Leavening Agents

NUT 106

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<u>Introduction</u>:

A leavening agent is an ingredient added to a food product to change the texture of the product by releasing gas when mixed with liquid, heat or acid. The three major types of leavening agents are physical, biological and chemical. A physical leavening agent is something that creates air bubbles in a food mixture without the addition of any chemical or biological agent. Physical leavening agents can be created through beating or whipping, steaming, or aerating fats such as in creaming. Beating incorporates air into a foam, increasing its volume. Steaming causes the expansion of water, and thus an increase in volume of the food. Creaming aerates a fat, and with the addition of sugar, incorporates air more readily and creates a fluffy mixture. The incorporated air bubbles are locked into the fat and expand under heat, adding to volume. A biological leavening agent is a live organism that creates a gas or other product that contributes to leavening in a product. Yeast, for example, ferments sugars added to a mixture and produces CO_2. The CO_2 gas creates rise in the baked product by getting trapped in the dough or batter. A chemical leavening agent is the use of a chemical reaction to create gas that increases the volume of a food. Baking soda, for example, with the addition of water and heat or acid, creates CO_2. Baking powder releases CO_2 when moistened, and again when heated. Chemical leavening agents are commonly used in goods that don't form as well using yeast, or have different textural outcomes desired.

A quick bread is a bread made without yeast. They can have a variety of textures due to differences in ingredients, ratios, and baking methods. All quick breads contain flour, liquid, and fat. Three of the main mixing methods for quickbread include the biscuit method, muffin method, and the conventional method.

In the biscuit method, all dry ingredients are sifted, solid fat is cut into small pieces in the flour, liquid is added all at once and not overmixed, and gentle kneading is done. Under heat, the fat melts and creates pockets for any steam or CO2 from baking soda to collect and expand. This method creates a flakey product. Less liquid to flour ratio creates a less sticky dough, and as a result, a less developed gluten. With less development of gluten, this method creates a flakey and not tough product. This method uses a physical leavening of steam, and a chemical leavening in the form of baking soda. The solid fat in the mixture creates pockets, which melt when baked, allowing steam and CO2 from any chemical leavening used to collect and expand the dough.

In the muffin method, liquid fat is dispersed with other liquid ingredients. All the dry ingredients are sifted together, and liquid ingredients blended separately. Then, the two are combined until moist, and a coarse, crumbly product is created. The muffin method mixes the two ingredient phases just enough so that all the baking powder is moist enough to react, but not so much that the gluten over develops. This method uses a chemical leavening, baking powder, to release CO2 gas, getting trapped in the small pockets of air from gluten formation.

The conventional mixing method creams solid fat with sugar. The solid fat—butter, margarine or shortening—is creamed with sugar. Then, an egg is added. The dry ingredients are added one third at a time, briefly incorporating after each addition, with two additions of liquid at half each time. This method uses a physical leavening to incorporate air bubbles into the mixture using a creaming method.

Leavening Agents

The purpose of this experiment is to evaluate the impact of adding heat and acid to baking soda and baking powder, as well as to investigate the aerating properties of chemical leavening agents such as baking soda, baking powder, cornstarch, and cream of tartar on all purpose flour and gluten free flour cakes and scones. The experiment also evaluated how the different variations of leavening agents and flours affect color, texture, and flavor of the baked products.

I hypothesized that adding heat to baking soda and baking powder would result in a fizzing chemical reaction for both, releasing CO2, with baking soda being more aggressive of a reaction. I also hypothesized that adding acid to baking soda would result in a more aggressive and fast fizzing chemical reaction, and adding acid to baking powder in a slower chemical reaction.

I hypothesized that adding baking soda to the all purpose flour cake would create a darker, fluffier, and richer tasting cake due to the alkaline nature of it promoting maillard reactions and more CO2 being produced, and would result in a slightly less fluffy version when added to gluten free flour cake due to the lack of gluten not creating a network to capture the gas released. I also hypothesized that adding baking powder to the cake would result in a lighter colored, denser, and more neutral flavored cake because it is not as alkaline, and does not react as aggressively, producing less gas. I hypothesized cream of tartar would result in a lighter colored cake due to the acidic nature of it, with a soft but not fluffy texture, and a neutral flavor, while cream of tartar and baking soda would result in a dark, fluffy, and salty flavored cake from more alkaline conditions and more gas produced.

I hypothesized that the scones made with all purpose flour and baking powder would result in a light colored, crumbly, neutral scone due to the double acting properties in the mixture and more acidic pH, and a similar but more dense and dry version when added to gluten free flour scones due to inability to trap gas and moisture without the complex network gluten creates in the dough. I hypothesized that the scones with baking soda added would result in darker, fluffier, airier, saltier scones due to the basic conditions of the mixture promoting maillard reactions and the baking soda mixing with the sour cream/acid to release more carbon dioxide. I also hypothesized that adding cream of tartar to the scones would result in a lighter, denser, and more salty flavored scone, while adding cream of tartar and baking soda would result in a lightly toasted color, fluffy, and rich favored scone. The scones with no leavening agent added would be off white, flat, dense, and have a bready flavor.

