The Effect of Calcium Supplementation on Banana Muffins

ABSTRACT
Calcium is a very important mineral needed in our bodies. Functions of calcium include bone health and osteoporosis prevention, maintenance of healthy teeth, and muscle contractions. Foods are being supplemented with calcium due to decreased intakes, leading to many health consequences. This experiment tested two different calcium supplements (citrate and carbonate) added to banana muffins to determine its effects on certain food qualities. These two variations, plus a control, were tested objectively by a texture analyzer and water activity machine, and subjectively according to taste, moisture, and color. The study found that overall, the addition of calcium to this product does not greatly affect these qualities, although the calcium citrate was said be salty.

KEY WORDS: calcium, bone, osteoporosis, supplementation, muffins

INTRODUCTION
Vitamin and mineral supplementation in foods and pill form have been very common in recent years. People are realizing the many benefits of each vitamin and mineral, and making it a point to incorporate them into their diets. Calcium is a very important mineral needed in our bodies. Calcium has proposed and some proven benefits in bone health, including the prevention of osteoporosis, healthy teeth, muscle contraction, and to a lesser extent, weight loss, and decreased ischemic heart disease and stroke (Larsen and others 2004; Karanja and others 1994). In regards to bone health, studies have been performed on everyone from young children to adolescents to the
elderly. A study completed on children ages three to five proved that the difference in leg bone mineral content gain between gross motor and fine motor was more pronounced in children receiving a calcium supplement than the placebo (Specker and Brinkley 2003). A study in Nutrition and Food Science performed studies on 11- and 12-year old girls and calcium, because the bone mass obtained in the first three decades of life is a major factor of bone mass later (Jenkins and other 1996). On the other side of the spectrum, a study which gave calcium and Vitamin D supplementation in the elderly demonstrated improvement for those at risk for osteoporosis and Vitamin D deficiency (Larsen and others 2004). Teeth can also be helped by calcium, especially in kids. In the UK, 43% of five-year-olds have a dental problem (Wells 2000). A study revealed that children who have a very high intake of soft drinks experience many more dental problems than children with a high milk intake. High amounts of calcium and phosphorus in milk help prevent damage to tooth enamel (Wells 2000). Many studies in the past have indicated that a diet sufficient in calcium may help prevent against heart disease and stroke (Karanja and others 1994). It does this by reducing the risk factors associated with them, such as making positive changes in plasma lipid and lipoprotein amounts in the body. Weight loss and calcium has been a hotly debated topic recently. However, there is not a significant amount of evidence to back this claim up yet. One study tested this hypothesis in pre- and post-menopausal women, yet there was no significant different in this particular study between the placebo group and the calcium supplemented group (Shapeses and others 2004). Calcium has also demonstrated positive effects on epithelial cell proliferation and differentiation (Holt and others 2001). This study administered 900 mg/day of calcium in the form of calcium carbonate and compared it to a low-fat dairy
food providing the same amount of calcium. Both forms of calcium showed reductions in epithelial cell proliferation (Holt and others 2001). It is obvious that calcium is very important in our diets. However, many people do not get the required calcium (RDA=1000 mg/day) that they need. Some reasons for not acquiring this may include: being lactose intolerant, not liking or eating dairy, or simply just not able to get enough in the diet. Ninety African-American women were interviewed at the grocery store, and based on a 24-hour dietary recall, it was determined that 80% of the subjects demonstrated intakes below 75% of the RDA (Zablah and others 1999). Barriers for not meeting these needs included perceived negative taste, perceived association with digestive problems and the perception that they were already getting enough in their diet. This is not just happening in this population; it is a very widespread problem. Whatever the reason, calcium consumption must be addressed because not meeting the requirements can have serious health implications and lead to increasing health care costs. By supplementing calcium to more foods, even if just by a small amount, people might be able to increase their calcium intakes to better meet the recommendations. The purpose of this experiment was to add different forms of calcium to banana muffins in hopes that it would not change essential qualities of the product, so that people can obtain calcium from this source. The independent variable was the type of calcium added. The dependent variables were texture, water activity, and taste.

