titled "What We Have Learned."

In their science journals, students should transfer the information from each completed chart.

Activity Two: Balloon on a bottle

Part One: Activating Yeast with Sugar

As noted in the sections on yeasts and chemical leaveners, the purpose of any leavener is to produce the gas that makes bread rise. Yeast does this by feeding on the sugars in flour, and expelling carbon dioxide in the process. This experiment uses *Saccharomyces cerevisiae*, commonly known as baker's yeast, the most common yeast used in homemade breads. Show the students that yeast is tiny - just one gram holds about 25 billion cells and can generate a significant amount of carbon dioxide, as long as it has the simple sugars it uses as food. The yeast can use its own enzymes to break down more complex sugars, like the granulated sugar in this activity, into a form that it can consume.

Students will make a yeast-air balloon to get a better idea of what yeast can do.

Materials for each group of 4-5 students:

2 packets of active dry yeast

2 cups very warm water (105° F–115° F)

2 tablespoons sugar

2 large rubber balloons

2 small (1-pint to 1-liter) empty water bottles

1. Stretch out the balloons by blowing them up a few times and then set aside. This step should be done by the teacher or another adult.
2. Pour a packet of yeast and the sugar into the cup of warm water.
3. Pour a packet of yeast only into the other cup of warm water.
4. Once the yeast and sugar have dissolved, pour that mixture into one of the bottles.
5. Pour the yeast and water into the other bottle.
6. The water will have begun bubbling as the yeast produces carbon dioxide. Attach the balloons to the mouths of the bottles, and set both aside. After several minutes, the balloon will stand upright as it inflates.

Students should write their observations in their science journals. What is happening in each bottle? Why do you think there is a difference?

Explain to the students that as the yeast feeds on the sugar, it produces carbon dioxide. With no place to go but up, this gas slowly fills the balloon. A very similar process happens as bread rises. Carbon dioxide from yeast fills thousands of balloon-like bubbles in the dough. Once the bread has baked, this is what gives the loaf its airy texture.

Part Two – Activating Baking Soda

Students will make a baking soda-air balloon to understand the chemical reaction that occurs.

This activity will demonstrate the power of gas produced when of baking soda and vinegar are mixed as the balloon is blown up by the gas created.

Materials for each group of 4-5 students:

4 ounces water

4 ounces vinegar

2 tablespoons baking soda

2 large rubber balloons

2 small (1-pint to 1-liter) empty water bottles

1. Using the funnel, add the baking soda to each balloon (two people will need to do this; one person to hold the balloon open and the other person to put the baking soda inside of the balloon).
2. Pour the vinegar into one bottle.
3. Pour the water into the other bottle.
4. Carefully fit the balloon over the bottle opening (be careful not to drop the baking soda into the vinegar yet).
5. Once the balloon is fitted snugly on the nozzle, hold up the balloon and allow the baking soda to fall into the vinegar or the water.
6. After several minutes, the balloon on the bottle with vinegar and baking soda will stand upright as it inflates.

Students should write their observations in their science journals. What is happening in each bottle? Why do you think there is a difference?

Activity Three: Reading a recipe

Materials: a set of copies of the seven bread recipes for each student, highlighters, glue sticks or tape, student science journals, teacher selection of text examples: story (book), poem, non-fiction text

Students will learn the unique structure of a recipe as it compares to the structure of a story, non-fiction text or poem. Show examples and discuss general features of each: several pages, characters, illustrations, etc.

In the selection of the bread recipes from the mentor text, students will locate the two major sections of a recipe in each example – the list of ingredients and the process or procedure for making the product.

Students will then locate the common ingredients in bread products and use these following color coding to indicate each component.

Flour – blue

Sugar – yellow

Yeast – green

Baking soda or baking powder – red

Eggs – orange

Liquid – purple

Other ingredients will remain unhighlighted, which will demonstrate the differences between the recipes, indicating cultural preferences and resources. Completed work will be glued or taped into student journals.

Activity Four: Comparing Chemical Reactions

Part One: Kneaded and Unkneaded Yeast Bread

Using the experience and information from Activity Two (activating yeast), students will learn how the carbon dioxide gas becomes trapped in the gluten sheets of bread that has been kneaded and stretched. Bread that has not been will show different results.