Methods

Leavening Agents

To set up the experiment to evaluate the effects of heat and acid on baking soda and baking powder, 8 graduated cylinders were labeled; four for baking powder, four for baking soda, and two of each set with cold water and hot water. One of the cylinders in each group was also labeled for acid. Next, one teaspoon of baking powder and one teaspoon of baking soda was added to each of the cylinders labeled for the corresponding leavening agent. 20 mL of cold water was added to each cylinder labeled for cold water, and the maximum volume in the cylinder was recorded. Next, 20 mL of hot water was added to each of the graduated cylinders labeled for hot water, and the maximum volume recorded. Then, 18 mL of cold water and 2 mL of vinegar was added to the cylinders labeled with cold water and acid, and the maximum volume recorded. Lastely, 18 mL of hot water and 2 mL of vinegar was added to the cylinders labeled for hot water and acid, and the maximum volume recorded.

Cakes

To prepare the different cake variations, an oven was preheated to 350 degrees fahrenheit first. The corn starch, baking soda, and cream of tartar variation combined the three leavening agents in a small bowl. Then, all variations combined 150 grams of either all purpose or gluten free flour, 200 grams of sugar, 63 grams of cocoa powder, 2.8 grams of salt, and leavening agents. One variation combined the all purpose flour with 4 grams of baking powder, one variation with 16 grams of baking powder, another with 6 grams of baking soda, one with 24 grams of baking soda, and another variation with 2.5 grams of cornstarch, 6 gram of baking soda and 6.8 grams of cream of tartar. One more variation with 6 grams of baking soda added to gluten free flour was also made. Next, 60 mL of oil, 295 mL of water, and 5 mL of vanilla was added to each variation all at once and stirred until combined. The different batters were baked in an 8x8 baking dish for 32-35 minutes, until set. A corner piece and a middle piece were set out for appearance and sensory observation after the cake cooled.

Scones

To make the scones, first an oven was preheated to 400 degrees fahrenheit. Next, 284 grams of either all purpose or gluten free flour, 100 grams of sugar, and the different leavening agent variations were sifted and combined in a bowl. One variation had all purpose flour with no leavening agents, the control had 14.2 grams of baking powder, another had 14.2 grams of baking soda, one with 14.2 grams of cream of tartar, one with 4.4 grams of baking soda and 9.8 gram of cream of tartar, and lastly one variation with 14.2 grams of baking powder with the gluten free flour. Next, cold butter was cut into 10-12 small pieces, and the dry ingredients rubbed into the butter. Then, 120 mL of milk and 120 grams of sour cream were added to the variations. The ingredients were incorporated and the dough shaped into eight rounds, about 4.5 inches in diameter and 0.75 inches high. After baking for 15-20 minutes and cooling, the scones from each variation were cut for visual and sensory evaluations.

Statistical Analysis

The average percent increase for each variation of baking soda and baking powder tested was calculated using this formula: (Final Value-Initial Value)/(|Initial Value|). A series of t tests were performed to calculate the p value for each comparison group of baking soda and baking powder under cold water, hot water, cold water and vinegar, hot water and vinegar, and baking powder compared to baking soda with hot water and vinegar, for a total of seven tests. A bar graph was made using the average percent increase and standard deviations for each variation, with error bars included.

Additional observational evaluations were done on the overall strength of reactions for baking soda and baking powder under each condition. Sensory evaluations were done on the cakes and scones on appearance, texture, and flavor for each variation.

Results:

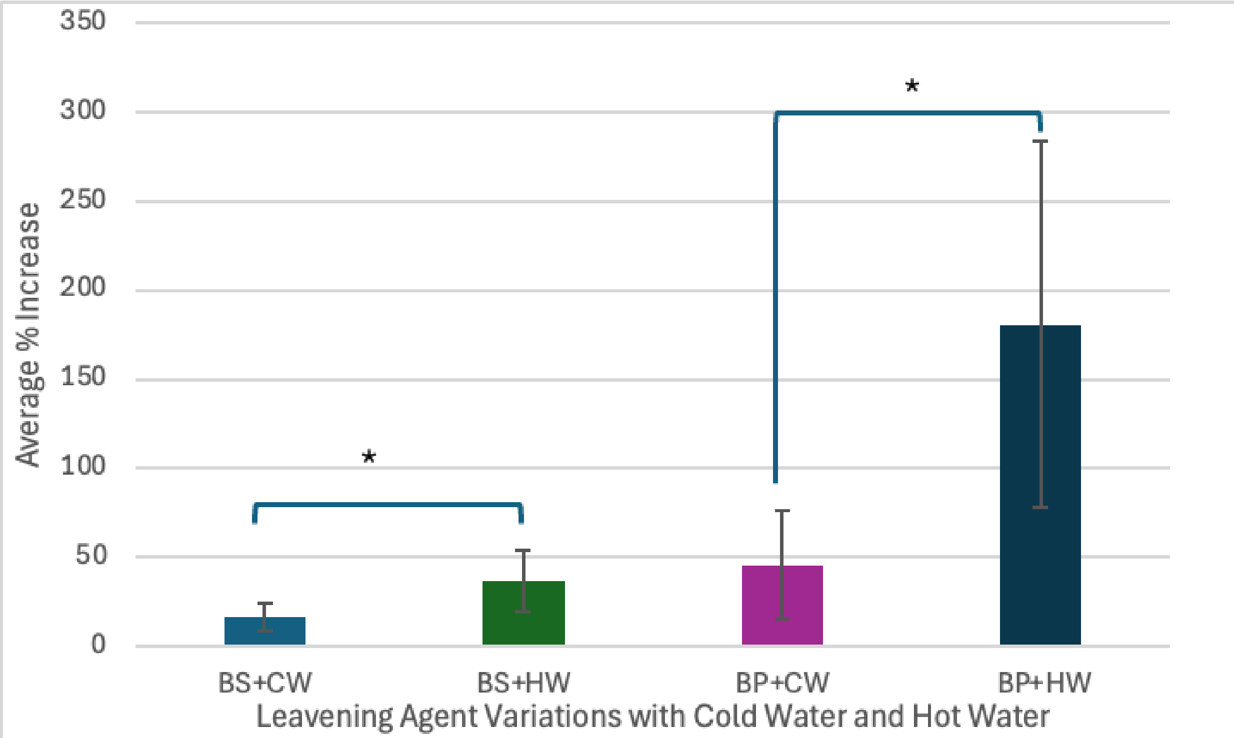

Figure 1A

The percentage increase in volume of water in a mixture with baking soda and cold water (blue) and baking soda (green) with hot water is shown. The p value between the two variations is 0.0262. The percentage increase in volume of water in a mixture with baking powder and cold water (purple), and baking powder (dark blue) and hot water is also shown. The p value between the two variations is 0.0115. Error bars of the standard deviation are also shown for each variation. $p<0.05$=*, $p<0.01$=**, $p<0.001$=***

In Figure 1A, the baking soda with hot water had a significantly different reaction than that of baking soda with just cold water added, with a p value both than 0.05. The error bars also do not overlap, indicating a significant difference. Baking powder with hot water was also significantly different reaction than with cold water with a p value less than 0.05, and no overlapping of error bars between the baking powder with cold water and baking powder with hot water variation.