**METHODS**

This experiment was performed three times. The overall design involved using the same recipe, ingredient weight, and procedures each time. After the muffins baked, they were measured for moistness, using the water activity machine, and texture, using the texture analyzer. The recipe for banana muffins comes from online from a site called
Southern U.S. Cuisine. The recipe includes:

110 g butter, room temperature
200 g granulated sugar
2 large eggs
2 large bananas, ripe, mashed
5 mL vanilla extract
259 g all-purpose flour
7.5 g salt
4.4 g baking powder
2.5 g baking soda
237 mL buttermilk

The preparation used in this experiment was as follows:

Line muffin tins with paper muffin liners. Cream butter and sugar with an electric hand-held mixer until light and fluffy (one minute). Beat in eggs, one at a time, beating after each addition (25 seconds after each egg). Add bananas and vanilla and beat until smooth (one minute). Mix together the flour, salt, baking powder, and baking soda. For the two variations where the calcium citrate and calcium carbonate will be added, they were added and mixed at this stage with the dry ingredients. Both supplements had protective coatings, so they were crushed then sifted to only get the powder. 400 mg of each supplement was added. GNC Calcium Complete contained 400 mg of calcium carbonate in one tablet. GNC Calcium Citrate used 1.5 supplements to obtain the 400 mg of calcium citrate. In order to get 1.5 tablets, the weight of one tablet was measured out, divided in half, then a second tablet was measured and half of that was obtained. The 1.5
supplements were crushed and added, the same as the calcium carbonate. Finally, the flour mixture was stirred into the butter mixture, alternating with the buttermilk. Stir just until the dry ingredients are moistened (stirred 30 seconds after dry ingredients and 20 seconds after the buttermilk). Spoon 53.5 g of the banana muffin batter into prepared muffin cups or liners, filling about 2/3 full. Bake at 204 degrees Celsius for 17 minutes. Cool muffins in pan on rack for a few minutes then turn muffins out into rack to cool longer. Once the muffins were cooked, they were objectively measured using the texture analyzer and water activity machine. The texture analyzer was adjusted to a muffin setting and the puncture probe was used. The parameter settings for the texture analyzer were as follows: Pre-test speed= 2.0 mm/s; Test speed=3.0 mm/s; Post-test speed= 5.0 mm/s; Distance=5.0 mm and Trigger force= 4 g. The muffin was placed under the probe and tested twice, once in the center of the muffin, once off to the side. Both measurements were recorded and averaged. Next, water activity was tested. This machine needed to warm up for 15-60 minutes and required the samples to be in plastic dishes. A small portion was taken from the top of each muffin tested. The sample was in the machine until it beeped, signaling that the test was completed. The last tests were necessary to determine subjective data. Eight people tasted each trial performed. They were instructed to put a check on the line that best described the taste of each muffin. When tallying the results, each line was given a number (1-9), and the average of these numbers was taken to obtain a taste score. A structured ranking scale was used to test moistness and color. The ranges went from very moist to very dry and dark brown for light gold, respectively. Each point on the scale will have a word anchor and the tester will be instructed to circle one of the word anchors. Again, when tallying the results, each
description was given a number and these were averaged based on how the testers answered. Each sample will be given a three-digit random number to help decrease bias. The panel included fellow classmates, all of whom are either food science or dietetics majors. A sample of the scorecard used for the sensory evaluation is included below.

_Sensory Evaluation_

Please put an X on the line next to the statement that best describes the taste of this muffin and write the sample number of the muffin you are tasting:

Sample #: _______________________

_____ Like extremely

_____ Like very much

_____ Like moderately

_____ Like slightly

_____ Neither like nor dislike

_____ Dislike slightly

_____ Dislike moderately

_____ Dislike very much

_____ Dislike extremely

For the same sample you just tried, please circle one of the words regarding moistness and one of the words regarding color.

Moistness:

Very moist  Moist  Slightly moist  Slightly dry  Dry  Very dry

Color:

DISCUSSION

This experiment demonstrated some interesting results. In trial one, the control and calcium carbonate showed the highest values on the texture analyzer (55.0 and 53.0, respectively). Refer to Table 1 to see all texture analyzer results for each trial. The control received the highest water activity score (.859), implying that is the most moist. Refer to Table 2 to see the water activity results for each trial. The calcium carbonate received the best score (7.6) for taste and the best score (2) for moistness. Calcium citrate was rated the lowest in taste for trial 1 with a score of 5.9, and many people reported a salty taste in this variation. Refer to Table 3 to see these scores for each trial. The control received a 5 for color, meaning it was more golden, while the variations both received 3.5, meaning they were light brown-deep golden. Refer to Table 4 to see the color scores from each trial. The calcium carbonate had the best moistness rating here with a score of 2 meaning moist; calcium citrate received the lowest moistness score of 3.5, meaning it was between slightly moist and slightly dry. Table 5 shows the results for each moisture sensory evaluation. Refer to Figures 1-5 for a visual comparison of all of the variations in each trial. In trial 2, the control had the highest texture analyzer value (53.8), indicating that it is the toughest. The calcium carbonate demonstrated the lowest texture analyzer results (32.1). Again, refer to Table 1 to visualize these results. In measuring the water activity, the control had the highest value at .923, while the calcium carbonate demonstrated the lowest values at .885. This indicates that the control is more moist than the other variables. The sensory scores reflected these values. The control was ranked the highest in taste, with a score of 7.4, compared to a 7.1 for calcium carbonate and 6.9 for the calcium citrate. Again, a salty taste was reported for the calcium citrate. This trend
may have stemmed from the fact that to get equal amounts of both variations, more calcium citrate needed to be added to the batch. This could have caused a salty taste. In regards to color for trial 2, the control and calcium citrate were both ranked a 5.5, indicating that they were golden-light golden. Calcium carbonate received a score of 3.5, meaning it was more brown than the other two. For moistness, in conjunction with the water activity machine, the taste panel rated the control the best moisture, with a score of 1.5, meaning between moist and very moist. Calcium citrate received the next highest score, also following the water activity results for moistness, with a score of 2. Calcium carbonate was ranked the lowest score in moistness, receiving a score of 2.5. Trial 3 showed some very different results. Calcium citrate was ranked the highest for taste (8.2) and moistness(2). This reflects the readings of each variation on the texture analyzer and water activity machine. The control and calcium carbonate demonstrated considerably higher readings on the texture analyzer, as seen in Table 1 and Figure 1. Calcium citrate had the highest water activity value (.840) meaning it was the most moist. Each variation was ranked about a 3.5 for color, meaning it was between a light brown and deep golden color. Tables 2 and 4 show these results.

It is becoming more common to supplement calcium to foods, especially to help people who are lactose intolerant, those who do not like dairy, or those who simply do not receive a lot of calcium in their diet. The closest product found to add calcium to this experiment was a company called Glutano, which supplements baguettes, rolls, and white sliced breads, with calcium. A baguette contains 964 mg per serving, a roll has 482 mg, and 2 slices of bread contain 362 mg of calcium (Nutrition and food Science 2004). These products have a considerably higher amount of calcium than the banana muffins in
this experiment. A concern of this high supplementation is that a person who consumes almost all of the RDA for calcium in one baguette plus getting more calcium from others sources, may experience kidney problems. This will be discussed later. An article in Food Marketing and Technology discussed possible implications of fortifying dairy and soy drinks with calcium (Gerstner 2004). Some qualities considered include: sources of calcium, such as inorganic salts, milk minerals and organic salts; problems with fortification, including solubility vs. calcium content; and taste and mouthfeel. The last one was interesting because the article mentioned that sometimes, calcium carbonate may have soapy or lemony flavors (Gerstner 2004). Although this study was testing supplementation in a different product than this experiment, it still maybe have implications for how calcium supplementation would affect the quality in muffins. However, in this experiment, calcium carbonate was ranked the highest taste score for the first trial and the second highest for the other two trials, so it did not seem to have a big impact on taste. The article also discussed adverse effects during processing of high levels of calcium supplementation; bioavailability of calcium sources; and economic considerations (inorganic salts are lower in price than organic ones). In regards to bioavailability, there was another article which discussed health benefits and some risks of calcium citrate supplementation (Levine and others 1994). Calcium citrate was chosen because it is the best absorbed of the calcium supplements. The absorption of calcium is something that needs to be taken into consideration when deciding what to supplement foods with in future studies. Different forms of calcium are absorbed better than others. The study performed by Levine and others performed experiments to see the effect of calcium citrate supplementation on the development of calcium-containing kidney stones
(Levine and others 2004). Sometimes, the extra calcium supplemented can be too much for the body and can lead to the formation of kidney stones, therefore outweighing the benefits of prevention of osteoporosis calcium has. However, this article does not discuss calcium fortified in food, only the oral supplementation. The oral supplementation gave the subjects 1000 mg of calcium, which is considerably more calcium than anyone eating a banana muffin (the whole batch had 400 mg added to it) would obtain. Therefore, the details of this are unimportant in relation to this experiment, but to realize that calcium citrate is more readily absorbed in the body and that too much supplementation can have health implications is important. Another study discusses the bioavailability of calcium between supplements in the form of calcium carbonate, increasing milk consumption (which is normally considered the gold standard of calcium intake), and calcium carbonate plus Vitamin D, which helps calcium absorption (Mortensen and other 1996). To measure absorption, a calcium and energy-fixed diet was produced by a dietician to keep these factors fixed, and urinary mineral excretion was measured. The study concluded that the bioavailability of calcium carbonate was comparable to that of milk and this supplementation greatly increased the intestinal calcium uptake. Further supplementation of vitamin D increased the short-term bioavailability of calcium (Mortensen and other 1996). There is some variability in micronutrient content in enriched dairy and fruit products, as demonstrated by the following study. This experiment tested for several vitamins and minerals (including calcium) within novel enriched foods (de Jong and others 2000). Four main factors, which could have contributed to any variability, were measured. These included: type of product, type of laboratory (between laboratory reproducibility), time of the year, and freshness of
product. Overall, the type of product and laboratory contributed the most variability. In regards to calcium, all products met the target levels (de Jong and others 2000). Another factor which this study did not include which maybe contributes to variability in foods is the effects of other food components on calcium. A study in the International Journal of Food Sciences and Nutrition discussed the availability of calcium from semi-synthetic meals and food model systems by an in vitro method (Kennefick and other 2000). Twelve food components were added and studied. These included: phytate, oxalate, wheat fibre- and barley fibre-extract, D-sorbitol, xylitol, galactitol, casein, three different casein phosphopeptide preparations, and lactose (Kennefick and other 2000). Phytate was the only food component which demonstrated a negative effect on calcium absorption. The others showed no effect (Kennefick and others 2000).

