

# **Four Leavening Agents Used for Baking**

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## **Overview**

In this unit prepared for ninth grade students we will explore the use of leavening agents. Experiments for each of the leavening agents, air, baking soda, baking powder and yeast, will be conducted to show visually the reactions taking place. These experiments will be followed by seven food preparation labs. Each lab will seek to replicate the leavening process. Students will be able to transfer knowledge gained from scientific experimentation to the preparation of particular foods. In addition, students will be introduced to the concept of using scientific formulae as they relate to the preparation of baked goods. This unit could be easily adapted and used by high school chemistry teachers as well as family and consumer science teachers.

## **Rationale**

The reason for this unit comes from the students lack of knowledge as to which ingredient does what when baking. As a teacher in the Family and Consumer Science Department, I frequently teach a Teen Living Class to ninth grade students. The curriculum for this course allots a nine-week time slot for cooking. Young teens love this section, and are enthusiastic and confident that they know everything. But their over-confidence causes them to flounder in the actual food preparation lab experience.

The students really enjoy baking. They love seeing the changes that occur when food bakes and they are ecstatic when the food product turns out correctly. However, I find the students do not have much knowledge about the ingredients of the recipe. As often as I ask, "What ingredient in the recipe makes the product rise?" they reply: flour, sugar, or shortening.

Because of this, I want to use some simple scientific experiments to visually show what is going on inside the baked goods. I believe that if the students see the phenomenon they will put the information into their long-term memory banks. They will understand that just because we use a

greater quantity of flour, sugar, or shortening, what really makes the product rise is a small quantity of leavening agent and they will know why. Although only a small amount of leavener is used; it must be measured accurately as it has a powerful effect on the finished product. Too much leavener will cause the baked goods to have a coarse texture and they will dry out easily. Too little leavener produces a product very fine in texture, but small in volume and the crust will be rough.

Past procedures for these cooking labs has not given the students a thorough understanding of what is really happening. My procedure was to introduce a recipe, going over it in detail, explaining what the ingredients do and why certain procedures are necessary to create acceptable food products. Then the students copied the recipe.

The next time we met I did a demonstration of the food product, again emphasizing the procedure and what each ingredient did. Students then answered questions, either orally or written, pertaining to the recipe. The following day or two, depending upon the time needed, the students prepared the food product independently.

### **Objectives**

The students will understand which chemical reactions occur that cause baked goods to rise. By gaining this knowledge, the students will be able to predict what will happen when a recipe is followed. The students will learn to expect the same results repeatedly if they measure accurately and follow the procedures for the recipe exactly. The students will apply the concept of leavening agents across various recipes, replicating results in each recipe. The students will transfer results from scientific experimentation to food preparation. From this experience the students will know the scientific nomenclature for the reactions of baking soda, baking powder and yeast, and be able to apply this knowledge in the production of baked goods.

### **Strategies**

The objectives of this unit will be achieved in a variety of ways. The fundamentals of reading a recipe and proceeding with making the product will be taught through lecture, demonstrations and the use of work sheets. The underlying scientific principles will be taught by demonstrations in the classroom using apparatus constructed from items accessible in most kitchens. Three plastic jars, one large and two smaller ones, will be needed. Also a larger see-through container will be used as a tub. It must be large enough it allow a smaller jar of water to be submerged in it. The jar housing the reaction will be connected to the submerged jar of water in the tub with plastic tubing. The students will observe these demonstrations and then proceed to make the food products. By hearing, seeing, and then doing, students' knowledge of what makes baked goods rise and how it happens should increase. Answering questions on the subject verbally and in written form will let the teacher know what learning is taking place. The hands-on experience of making baked goods will give the students confidence and satisfaction.

Generally speaking, leavening agents, when mixed with certain other ingredients, create carbon dioxide and air. These gases are trapped in the flour

mixture. Once heated, the trapped bubbles of gas expand, causing the product to rise. We will demonstrate this by inflating a balloon. The balloon traps the air inside. Place the balloon in the freezer for five minutes, remove it and quickly measure its circumference. Allow the balloon to warm up to room temperature and measure its circumference again. Finally, place the balloon in an oven that has been preheated to 150 degrees Fahrenheit and then turned off. Remove the balloon after five minutes and immediately measure its circumference again.

This demonstration will show how heat expands trapped air. The same phenomenon occurs in baking. Heat expands trapped bubbles of air, steam and carbon dioxide in baked goods, which causes the product to enlarge or rise.

## **Classroom Activities**

### Lesson One

The unit will be introduced to the class by stating the objectives and demonstrating the circumference of the inflated balloon changing with temperature changes. Followed by a short lecture on what a leavening agent is and what they contribute to the baking process.