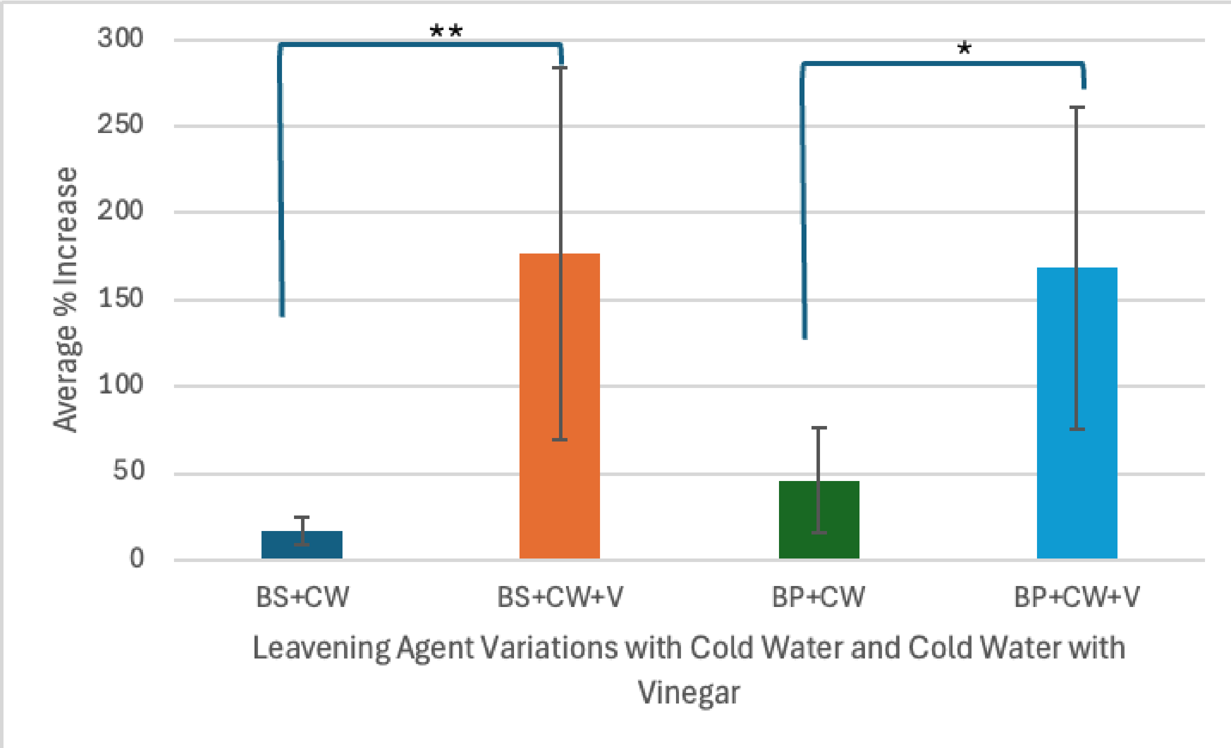

Figure 1B

The percentage increase in volume of water in a mixture with baking soda and only cold water (dark blue), and baking soda with cold water and vinegar (orange) is shown. The p value between the two groups is 0.00349. The percentage increase in volume of water in a mixture with baking powder and only cold water (green), and baking powder with cold water and vinegar (light blue) is also shown. The p value between the two variations is 0.0119. Error bars of the standard deviation are also shown for each variation.p<0.05=*, p<0.01=**, p<0.001=***

In Figure 1B, baking soda with cold water and vinegar had significantly different reactions than just baking soda and cold water, with a p value less than 0.01, as observed in Figure 1B. There is also no overlap of error bars, indicating they are significantly different. Baking powder with cold water and vinegar had a significantly different reaction than baking powder with just cold water, with a p value less than 0.05. There are also no overlapping of error bars between the two variations, indicating significant differences.

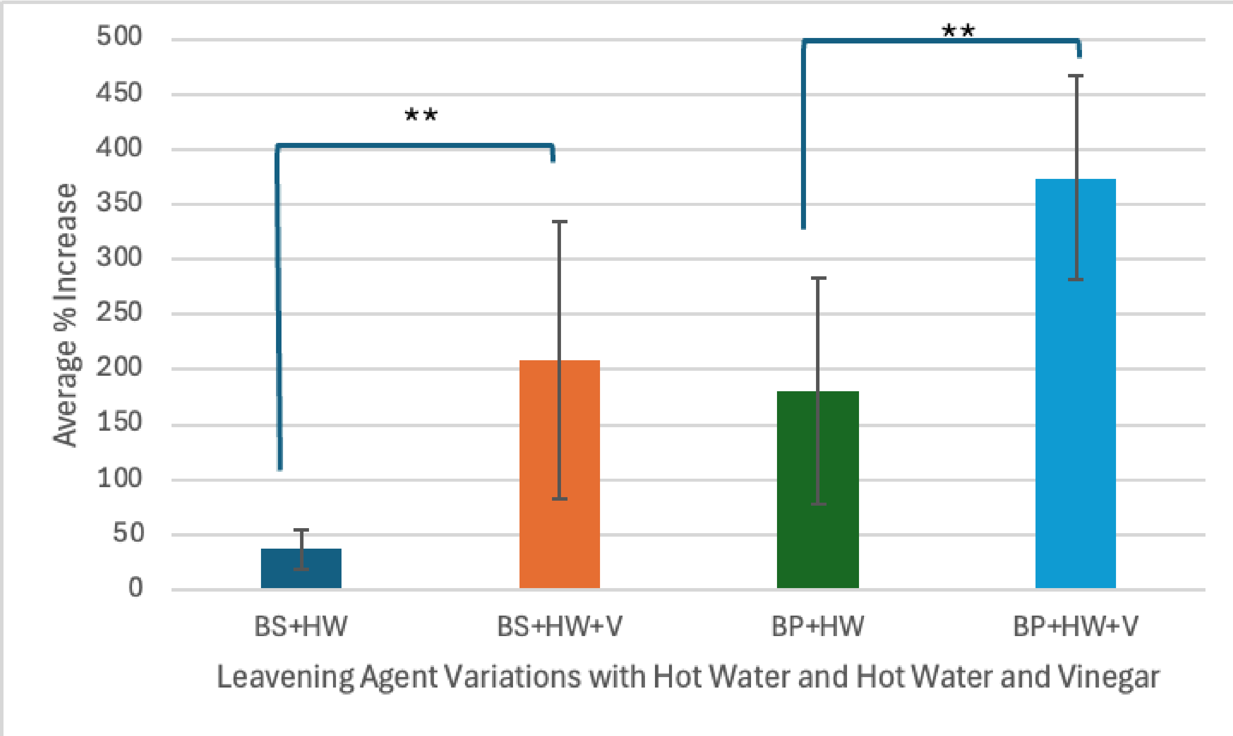

Figure 1C

The percent increase in volume of water in a mixture with baking soda and only hot water (dark blue), and baking soda with hot water and vinegar (orange) is shown in Figure 1C. The p value between the two variations is 0.00787. The percent increase in volume of water with baking powder and only hot water (green), and baking powder with hot water and vinegar (light blue) is also shown. The p value between the two variations is 0.00642. Error bars from standard deviation are also shown for each variation. $p<0.05$=*, $p<0.01$=**, $p<0.001$=***

In Figure 1C, baking soda with hot water and vinegar had a significantly different reaction than just baking soda with hot water, with a p value less than 0.01. The two variations also had no overlapping of error bars, indicating they are significantly different. The baking powder with hot water and vinegar was also significantly different from baking powder and just hot water, with a p value less than 0.01. The two variations also do not have any overlap of error bars, indicating they are significantly different.