There have been many studies on calcium supplementation in many varieties of foods, which types of calcium to use, how it affects the quality of the product, and the absorption of calcium in the body. Future studies might look at adding more calcium to baked goods, such as this experiment, but trying to add more calcium, without altering the product, to obtain more calcium per muffin. Also, if the resources were available, it would be interesting to see how much calcium the body actually absorbs from these muffins by having subjects perform urinary excretions. Also, adding Vitamin D to such a product would help to enhance absorption in the body. Yet, the addition of both the vitamin and mineral to a product would have to be studied to ensure that the quality of the product is unchanged.
RESULTS

Table 1. Texture Analyzer results (g) for 3 trials

<table>
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<tr>
<th>Test</th>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
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<tbody>
<tr>
<td>Control</td>
<td>55</td>
<td>53.8</td>
<td>74.9</td>
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<tr>
<td>Ca Carbonate</td>
<td>53</td>
<td>32.1</td>
<td>87.6</td>
</tr>
<tr>
<td>Ca Citrate</td>
<td>32.1</td>
<td>39.5</td>
<td>45</td>
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Figure 1. Texture analyzer results (in grams) for 3 trials

Table 2. Water activity results for 3 trials

<table>
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<th>Test</th>
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<th>Trial 3</th>
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<tr>
<td>Control</td>
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<td>0.788</td>
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<td>0.816</td>
<td>0.885</td>
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<td>Ca Citrate</td>
<td>0.822</td>
<td>0.905</td>
<td>0.84</td>
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Figure 2. Water Activity results for 3 trials

Table 3. Sensory evaluations-Taste(1=worst, 9-best)

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<tr>
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</tr>
<tr>
<td>Ca Carbonate</td>
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<td>7.1</td>
<td>7.6</td>
</tr>
<tr>
<td>Ca Citrate</td>
<td>5.9</td>
<td>6.9</td>
<td>8.2</td>
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Figure 3. Taste sensory evaluations

Table 4. Sensory evaluations-Color(1=deep brown, 6-Light Gold)

<table>
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<th>Trial 3</th>
</tr>
</thead>
<tbody>
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<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Ca Carbonate</td>
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<td>3.5</td>
<td>4</td>
</tr>
<tr>
<td>Ca Citrate</td>
<td>3.5</td>
<td>6</td>
<td>3</td>
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Table 5. Sensory evaluations-Moistness(1=Very moist, 6=Very dry)

<table>
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<tr>
<td>Ca Carbonate</td>
<td>2</td>
<td>2.5</td>
<td>3.5</td>
</tr>
<tr>
<td>Ca Citrate</td>
<td>3.5</td>
<td>2</td>
<td>2</td>
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Figure 4. Color Sensory Evaluations

Figure 5. Moistness Sensory Evaluations
REFERENCES