Leavening agents produce air bubbles and cause the baked goods to rise. There are mechanical and chemical leaveners. Air incorporated into a batter and heated acts in a mechanical way. Water turning to steam is also a powerful mechanical leavening agent. The baking powder, baking soda, and yeast produce chemical reactions which produce carbon dioxide ( $\text{CO}_2$ ) to leaven baked goods. Although yeast is a single-celled fungi that needs sugar to metabolize, this process causes fermentation and a chemical reaction takes place producing alcohol and carbon dioxide. These gases become trapped in the gluten, which is a mixture of the protein in the flour and liquid. Gluten resembles the mixture of flour and water you have perhaps made to make glue or paste. It is sticky. As the mixing of the dough continues the gluten becomes elastic and pliable. Once these gases are trapped, the dough or batter is heated and the trapped gases expand causing the product to rise.

Perform a scientific experiment for each of the leavening agents to demonstrate visually the gases produced in the reaction. Explain that air and steam are also gases and can act as leavening agents in and of themselves. One might assume, since no chemical leaveners are present, nothing will happen. Air and steam are gases that leaven a baked product mechanically, not chemically. (Have an inflated balloon in the freezer.) Tell the students this and that it has air trapped inside its walls. Then, remove it from the freezer and measure its circumference very quickly. Record the measurement.

Allow time for the balloon to warm to room temperature. Ask the students to try to imagine a recipe that calls for no leavening agents but yet it puffs up and rises. "Puffs" is a hint. Cream

puffs is correct, and another recipe without a leavening agent is popovers. (For recipes see Appendix III below.) Pass out a copy of these two recipes to the students. Question the students as to what ingredient makes these baked goods rise. Tell the students that if you are looking, you probably will not see one; but then "air" is hard to see at anytime, and that is the correct answer. Emphasize, that air and steam make cream puffs and popovers rise, and they do it mechanically.

Hold that thought a moment. Have the students measure the circumference of our balloon at room temperature. What is the measurement? Now, turn off this oven, which is preheated to 150 degrees Fahrenheit, and place the balloon inside. Set the timer for five minutes.

Then remind the students that air and steam make the cream puffs and popovers rise. Question the students as to how air and steam (which is highly heated water vapor and is no longer visible) make cream puffs and popovers rise. Have the students look at the procedures of both recipes. Popovers are prepared by beating an egg vigorously with milk (which contains a lot of water that will turn to steam when heated) then adding a flour mixture. They are then placed in custard cups and baked in a hot oven. Cream puffs are prepared by boiling water and margarine in a saucepan and then adding flour. The dough is stirred until it looks like softball. It is then removed from the heat source and the eggs are beaten in, while the preparer beats the dough vigorously. Now, if you are using all of that vigor to beat these eggs what do you suppose you are beating into them? (Air.)

Once the buzzer sounds, quickly measure the circumference of the balloon again. What is the measurement? The circumference of the balloon has doubled since its time in the freezer. Possible questions include: What does that tell you about trapped air? Do you think it could be used to make baked goods rise? What happens when you beat an egg? (Explain that the egg's yolk and white are all mixed together and the color is very yellow.) As one continues to beat air into the mixture the color turns to light yellow. Eggs are high in protein so the liquid protein is trapping the bubbles of air. Now if you could beat that really well one could incorporate a lot of trapped air into the mixture. And you saw what happened to the size of the balloon with about a 200 degree change in temperature. If we would put our popovers and cream puffs in a hot oven, say 400 degrees Fahrenheit; do you think they would rise? How high? What effect will the flour have on the rising of the product? When baked, the gluten in flour will coagulate or become firm. The gluten along with the starch in the flour creates the structure of the product and after awhile it will not continue to stretch. Once hardened, the cream puffs and popovers will stop getting bigger because the walls that trapped the air can no longer expand.

The next day, demonstrate the mixing and baking of popovers. The students will watch and answer questions orally as we progress through the demonstration. Once in the oven, take out some that were baked prior to class because the baking time is 45 minutes. Students will serve and eat these with butter and jelly if they wish.

The following day, the students will test their skills of following the recipe, measuring accurately and performing the procedures correctly. Once the product is in the oven they will wash their dishes and clean up the foods lab. Their popovers will be eaten the following day due to the time needed to bake them.

The next day, demonstrate the mixing and baking of cream puffs. The students will watch and answer written questions during the demonstration. Once the cream puffs are in the oven, the students will serve and eat the popovers, which were baked yesterday.