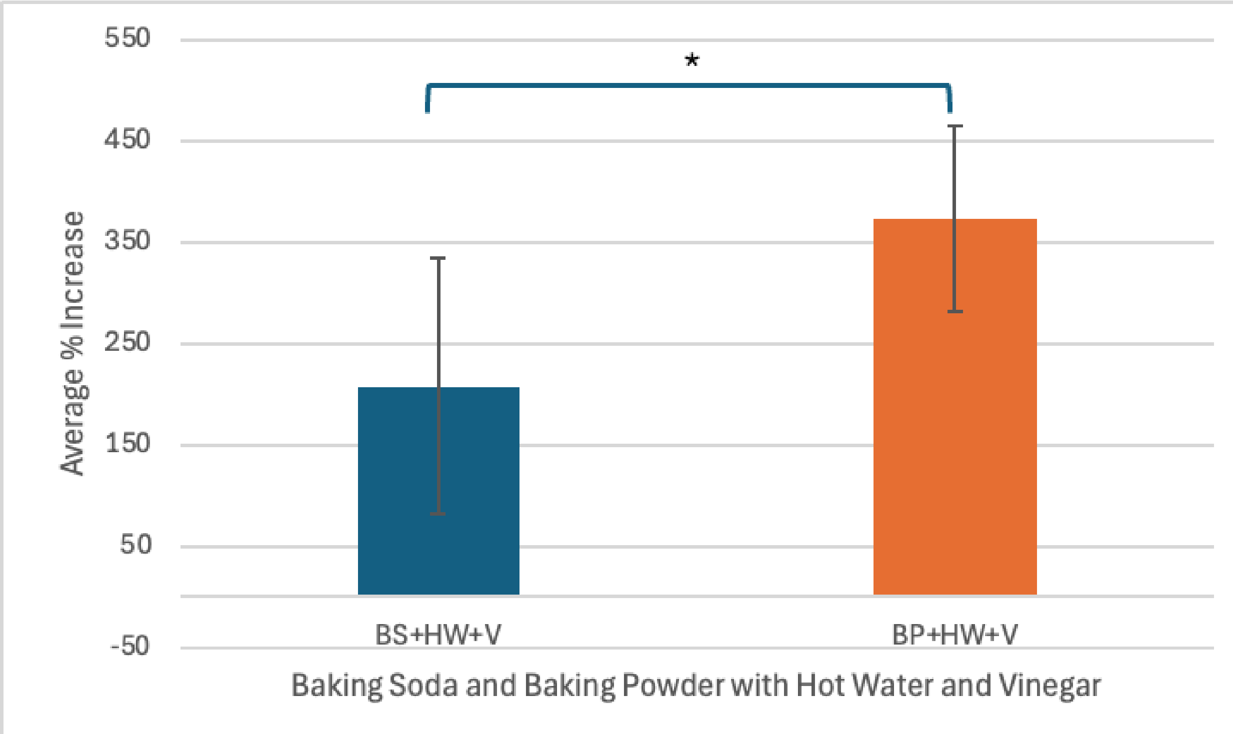

Figure 1D

The percent increase in volume of water between baking soda (dark blue) and baking powder (orange) with hot water and vinegar added is shown. The p value between the two groups is 0.0262. Error bars of standard deviation are also shown for each variation. $p<0.05$=*, $p<0.01$=**, $p<0.001$=***

In Figure 1D, there was a significant difference in the reaction between baking soda and baking powder with hot water and vinegar, with a p value less than 0.05. There is some overlapping of error bars in the graphs.

The reactions with baking powder overall had stronger appearing fizzing and larger bubbles formed. Reactions with hot water added were also observed to be faster than cold water reactions, and reactions with vinegar had the strongest and fastest appearing reactions.

Cakes

The cake made with 4g of baking powder had a bland, chalky flavor. It did not have a strong sweet or chocolatey flavor. It had a dense, slightly sticky texture, similar to a brownie. It also had a short brownie like appearance with lots of pockets of air on the surface, and a medium brown color.

The cake made with 16g of baking powder had a stronger chocolatey flavor, with a spongey, moist texture. It also had a slight crunch to it. It was thick, airy, and had cracks on the surface, with a medium brown color.

