Effect of Almond Flour Substituted for All-Purpose Flour on Chocolate Chip Cookies

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FN 453

November 22, 2010
Title:

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Abstract:

People battling celiac disease are at a disadvantage because of their inability to consume gluten-containing products (Mezaize, 2009). Also, one of the 2010 Dietary Guidelines is to consume adequate protein (United States Department of Agriculture, 2010). Almond flour is high in protein, which is the structural part of all cells in the body and aids in the functioning of enzymes and hormones. The overall purpose of this experiment is to test the success of substituting almond flour for all-purpose flour in chocolate chip cookies. If successful, it could lead to further research in substituting almond flour in other foods. The experiment analyzed the affect on overall likability (mainly taste) and appearance on chocolate chip cookies when almond flour is substituted for all-purpose flour. Objective tests were done to measure texture, color, and water activity. The experiment was utilized by baking in a conventional oven using the same equipment for all variables. The results did not produce a desirable product. The almond flour cookie was much less visually appealing and did not taste as good. The texture analyzer results showed a much lower value for the almond flour cookie. Overall, its texture was much less appealing than the other two variables. The water activity of the almond flour cookie was much higher than that of the other two variables. Future studies could try a half substitution for the almond flour instead of a complete substitution. The product would no longer be suitable for a person with celiac disease, but it would still provide more fiber and protein.

Introduction:
Getting enough fiber has been a big concern with nutritionists in recent years and over half of Americans do not meet the ADA’s fiber intakes. Also increasing protein intake is a new 2010 dietary guideline, and it is the main structural component for cells, helps enzymes, and aids in the functioning of hormones (United States Department of Agriculture, 2010). Gluten free diets have shown beneficial results for patients with celiac disease, and almond flour is gluten free (Mezaize, 2009). Adding these important components into a commonly consumed dessert would be a good way for people to increase their intake without sacrificing anything. It would also be a great dessert for patients with celiac disease because celiac patients are not able to consume gluten.

Gluten is one of the main components in flour, so replacing all-purpose with almond led to some imperfections in the structure of the final product. Gluten is a combination of a prolamine called gliadin and glutenin. Gliadin provides extensibility and viscosity to dough and batter. Glutenin provides elasticity to the dough or batter. The combination of the two creates gluten, which traps the leavening gases and allows the baked products to rise. Almond flour does not contain gluten, and this caused the almond flour cookies to be completely flat. They could not rise without a structural component. The methods used for each variable were identical to avoid as much error as possible. All equipment was kept the same for all variables including which oven and type, cookie sheets, and scales. All dough was measured with a 1-tablespoon cookie scoop. The cookies were all baked for the same amount of time.

The overall purpose of this experiment is to test the success of substituting almond flour for all-purpose flour in chocolate chip cookies. The independent variable was the almond flour, and the dependent variables were the taste, texture, color, appearance, and water activity.
### Method:

The design of this experiment was to substitute almond flour into a standard, all-purpose flour chocolate chip cookie recipe. There were three variables. One variable was the original chocolate chip cookie recipe using all-purpose flour. Another variable was the almond flour substitution recipe cookie at a 1:1 ratio to all-purpose flour. The last variable was a pre-packaged break and bake cookie used to assess palatability difference. All three variables were baked three times to create repetition and obtain consistent results. The original recipe cookie was baked at 190.5 degrees C (375 degrees F) in a conventional oven. To account for the difference the almond flour poses it was baked at 179.4 degrees C (355 degrees F) in the same conventional oven. All cookies were baked for 9 minutes.

The recipe was obtained from the Nestle Toll House website.

- 365 grams Nestle Toll House Semi-Sweet Chocolate Morsels
- 150 grams granulated sugar
- 165 grams brown sugar
- 5 mL vanilla extract
- 4.2 grams baking soda
- 227 grams butter, softened
- 2 whole eggs
- 288 grams all-purpose flour
- 4.2 grams salt

The ingredients for both the original recipe cookie and the almond flour cookie were put together the exact same way in a large mixing bowl. First the flour (almond or all-purpose), baking soda, and salt were adding to the mixing bowl and stirred until uniform. The butter for both recipes
was heated in the microwave for 10 seconds each to soften and make it easier to mix. The softened butter, granulated sugar, brown sugar, and vanilla extract were mixed with a hand mixer in a separate bowl. The eggs were then added and mixed with the hand mixer until completely blended into the butter, sugar, and vanilla mixture. Then flour, baking soda, and salt mixture was added a small amount at a time to keep a uniform mixture. The flour mixture was added until completely mixed into the other mixture. Then the chocolate chips (chocolate morsels) were added and mixed thoroughly with the other ingredients.

Once the ovens were preheated to the correct temperatures the cookie dough was placed onto the cookie sheets. The cookie sheets were all lined with parchment paper to avoid burning the bottom of the cookies. Using a 1-tablespoon cookie scoop, the dough was placed on the cookie sheet. The same type of cookie sheet was used for the original recipe cookies, the almond flour cookies, and the Nestle Toll House break and bake cookies.