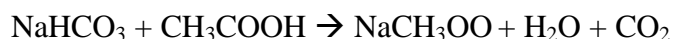
The next day, do a brief demonstration on cutting off the tops of the cream puffs, hollowing out the fiber from the inside, filling the cream puff with prepared pudding, replacing the lid, and dusting the cream puff with powdered sugar. Have the students measure the ingredients for the cream puff recipe. Then carefully following the procedure, they will make cream puffs. Once placed in the oven and the foods lab is cleaned, they may eat the filled cream puffs from yesterday's demonstration.

The following day, administer a quiz on air and steam as leavening agents and the procedures for incorporating air into a bakery product. After which the students will cut the tops off their cream puffs, hollow the fibers out of the inside, fill with prepared pudding, replace the lid, dust with powdered sugar, and eat.

## Lesson Two

The second lesson in this unit is baking soda as a leavening agent. Baking soda has been around for many years; what have you or your parents used it for? –Scouring abrasive, refrigerator odor control, carpet freshener, substitute for tooth paste, put out grease fires, fire extinguishers, and neutralize battery acid. Well baking soda is also a leavening agent. It makes baked goods rise, but it must have an acid to react with before the process can happen. The scientific formula for baking soda is  $\text{NaHCO}_3$  and it is an inexpensive alkaline, which you know is used for many things around your homes. For baking soda to leaven bakery goods an acid must be also present or no chemical reaction would occur. In the presence of an acid, baking soda releases carbon dioxide in large amounts. These gas bubbles are trapped in the flour mixture and expand upon heating in the oven.

To demonstrate the power of baking soda as a leavening agent, show the students the reaction of vinegar,  $\text{CH}_3\text{COOH}$ , with baking soda. Vinegar is acetic acid diluted to 5% acidity.



Have vinegar (acetic acid) placed in the large plastic jar. (See Demonstration Apparatus in Appendix II below.) When adding baking soda, a reaction will be visible in the jar. Quickly tighten the lid. The only escape route from this jar will be a plastic hose, which you can see coming out of the jar and going into the container filled with water. The end of the hose will be in a smaller plastic jar of water inverted in a larger container (tub) of water. Prior to lab, mix some baking soda and water together and freeze the mixture in a small plastic cup to make a frozen pellet. The reason for this is to allow enough time to shut the lid before the reaction begins.

Have a student drop the baking soda pellet into the jar containing vinegar. Remove their hand quickly, so you can place the lid on the jar. As the baking soda sinks, the reaction begins. And you can see many bubbles forming, rising, and bursting. Focus your eyes on the inverted plastic jar that was full of water. Keep watching. Some thought provoking questions include: "What is happening?" Tell the students that the water (in the inverted plastic jar) is being displaced by a gas due to the reaction of baking soda with the vinegar. "What is that gas?" Explain that the gas is carbon dioxide. "Is there a lot of CO<sub>2</sub>?" "If this reaction is enough to empty a jar full of water and fill it with CO<sub>2</sub>, do you think baking soda could make a cake rise?" Explain that there would be no reaction without an acid present.

Instruct the students to look at these recipes for biscuits and chocolate cake! (For recipes see Appendix IV below.) Vinegar is not one of the ingredients listed. Question the students, "Is there anything else that would be acidic?" "What about the buttermilk, sour milk?" Explain that both are acidic, and as baking soda is neutralized, it gives off a lot of carbon dioxide. Baking soda provides the leavening action of four times its volume of baking powder. Have the students compare the amounts of baking soda and baking powder in their biscuit recipes.

The next day, demonstrate the making of buttermilk biscuits. The students will watch and answer oral and written questions during the demonstration. Their copy of the recipe for biscuits will include two for comparison, one using baking soda and the other one using baking powder. Question the students, "If both recipes use equal amounts of flour, why does one recipe call for four teaspoons of baking powder and the other call for one teaspoon of baking soda?"

Measure the dry ingredients into a medium size bowl and stir them together with a fork. Add the solid shortening. Cut it into the flour mixture with a pastry blender. When all the shortening particles are small and coated with the flour mixture, add the buttermilk all at once. Stir it slowly and deliberately with a spoon no more than ten times, then turn it onto a floured waxed paper and knead a few times, just enough to hold it together. Then, using a rolling pin roll the dough about one-inch thick. Dip a biscuit cutter in flour and cut out the biscuits. Place them onto a cookie sheet and bake in a hot oven.

Inform the students that the ingredients in both recipes for biscuits were the same except for two. Then ask, "What were they?" Draw their attention to the fact that the recipe using baking soda called for one teaspoon of this leavening agent and one cup of buttermilk. The recipe using baking powder called for four teaspoons of that leavening agent and one cup of regular milk. Please note: To leaven the same amount of flour you have to use four times as much baking powder as compared to baking soda. And the other difference is the liquid. Baking powder reacts with regular milk, but baking soda must have an acid to react with and the buttermilk provides that acid. Tell the students we will learn more about this later. When the biscuits are finished baking, the students may eat them with butter and jelly if they wish.