The cake made with 6g of baking soda and all-purpose flour had an off tasting, almost smokey flavor. It was fluffy with granules of sugar dispersed throughout it. It was thick, glossy, and had a very dark brown color.

The cake made with 24g of baking soda was very salty and bitter tasting. It was moist and spongy, with a porous surface and a very dark color.

The cake made with 2.5g of cornstarch, 6g of baking soda, and 6.8g of cream of tartar had a faint chocolate flavor and was very salty. It had a soft, airy, moist texture, with some crunch. It had a smooth surface and a dark brown color.

The cake made with 6g of baking soda and gluten free flour had a hot chocolate flavor, with a gummy, chewy texture. It was dense and heavy, with lots of moisture. It had a dark, lumpy appearance.

Scones

The scones with no leavening agent had a nutty, hardy full mouthed flavor. They were moderately moist and slightly crunchy. They had a flat, light brown appearance with a cracked surface and an opaque inside.

The scones with baking powder and all purpose flour had a salty flavor with a sight buttery taste. They were fluffy, but had some density to them. They had a white inside and a brown outside with a cakey appearance.

The scones with baking soda had a neutral, muffin-like flavor, with a crumbly, soft, dry texture. They also had a brown outside with a yellow interior, and many air pockets.

The scones with cream of tartar had a sour flavor. They were gummy and slightly tough. They also had a gel-like inside and a white surface.

The scones with baking soda and cream of tartar had a buttery, savory favor, with a fluffy moderately moist texture. They also had a brown surface and a fluffy, clumpy appearance.

The scones made with baking powder and gluten free flour had a slightly salty flavor, with a dry, crumbly, and crunchy texture. They had a cakey appearance, with a light brown outside. They were taller than other scones.

Discussion:

When comparing the baking powder and baking soda in cold water, hot water, and the addition of vinegar, the effects of heat and acid on a chemical leavening agent are evaluated. With the addition of cold water, a small reaction occurs in both baking powder and baking soda, releasing some CO2, increasing the volume, observed in Figure 1A. With hot water, the reaction is catalyzed, and a significantly stronger reaction occurs in both leavenings. Figure 1A shows no overlapping of error bars in either of the two variations, and the p values calculated from the t test were both less than 0.05, showing the significant impact increasing moisture temperature has on leavening agents. The addition of moisture to a chemical leavening agent like baking soda makes sodium bicarbonate react with water, producing carbonic acid, which then breaks down to release CO_2 and water. Baking powder already contains sodium bicarbonate and an acid, and when it gets moisture, the acid and bicarbonate react to produce a sodium salt, water and CO_2. When water is heated, the molecules move faster. When added to the leavening agents, the faster movement increases collisions of molecules, leading to a faster reaction, and more CO_2 released.

When acid is added to cold water, the reaction is significantly stronger than just with cold water for both leavenings in Figure 1B. Figure 1B shows there is a greater significance on the effect of acid in baking soda than in baking powder, with p values less than 0.05 and 0.01 respectively, and neither have error bar overlap. Adding an acid to baking soda forms an acid-base reaction where a sodium salt, water, and CO_2 is produced. Adding acid to baking powder results in the same products, however it is not as vigorous because it contains additional compounds that require heat to release the rest of the CO_2. Baking powder is considered double acting because it contains multiple acids that react at different times, such as monocalcium phosphate and sodium acid pyrophosphate. One acid reacts with initial moisture to release CO_2, while the other is activated at higher temperatures, usually above 140 degrees fahrenheit.

Hot water with vinegar, in Figure 1C, had the strongest reaction of all variations for both leavenings. Adding hot water and acid increased the movement of molecules when mixed with both leavenings, increasing collisions, and creating a stronger reaction, as well as adding the heat component needed in order to activate the second acid in baking powder.

Baking soda is a base, and when mixed with an acid, creates carbonic acid, which produces water and CO_2. Baking soda reacts best under acidic conditions and heat, as observed in Figure 1C, but can also react with just hot water, as seen in Figure 1A.

When hot water and vinegar is added to baking soda and baking powder, there was a significant difference according to the t test, with p less than 0.05 in Figure 1A. Because the double acting properties of baking powder allows it to release more CO_2 under heat than baking soda can, it has a higher percent increase of water volume. In Figure 1D, there is overlapping of the error bars, indicating there isn't any significant difference between baking soda and powder under these conditions. The contradiction in data may be due to the high variance in data collected among different groups, leading to large standard deviations, and larger error bars for both.

In addition to large variance in data collected, another limitation of this experiment is the activation of the chemical leavening agents with hot water. The dispenser used to collect hot water needs to be run for a few seconds in order to get the hottest water. Some groups may have gotten different results because the temperature of the hot water was inconsistent, and the data skewed due to this.