Students, in three groups and with adult support, will prepare the following recipe:

2 cups warm water (110 degrees F/45 degrees C), 2/3 cup white sugar, 1 ½ tablespoons active dry yeast, 1 ½ teaspoons salt, ¼ cup vegetable oil, 6 cups bread flour

1. In a large bowl, dissolve the sugar in warm water, and then stir in yeast. Allow to proof until yeast resembles a creamy foam. Mix salt and oil into the yeast. Mix in flour one cup at a time.
2. Divide the dough in half. Place one half in a well-oiled bowl and turn to coat. Cover with a damp cloth. Be careful that the dough is not kneaded after mixing and sits until placed in the loaf pan in Step 4.
3. Knead the remaining dough on a lightly floured surface until smooth. Students may take turns with this part. Place in a well-oiled bowl, and turn dough to coat. Cover with a damp cloth. Allow to rise until doubled in bulk, about 1 hour. Punch dough down. Knead for a few minutes.
4. Shape dough into loaves, and place into two well-oiled 9x5 inch loaf pans. Allow to rise for 30 minutes, or until dough has risen 1 inch above pans. Bake at 350 degrees F (175 degrees C) for 30 minutes.

Students will observe similarities and differences and document their learning in their journals. Once bread has cooled, students can feel, smell, and taste samples of each loaf. Questions for students to consider in their writing: What seems the same? Different? What do you prefer and why? What happened in each loaf and why?

Part Two: Leavened and Unleavened Cornbread

Baking powder acts immediately upon addition of water. As soon as the powder gets wet, the two chemicals begin to dissolve and react with each other to produce carbon dioxide. In our quick bread recipes, we don’t want the baking powder to release all its gas as soon as we mix the batter, before it is baked enough to trap the CO_2 bubbles in place. This experiment demonstrates the what happens when the CO_2 escapes before baking.

Students will work in four groups. Each group will prepare the following recipe:

1 cup all-purpose flour, 1 cup yellow cornmeal, 2/3 cup white sugar, 1 teaspoon salt, 3 ½ teaspoons baking powder, 1 egg, 1 cup milk, 1/3 cup vegetable oil

Preheat oven to 400 degrees F (200 degrees C). Spray or lightly grease one 9-inch round cake pan for each group.

Groups 1 & 2 will *gently stir* the ingredients.

In a large bowl, combine flour, cornmeal, sugar, salt and baking powder. Stir in egg, milk and vegetable oil until well combined. Pour batter into prepared pan.

Bake in preheated oven for 20 to 25 minutes, or until a toothpick inserted into the center of the loaf comes out clean.

Groups 3 & 4 will *mix with an electric mixer*

In a large bowl, combine flour, cornmeal, sugar, salt and baking powder. *Add* in egg, milk and vegetable oil and *mix thoroughly for 1 minute*. Pour batter into prepared pan.

Bake in preheated oven for 20 to 25 minutes, or until a toothpick inserted into the center of the loaf comes out clean.

Students will observe similarities and differences and document their learning in their journals. Once bread has cooled, students can feel, smell, and taste samples of each loaf. Questions for students to consider in their writing: What seems the same? Different? What do you prefer and why? What happened in each loaf and why?

Activity Five: Visit a bakery

Students will enjoy a trip to one of our local New Haven bread bakers – Lupi Marchigiano Bakery or Apicella's Bakery. Both bakeries have long histories as family-owned businesses and offer opportunities to learn about "how bread is made."

Activity Six: Host a bake sale

Students and their families will bake a favorite recipe or two to include in our classroom bake sale to be held during school lunch time. The students will be able to share their learning with students from all grades. All of the recipes of the baked goods sold at the bake sale will be compiled into our own cultural recipe book. Families may include stories or the history of the recipes in their write-ups.

Endnotes

1. https://www.usda.gov/
2. Harold McGee, *On Food and Cooking*, 516-517.
3. Carl Zimmer, "How the First Farmers Changed History."
4. McGee, 517-520.
5. Peter Barham, *The Science of Cooking,* 107-108.
6. http://www.madehow.com/Volume-3/Flour.html
7. McGee, 529.
8. Barham, 108.
9. http://www.foodnetwork.com
10. McGee, 532.
11. http://www.cooksinfo.com/baking-soda
12. https://whatscooking.fns.usda.gov/
13. Robert L. Wolke, *What Einstein Told His Cook,* 98.
14. Wolke, 24.

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Appendix – Implementing District Standards

A24 Describe how people in different cultures use different food sources to meet their nutritional needs.

The mentor text in this curriculum unit, *Everybody Bakes Bread,* focuses on a multicultural neighborhood and discusses the various types of breads from the many cultures included in the story. In Activity Three, students learn how to read a recipe, identifying the common ingredients in breads as well as the ingredients specific to each culture.

A INQ.2 Use senses and simple measuring tools to collect data.

During Activity Four, as the students prepare and bake samples of each bread recipe in the unit, they observe and document any similarities and differences in their science journals, including what they feel, smell, and taste.

A INQ.6 Present information in words and drawings.

Throughout the unit, the students will track their learning and understanding through words and drawings in their science journals, including prior knowledge, hypotheses, observations and conclusions. The journal serves as an informal assessment and a source of data for student discourse.