The following day, the students will test their skills at following a recipe, measuring accurately and performing the procedure correctly. Once the biscuits are in the oven, the students will clean up the foods lab. It only takes ten minutes for them to bake, so as soon as they are cooked, the students may serve and eat them.

The next day, demonstrate chocolate cake using baking soda as the leavening agent and sour milk as the acid to cause the reaction to take place. Elaborate on the procedure as you are mixing it up. Then bake the cake in cupcake liners so it will be easy to serve. The students will answer questions concerning the lab while the demonstration is in progress.

The next day, the students will measure the ingredients and following the procedures make their own cake. Once they have it in the oven, demonstrate how to frost the cupcakes from yesterday's demonstration, and the students can then eat them.

The following day, the students will have a quiz on baking soda as a leavening agent. Then they will have time to frost and eat the cupcakes they made yesterday.

### Lesson Three

The third lesson in this unit is baking powder. Baking powder is a mixture of baking soda and a powdered acid in the form of salt crystals. Ground dry starch is also added to absorb moisture so the baking powder does not start reacting in storage. Double-acting baking powder has its first reaction when moisture is added. Lots of small  $\text{CO}_2$  bubbles are formed. During the second reaction phase, heat is added and many more  $\text{CO}_2$  bubbles form and the trapped bubbles expand. That is why it is called double-acting baking powder. The double action occurs because there are two different acids in the baking powder causing one to react at room temperature and another to react at higher temperatures. The most common low-temperature acid is cream of tartar ( $\text{KHC}_4\text{H}_4\text{O}_6$ ), though others such as tartaric acid and monocalcium phosphate are also used. Aluminum sulfate ( $\text{Na}_2\text{SO}_4 \text{ Al}_2 (\text{SO}_4)_3$ ) is the most common high-temperature acid.

Add a little double acting baking powder to the apparatus and have the students observe what happens. Question, "Is the liquid in the plastic jar vinegar?" When they respond "No." Ask, "Why not?" Explain there is acid in the baking powder in the form of a salt. Baking powder does not need an acid to react with because it is a mixture of an acid and a base. All that is needed to get an initial reaction is moisture. Conclude that the liquid in our plastic jar is water. Ask, "Do I have a volunteer to add the baking powder?" Ask, "Do you see bubbles forming, rising, and bursting?" It is time to focus your eyes now on the inverted plastic jar filled with water submerged in the tub of water. Inquire, "What is happening?" Explain that the water is being displaced by gas. And that we know the gas is carbon dioxide. Tell the students to watch what happens when you add boiling water to heat up the reaction. Question, "Did the making of carbon dioxide speed up?" Explain that this gives you a little idea of the second reaction of baking powder in the oven. And that is why it is called double acting. The first reaction taking place at room temperature when moisture is added causing the baking soda to react with the low temperature acid, and the second reaction taking place when heated. Both produce  $\text{CO}_2$ , but at different temperatures.

Our recipes to go along with baking powder as a leavening agent are muffins and pancakes. (For recipes see Appendix V below.) Please examine these recipes carefully.

The following day, demonstrate muffins. The students will watch and answer oral questions. In medium-size bowl mix all of the liquid ingredients together. In another medium-size bowl mix

together all of the measured dry ingredients with a fork. Then pour the liquid ingredients into the dry ingredients and stir no more than twenty times; only until the dry ingredients are moistened. The batter should be lumpy. Now we will take a large spoon and fill the muffin tins half full and place them in a moderately hot oven for twenty minutes. While you clean up the lab, the students will answer a few questions on the lesson. When the muffins are done, they should have doubled in size and the tops should be rounded. Remember to only stir the batter until moistened. If the batter is stirred too much, the tops of the muffins will be pointed due to air tunnels and the texture will be less tender than it should be. Take a moment and examine our product. Note if any muffins have pointed tops. Allow the students time to eat the muffins with butter and jelly if they wish.

The next day, the students will measure the ingredients for muffins and follow the procedure to make them. They will clean up their areas and eat the muffins when they come out of the oven.

The following day, demonstrate pancakes made with baking powder. All ingredients are added together and beaten until all lumps are gone. The batter is placed on a hot griddle using 1/3-cup measure for a dipper. Bubbles come to the surface and break and for a while close up again for about two minutes. But when the bubbles break and the hole remains open then it is time to flip the pancake over and cook the other side. Allow a minute or so for the pancake to finish cooking and brown. Then, remove it from the griddle. Students will eat the pancakes with butter and syrup.

The following day the students will make the batter for pancakes and cook them on a hot griddle. They will practice turning them at the appropriate time. Then, they will eat them with butter and syrup.