The cakes with 6g of baking soda and 24g of baking soda have very different sensory qualities. The 6g baking soda cake tastes almost smokey, and has a slightly off aftertaste. It is thick and glossy, and has a dark brown color. The 24g baking soda cake is very bitter and salty. It has many more air pockets and a very dark, almost black color. Because baking soda is a salt, made up of a sodium cation and a bicarbonate anion— sodium bicarbonate—it has a very salty flavor. Adding 4 times the amount in the ladder cake made it substantially saltier tasting. Baking soda is also a base, and creates alkaline conditions when baked, something favored by maillard browning. When the cake is being baked, the alkaline conditions and heat help promote maillard browning, forming more melanoidins and a darker brown color. Adding even more baking soda leads to more browning, and is why the 24g cake is almost black looking. Adding 4 times the baking soda amount to the cake did not produce an acceptable cake. The texture is more porous, possibly due to gluten being stretched too far from excessive CO_2 release, and not as visually appealing as the 6g cake, the color is almost black, as opposed to a dark brown chocolate color, and the cake is extremely salty and bitter. Adding more baking soda did not improve any qualities of the cake, and created an inedible product.

The 6g baking soda cake made with gluten free flour, compared to the all purpose flour, has a stronger chocolaty flavor, and a chewier, denser texture. The gluten free flour lacks gluten, and therefore is unable to create the air pockets within the batter when being baked that normally form, allowing the steam and CO_2 produced from the baking soda to collect and raise the cake. This results in the observed denser, chewy cake. Without being as aerated, the gluten free cake may be more concentrated in flavor as well.

The 4g baking powder cake has minimal chocolate flavor or sweetness. It also has a dense, slightly sticky texture, and a short brownie like appearance. Conversely, the 16g baking powder cake has a strong chocolate flavor and a thick, spongey, moist texture. Adding 4 times the amount of baking powder produced an acceptable cake that is taller, fluffier, and has a richer flavor. More baking powder allowed the cake to produce more CO_2, raising the cake more, and allowing more air pockets to capture gas and trap moisture throughout the batter. In this case, there may not have been enough leavening to produce CO_2 in the 4g variation to stretch the gluten enough to create rise, contributing to a brownie appearance. Baking powder can not be used in replacement of baking soda. Baking powder has different components that can make it initially not as strong as baking soda, and will need to be used in higher amounts to achieve a similar effect in baked goods. Baking powder also already has sodium bicarbonate and an acid as part of its composition, meaning slight adjustments need to be made depending on any acids in a recipe. Baking soda would need an acid added additionally in order to release more CO_2. The color of each product would also be different. Baking soda undergoes maillard browning more readily, and thus would create a darker product than baking powder. Baking soda also has a saltier flavor which would affect the taste of any substituted product.

The cornstarch, baking soda, and cream of tartar cake most closely resembled the 16g baking powder cake. They both had a soft, airy, and moist texture, with notable chocolate flavor, differing slightly in intensity. The cornstarch, baking soda, and cream of tartar cake did have a much saltier flavor however. The mixture created for this cake is essentially the mixture found in baking powder, and is why the two cake variations have such similar sensory properties. Baking powder is made from sodium bicarbonate, some sort of starch-usually cornstarch, and an acid, which is cream of tartar in this case. Because baking soda is so salty, adding 6 grams of it in the mixture was still enough to create a salty tasting cake, and overpower the chocolate flavor.

The scones made with baking powder and all purpose flour had a savory, buttery flavor with a fluffy texture, and browned outside, with a white inside. The scones made without any leavening had a nutty flavor with a moist, dense inside, with a flat and opaque appearance. Without any leavening agent, the scones were not able to rise, and thus retained a flat, opaque appearance due to lack of air pockets throughout the batter, and gelatinization as the moisture moves from the gluten to the starch after reaching 140 degrees fahrenheit. The gluten in the batter also doesn’t have anything inhibiting it from developing, creating a denser product. The scones made with baking soda had a muffin-like flavor, with a crumbly, soft, and dry texture, and a brown outside with a yellow interior. The dry texture may be due to baking soda not being double acting, meaning it reacts faster and doesn’t retain moisture as well as a double acting baking powder which releases more CO_2 when heated, drying out the batter under heat. The yellow interior of the baking soda scone, as opposed to the white interior of the control scone is due to the alkaline conditions of the baking soda promoting maillard browning of the interior.

The scones made with cream of tartar have a very sour flavor, with a gummy texture and a gel-like inside, with no browning on the outside. The cream of tartar scone variation tastes sour because it is adding an acid to a recipe that already has an acid; sour cream. The gel-like inside is due to no leavening agent producing CO2 to aerate the inside to create a fluffy texture, in combination with gelatinization of the starch molecules in the batter. Additionally, gluten is able to bind and coagulate without any leavening inhibiting it, contributing to its tough texture. They have a white surface because maillard browning doesn't favor acidic conditions.