#### Lesson Four

The fourth lesson in this unit is leavening with yeast. Now yeast is not a chemical, it is a living organism that feeds on sugars, first simple sugars then more complex as flour (starch) is turned to sugar, and the yeast cells reproduce. What this reaction produces is alcohol and carbon dioxide. You will be pouring warm water in our smaller plastic jar and adding yeast and sugar. Temperature is very important for this reaction to take place. If the water is too hot, it will kill the living organism (yeast), and if it is not hot enough, the reaction will be very slow. The optimum temperature is 80 to 90 degrees Fahrenheit. Using the thermometer allows you to get tap water for this experiment at 90 degrees Fahrenheit. Request a volunteer to add the yeast and sugar. Mix these together well, then place the mixture in the plastic jar. Yeast takes a little time to start growing so one does not have to be as quick as one was with chemical leavening agents. In about ten minutes you will see evidence of a reaction taking place and in about twenty minutes the reaction should be well under way. There will be foam coming up, bubbles bursting, and CO<sub>2</sub> traveling through our plastic tubing into the inverted jar full of water. In an hour, the foam would completely fill our plastic jar and if the lid were opened, it would froth out and down the sides. The formula for what you are about to observe is -- yeast + C<sub>6</sub>H<sub>12</sub>O<sub>6</sub> → 2C<sub>2</sub>H<sub>5</sub>OH + 2CO<sub>2</sub>

The yeast is a single-celled fungus called *Saccharomyces cerevisiae*. This organism is used to make bread rise, to make various cheeses, and to convert grain or fruit juice into alcohol for the making of beer and wine. Carbon dioxide and alcohol are produced as the yeast metabolizes sugar and the yeast cells multiply. Yeast can be obtained as compressed or cake which is partially dried then compressed into solid cakes; or it can be bought in a foil package as dry yeast. Compressed yeast's shelf life is shorter than that of dry yeast. Storing them in the freezer can lengthen the shelf lives of both.

Once the reaction begins, draw the students' attention to the bubbles. Notice there are bubbles forming some frothing and some bubbles bursting. Also make the students' aware of the gas traveling through the tubing into our inverted jar of water. Question the class, "Does anyone notice a distinctive smell?" "What is it?" Offer the following explanation, this odor is always produced as yeast metabolizes sugar. It is the result of the fermentation process and what you smell is alcohol. Continue to watch this until time for class to be dismissed.

The next day, demonstrate bread making with yeast. (For recipe see Appendix VI below.) Mix together warm water and yeast, once dissolved add the sugar and stir. Then add the remaining amount of the water or milk and half of the bread flour. Beat this with the electric mixer. When it becomes too difficult to mix, turn the dough onto a floured counter or pastry cloth and knead the dough by hand.

Kneading improves the aeration of the dough and helps develop gluten. Question, "What is gluten?" Explain that gluten is an elastic protein formed when hard winter wheat flour is moistened and kneaded. Gluten gives yeast dough its characteristic elasticity. Have the students watch as you fold it over; push it down then fold it over again and again. Explain that that process is called kneading the dough. One should continue kneading the dough while adding the remaining flour or until the dough no longer becomes stiffer. Because kneading largely determines the final texture of the bread one should continue kneading until the dough has a fine, soft, silky appearance. Now form the dough into a ball with a smooth top; oil the top and place it into a greased bowl to rise. This will take over an hour at about 80 degrees Fahrenheit and longer if the room is cooler. Or if you want it to take overnight to rise, cover the bowl with a damp cloth and put it in the refrigerator to rise at 40 degrees Fahrenheit. Because of the bell schedule, this will be our choice.

The following day, remove the dough from the refrigerator, allowing it to warm to room temperature before the students come. When they come, punch the dough down, shape it into rolls, brush the tops with oil and again allow them to rise slowly in the refrigerator. The students will then measure and mix the ingredients following the procedures necessary for bread making. They will store their dough in a bowl in the refrigerator.

The following day, remove the students' dough and your rolls from the refrigerator and allow them to warm up to room temperature before class. Your rolls should be ready to place in a hot oven for baking, approximately 425 degrees Fahrenheit. Due to the trapped carbon dioxide expanding, there is rapid rising or what is called "oven spring" when first placed in the hot oven. This rising will continue until the interior portion of the rolls reaches 140 degrees Fahrenheit and the yeast cells are killed. Also the rising stops when the gluten hardens and the carbon dioxide

bubbles can not expand farther. The students will punch down their dough, knead it a little, then shape it into rolls and brush the tops with oil. They will place them in the refrigerator to rise. Then they will clean up the foods lab and eat the rolls that you baked with butter.

The following day, remove the rolls from the refrigerator and allow them to warm up to room temperature before class. The students will bake and eat the rolls they have prepared. And take a quiz on yeast as a leavening agent.

### **Culminating Activity**

The concluding activity for this unit on leavening agents will be to write an essay describing the four leavening agents we explored. They will compare and explain how each does its work. Learning is very effective when one critically evaluates, compares, investigates, and writes their findings. It is hoped that this unit acts as an inspiration to students to always learn more, for there is more to learn.

### **Bibliography Resources**

Crocker, Betty Editors, Betty Crocker's Cookbook. Revised edition. New York: Golden Press, 1983. 194-209, 234, 306.

A collection of 1,500 recipes, many color photographs and hundreds of helpful hints. These are recipes one can use with confidence because they have been rigorously tested and retested.

Donovan, Mary Devidre, editor. Cooking Essentials. New Jersey: John Wiley and Sons, Inc., 1997. 425-467.

An interesting textbook for a new professional chef. An introduction to a great and rewarding profession. It includes the fundamentals of food preparation, serving, garnishing and restaurant management. There is also a limited 200-page recipe section, and a glossary.

Gardener, Robert. Science Project About Kitchen Chemistry. New Jersey: Enslow Publishers, Inc., 1999. 89-106.

A small stimulating textbook for younger audiences. Using kitchen instruments, chemistry labs and simulated. A great book for ideas especially for Science Fair Projects.

Hillman, Howard. Kitchen Science. Revised edition. Boston, MA: Houghton Mifflin Company, 1989. 203-220.

A question and answer format for more than 150 frequently asked questions. Explanations are thorough yet concise. Recipes are included for some things. It calls "old wives tales" nonsense and reveals the scientific answers. Interesting reading for high school age and older.

McGee, Harold. On Food and Cooking. "The Science and the Lore of the Kitchen." New York: Fireside, Simon and Schuster Inc., 1997. 273-326.

A scholarly book offering scientific explanations to many cooking questions and phenomenon. The information is easy to read and presented in a straight-forward manner. It is laid out in a logical manner, exploring one type of foods and then another.

Nebergall, William, Schmidt, Frederick, Holtzclaw, Jr., Howey. College Chemistry with Qualitative Analysis. 5<sup>th</sup> edition. Massachusetts: Heath and Company, 1976. 943-946.

A general chemistry textbook which includes qualitative analysis and a supplement of analytical procedures. It is a very useful text, easy to read and understand. It is out of date for time sensitive topics.

Bread Dough Ductility. "Kitchen Chemistry Workshop"  
<http://scienceworkshop.freeyellow.com/9.html>

A write up of an experiment testing the strength of dough by seeing how much weight it can hold before tearing.

The Bubbles Page. "Bizarre Stuff." <http://freeweb.pdq.net/headstrong/bubble.html>

A concise and methodical explanation for developing the best formula for blowing bubbles from dishwashing soap and water. It is educational and entertaining.

Gas Me Up, or, A Baking Powder Diver. "Journal of Chemical Education." By Tricia Lewis. February 2000, Vol. 77, No. 2. 171.  
<http://jchemed.chem.wisc.edu/Journal/Issues/2000/Feb/abs171.html>

A write up of an experiment that illustrated the reaction of baking powder as it propelled a diver in water.

What is the difference between baking powder and soda, and what are they used for. "Chemistry Question? #6." <http://www.geocities.com/NapaValley/6803/why.html>

Short specific answers to specific questions, which can be submitted by the general public at: [michael.linhares@snet.net](mailto:michael.linhares@snet.net)

### **Bibliography: Student Reading List**

Gardener, Robert. Science Project About Kitchen Chemistry. New Jersey: Enslow Publishers, Inc., 1999.

This is a small stimulating textbook for younger audiences. Using kitchen instruments, chemistry labs are simulated. A great book for ideas especially for Science Fair Projects.

Haines, Robert G. Food Preparation. Illinois: American Technical Publishers, Inc., 1988. 80-91.

This is an excellent textbook for students studying to become a professional chef. The text has detailed explanations of procedures, and is filled with recipes. It is 661 pages of vital material necessary for the quantitative foods industry.

Ray, Mary Frey and Dondi, Beda A. Professional Cooking and Baking. Illinois: Bennett Publishing Company. 1981. 323-401.

This book is easy to read. It gives detailed explanations of each topic. Chapters are divided into short topical sections and a "Words to Remember" list introduces each short section within the chapter.

Ray, Mary Frey and Lewis, Evelyn Jones. Exploring Professional Cooking. Revised edition. New York: McGraw Hill, 1988. 251-306.

This is a well-written textbook for students exploring a career in professional cooking. Topics are concise, but adequately explained. Vocabulary words are at the beginning of the chapters and each chapter is ended with a section of questions. There are many colorful illustrations throughout the book.