The scones made with baking soda and cream of tartar had a buttery, savory flavor and a fluffy texture, similar to the control scone. They also had similar browning on the outside, and a white interior. The baking soda in the recipe allows for maillard browning to occur on the outside of the scone, but not enough to change the interior color. This variation, being activated with the acidity of the cream of tartar, created the same qualities of baking powder, reacting when initially moistened, and slowly and releasing more CO2 when heated, allowing for more rise and retaining of moisture.

The scones made with baking powder and gluten free flour had a salty flavor, and a dry, crunchy texture. They also had a tall, cakey appearance with a light brown outside. Because this variation lacked gluten, and the baking powder is double-acting, releasing CO2 when initially mixed, and again when baked, the scones likely rose a lot more than the other variations. There is no gluten developed to toughen the scones or inhibit the rising ability after a certain point. Without gluten, there is also less stability on the scones due to lack of any proteins coagulating under heat and forming any sort of viscoelastic network, making the scones crumbly. Additionally, without gluten, there is little way to trap any moisture in the scones from evaporating, leading to the crunchy, dry texture.

Some limitations of the experiment include the mixing time and technique of the scones. Some scone variations may have been over kneaded, which would have led to more development of gluten than desirable, and made the scones tough.

The scones made with baking soda and cream of tartar have similar qualities to the baking powder scone. Adding cream of tartar to the baking soda creates a baking powder like mixture, which is likely why the two scone variations are similar. The baking soda base reacts when moist and the acid from the cream of tartar reacts under heat, creating a slower CO2 release, and thus a softer, fluffy, moist scone.

The mixing method to make the scones is called the biscuit method. The biscuit method involves solid fat being cut into the flour of the mixture. The dry ingredients for the scones were mixed together, then solid fat, butter, was cut into the flour until there were pea sized fat chunks throughout the flour. Then, all the liquid for the recipe was added and stirred until just moistened. The dough is gently kneaded a few times, then shaped and baked. Cutting the fat into the flour helps create pockets of meted fat throughout the biscuit leaving a space for steam and CO2 to accumulate, and make a flakey product. If the dough is overmixed, the gluten in the flour will start to develop too much, and a tough scone will result. If too much liquid is added, the ratio of flour to liquid will be off, and the added moisture will start to overdevelop the gluten, also leading to a tougher scone.

The gluten free flour scone has a saltier flavor, and a dry, crumbly texture, and rose more. It has the same browning on the outside and white on the inside as the all purpose flour. The gluten free flour is not able to form the same viscoelastic network as the normal flour, and thus has less stability, making it more crumbly. It also isn’t able to trap moisture as readily without the air pockets formed by gluten formation, and thus has a dry texture. The gluten free scones may have been taller than the others because they didn't have any gluten coagulation under higher temperatures, so the CO2 released from the baking powder the second time, under heat, created more height in the scones. Because there is still some amount of starch and protein in the gluten free flour mixture, maillard browning is still possible if baked long enough.

Using a biological leavening like yeast produces very different results compared to a chemical evening such as baking soda and baking powder. Yeast usually needs to be activated by being added to warm water with sugars to stimulate fermentation, where a chemical leavening is activated by moisture and acid, and influenced by how hot the environment is. Hot water can invoke a stronger reaction from a chemical leavening, however it can kill a biological leavening like yeast. The addition of salt, and influence of pH on the environment the yeast is in can also change how effectively it produces CO2. Adding a little salt helps the yeast to break down starches for food, but too little salt can allow protease activity to weaken gluten, and result in a porous, weak bread. Yeast is able to produce a more moist, spongey, and hearty baked good, and compliments the savory flavor in those types of products. A chemical leavening agent creates more of an airy, soft, cakey texture, with little influence other than saltiness on the product flavor. When baking with gluten free flour, using a chemical leavening agent tends to create more rise than using a biological one. Yeast interacts with the gluten in gluten containing flour, breaking down the starch in the gluten granules for food, releasing more CO2 as it goes. In a gluten free product, there is little protein to coagulate as the product bakes, and as the yeast breaks down the starches in the flour, a lot of the stability of the bread is lost, and there is no network formed to catch the CO2 from the yeast. Because yeast takes longer to release gas than a quick acting chemical leavening, a lot of the CO2 is also able to escape before the product is cooked, reducing rise. In a chemical leavening reaction, no starch is broken down, and the CO2 released is able to add some volume to the dough/batter without total loss of stability or volume.

<u>Conclusion</u>:

Leavening agents are extremely valuable in the culinary world, and have drastically different effects on texture, flavor, appearance of baked goods. Chemical leavening agents like baking powder and baking soda have different properties that make them better suited for different recipes; such as using baking soda in cakes or baking powder in scones to achieve the best sensory qualities. Testing the effects of these two leavening agents on various recipes not only highlights how important the chemistry behind how they interact with other ingredients under different conditions, but also helps outline the function of biological and physical leavenings in baked goods. Leavening is a huge component of baking, and understanding the different effects it can have on a good helps artisan bakers, manufacturers, and other culinary entrepreneurs create better products.