Sultan, William J. Elementary Baking. New York: McGraw Hill Book Company, 1969. 1-41.

This is an older textbook containing good timeless information. There are black and white pictures, and there are many drawings used for illustrations. There are no review questions or other exercises to check student comprehension.

## List of Materials

### Equipment List Food List

2 balloons	baking powder
gas and/or electric ovens	vinegar
1 large plastic jar with lid	water
1 large clear plastic tub	½ pint vanilla
2 small plastic jars with lids	1 gallon vanilla pudding
3 feet plastic tubing	baking soda
1 tubing coupler	2 pounds jelly
1 small plastic cup	yeast
sinks	4 dozen eggs
measuring tape	25 pounds all-purpose flour
8 medium-size mixing bowls	25 pounds bread flour
timer	25 pounds sugar
4 griddles	2 pounds confectioners sugar
6 cookie sheets	1 pound salt
1 kitchen thermometer	2 gallons milk

4 - 4-cup liquid measuring cups	2 quarts buttermilk
4 - 2-cup liquid measuring cups	2 pounds butter
4 medium metal spatulas	3 pounds margarine
4 small metal spatulas	3 pounds shortening
4 rubber spatulas	2 quarts vegetable oil
4 pastry cloths	1 pound cocoa
4 electric mixers	24 custard cups
4 large mixing bowl	100 paper cupcake liners
4 pastry blenders	4 sets dry measuring cups
4 sets measuring spoons	4 pastry brushes
4 pancake turner	4 biscuit cutter
1 roll waxed paper	

## **Appendix I**

### ***Educational Standards***

#### **Communication Standards**

CO 3 All students respond orally and in writing to information and ideas gained by reading narrative and informational texts and use the information and ideas to make decisions and solve problems.

CO 6 All students exchange information orally, including understanding and giving spoken instructions asking and answering questions appropriately, and promoting effective group communications.

CO 7 All students listen to and understand complex oral messages and identifies the purpose, structure, and use.

#### **Family and Consumer Science Standards I**

FCS 1 All students demonstrate their knowledge of principles of consumer behavior as a foundation for managing available resources to provide for personal and family needs.

#### **Mathematics**

MA 2 All students compute, measure, and estimate to solve theoretical and practical problems, using appropriate tools, including modern technology such as calculators and computers.

#### **Science and Technology**

ST 1 All students explain how scientific principles of chemical, physical and biological phenomena have developed and relate them to real-world situations.

ST 2 All students demonstrate knowledge of basic concepts and principles of physical, chemical, biological, and earth sciences.

ST 3 All students use and master materials, tools, and processes of major technologies, which are applied in economic and civic life.

## Appendix II

### *Demonstration Apparatus*



#5 #6 #7 #8 #9

#1 #2  
#3  
#4

**#1 Baking Soda**

**#2 Frozen Baking Soda Pellet**

**#3 Clear Plastic Bottle with plastic hose glued through the top and about one-inch of vinegar in the bottom.**

**#4 Hose coupler for exchanging jars and plastic tubes**

**#5 Clear-plastic tub filled with water**

**#6 Small clear plastic jar with clear plastic hose glued through its bottom, and the neck weighted so that it will float upside down**

**#7 Yeast**

**#8 Small clear-plastic jar with a hose glued through the top**

**#9 Baking powder**

## **Appendix III**

### *Recipes*

#### **Popovers**

Ingredients:

2 eggs  
1 cup all-purpose flour  
1 cup milk  
½ teaspoon salt

Procedure:

Preheat oven to 450° Fahrenheit.  
Grease six 6-ounce custard cups.  
Beat eggs with wire whip in medium size bowl.  
Continue beating while adding milk, salt, and flour.  
Beat until smooth. Stop.  
Fill custard cups ½ full.  
Bake at 450° Fahrenheit for 20 minutes.  
Decrease the temperature to 350° Fahrenheit.  
Continue baking for 20 to 25 more minutes.  
Remove from oven.  
Remove from custard cups immediately.  
Serve hot.

#### **Cream Puffs**

Ingredients:

½ cup water  
¼ cup margarine or butter  
½ cup all-purpose flour

2 eggs  
prepared pudding  
powdered sugar

Procedure:

Preheat oven to 400° Fahrenheit.  
Heat water and margarine to rolling boil in saucepan.  
Stir in flour.  
Stir vigorously over low heat until mixture forms a ball.  
Remove from heat.  
Beat in eggs all at once.  
Continue beating until smooth.  
Drop dough by scant ¼ cupfuls about 3 inches apart onto ungreased cookie sheet.  
Bake 35 to 45 minutes. They should be puffed and golden brown.  
Cool away from draft.  
Cut off tops; pull out any filaments of soft dough.  
Fill puffs with prepared pudding.  
Replace tops.  
Dust with powdered sugar.  
Refrigerate until serving time.  
Makes six cream puffs.

## Appendix IV

### *Recipes*

#### **Biscuits**

Ingredients:

Buttermilk Biscuits  
*2 cups flour*  
*1 teaspoon baking soda*  
*1 teaspoon salt*  
*1/3 cup shortening*  
*2/3 cup buttermilk*

*Baking Powder*  
*2 cups flour*  
*4 teaspoons baking powder*  
*1 teaspoon salt*  
*1/3 cup shortening*  
*2/3 cup milk*

Procedure:

Preheat oven to 450° Fahrenheit.  
Measure dry ingredients and place in bowl and stir together  
Measure shortening and add to dry ingredients.  
Cut shortening into dry ingredients with pastry blender.  
Measure liquid ingredients.  
Add liquid ingredients to flour mixture all at once.  
Stir just until moistened (10 to 15 strokes).  
Turn onto floured waxed paper.  
Knead gently, folding in half and pressing down 6 to 8 times.  
Roll out 1-inch thick.  
Cut with floured biscuit cutter.  
Place 1 inch apart on ungreased cookie sheet.

Bake 10 to 12 minutes- until golden brown.  
Immediately remove from cookie sheet.  
Serve hot.  
Makes about 16 biscuits.

## **Cocoa Fudge Cake**

Ingredients:

1 2/3 cups all-purpose flour or 2 cups cake flour  
1 1/2 cups sugar  
2/3 cup cocoa  
1 1/2 teaspoons baking soda  
1 teaspoon salt  
1 1/2 cups butter milk or whole milk curdled with 1 tablespoon vinegar  
1/2 cup shortening  
2 eggs  
1 teaspoon vanilla

Procedure:

Preheat oven to 350° Fahrenheit.  
Grease and flour, baking pans or use paper liners for cupcakes.  
Measure all ingredients and place in large mixing bowl.  
Beat with electric mixer on low speed 1 minute.  
Scrape bowl.  
Beat on high speed for 3 minutes.  
Pour into pans or cupcake liners.  
Bake 30 to 35 minutes; 22 to 25 minutes for cupcakes.  
Cool, Frost, and Serve.

## **Appendix V**

### ***Recipes***

#### **Muffins**

Ingredients:

1 egg  
1 cup milk  
1/4 cup vegetable oil  
2 cups all-purpose flour  
1/3 cup sugar  
3 teaspoons baking powder  
1/2 teaspoon salt

Procedure:

Preheat oven to 400° Fahrenheit.  
Grease 12 medium muffin tins.  
Measure liquid ingredients and place in medium bowl.  
Beat.  
Measure dry ingredients and place in another bowl.  
Stir.  
Add liquid ingredients to dry ingredients all at once.  
Stir until moistened, about 20 strokes.  
Batter should be lumpy.  
Fill muffin cups  $\frac{3}{4}$  full.  
Bake about 20 minutes, until golden brown.  
Remove from pan immediately.

Makes 1 dozen.

## **Pancakes**

Ingredients:

1 egg  
1 cup all-purpose flour  
 $\frac{3}{4}$  cup milk  
2 tablespoons vegetable oil  
1 tablespoon sugar  
3 teaspoons baking powder  
 $\frac{1}{2}$  teaspoon salt

Procedure:

Beat egg with wire whip.  
Measure and add remaining ingredients.  
Beat with wire whip just until smooth.  
Grease heated griddle.  
Pour batter on griddle from pitcher, or place on griddle using  $\frac{1}{3}$ -cup measure for dipper.  
Cook until air tunnels remain open and edges are dry.  
Turn and cook the other side until golden brown.

## **Appendix VI**

### ***Recipe for Bread***

Ingredients:

2 packages active dry yeast  
¾ cup warm water (105° F)  
2 cups lukewarm milk (scalded then cooled)  
3 tablespoons sugar  
3 tablespoons shortening  
1 tablespoon salt  
7 to 8 cups bread flour

Procedure:

Dissolve yeast in warm water in large mixing bowl.  
Stir in milk, sugar, shortening, salt, and 4 cups of flour.  
Beat with electric mixer until smooth.  
Gradually add more flour until dough becomes easy to handle.  
Turn onto a lightly floured counter.  
Knead until smooth and elastic (about 10 minutes).  
Place in a greased bowl. Grease top of dough. Cover.  
Let rise until double in size.  
Punch down.  
Divide, shape, and place in pans.  
Let rise until double.  
Bake 425° Fahrenheit 25 to 30 minutes.  
Remove from pans immediately.