Scoop the dough using the 1- tablespoon cookie scoop onto a large, ungreased cookie sheet. Bake for 9-11 minutes and allow to cool for 2 minutes. This procedure will be done exactly the same for the almond flour substitute. The “break and bake” cookies were baked following the directions on the package. The purpose of using the break and bake cookies was to assess the difference of appearance between baked from scratch cookies using both types of flour to pre-packaged cookies. All ingredients were measured using the same scales and equipment to avoid error. Testing was then conducted the same day for all three trials to ensure freshness of the cookies.

**Subjective Results:**

Participants willingly participated in the subjective tests for this experiment. None of them knew the hypothesis or overall purpose to avoid bias. Subjects included Foods and Nutrition 453
students, staff members in the Foods and Nutrition department at Purdue University, and six random people not associated with the Foods and Nutrition department. Taste and appearance were both rated on a 1 to 3 scale, with 3 being the most liked or most visually appealing cookie. The subjective results were then averaged and then analyzed in Graphs 1 and 2.

Taste Test: Rank the three cookies from 1 to 3, with 3 being the most liked cookie.

Cookie 360 ____________
Cookie 112 ____________
Cookie 714 ____________

Appearance Test: Rank the three cookies from 1 to 3, with 3 being the cookie that is most visually appealing.

Cookie 360 ____________
Cookie 112 ____________
Cookie 714 ____________

Graph 1: Average of overall likeability of each cookie.
Graph 2: Total appearance ratings for which cookies was most visually appealing

Objective Tests:
Objective tests included a texture analyzer, Hunter colorimeter, and the water activity meter. Texture analyzer was measured in grams. The settings were at 1.0 mm for the probe. A small piece of cookie for each variable from each trial was placed under the probe and force in grams was measured. See Graph 3 for results. L, a, and b values were recorded with the Hunter colorimeter. This included the darkness, hue, and chroma of each variable from each trial. See Graphs 4, 5, and 6 for the results. The water activity was measured by placing a small amount of each variable from each trial in a sample container, and the container was then placed in the machine. The water activity was taken at 23 degrees C See Graph 7 for the results.

Graph 3: Average of Texture Analyzer for force in grams for trials one through three

![Graph 3](image)

Standard deviations: “Break and bake”-72.26 Almond Flour- 83.96 Original- 76.94

Graph 4: Average L values from Hunter colorimeter trials one through three

![Graph 4](image)
Standard Deviations: “break and bake”-2.12 Almond Flour- 2.85 Original- 3.65

Graph 5: Average a values from Hunter colorimeter trials one through three

Standard Deviations: “break and bake”- 0.93 Almond Flour- 0.32 Original- 5.63

Graph 6: Average b values from Hunter colorimeter trials one through three
Standard Deviations: “break and bake”- 1.13 Almond Flour- 1.26 Original- 1.97

Graph 7: Average water activity levels for all three trials

Standard Deviations: “break and bake”- 0.05 Almond Flour-0.06 Original-0.01

Discussion:
The null hypothesis posed was that by substituting almond flour into chocolate chip cookies there would be no difference in texture, appearance, and palatability. There were pre-made cookies, “break and bake”, tested using all of the same equipment as the almond flour and original recipe cookies to help remove any error in the baking process for the made-from-scratch cookies (original cookies). The almond flour was chosen as a substitute for its gluten-free nature and high fiber as well as being low carbohydrate. Diets today are lacking in fiber and digestive diseases such as celiac disease are becoming more common and a gluten-free cookie option would be an ideal snack, in relation the Journal of Food Science posted an article on the gluten-free nature of some French breads in which they substituted buckwheat flour, another gluten-free option.

The water activity test performed showed no significant difference between the original cookies and the “break and bake” cookies, no difference between the “break and bake” cookies and the almond flour cookies, however there was a significant difference between the original cookies and the almond flour substitutes the p-value was <0.05 in this instance the null hypothesis was rejected. The lack of gluten may have caused this difference.

The Texture Analyzer was used to determine the different textures between the three cookie variations. The null hypothesis would be no significant difference in texture between the original cookies and the almond flour cookies. The results show that there is no significant difference between the original cookies and the “break and bake” cookies. There was a significant difference between the almond flour cookies with the original and pre-made cookies at a p-value of <0.001. The null hypothesis is rejected based on these results. The difference in texture may be attributed to the lack of gluten and extra fiber and protein in the almond flour.
Hunter Colorimeter measurements were taken to determine the colors and darkness of the cookies. The l, a, and b values were recorded. The null hypothesis would be no difference in color values for all three of the cookies. The l values which relate to the darkness of the cookies showed no significant difference between the “break and bake” cookies and the original cookies as well as no significant difference between the almond flour cookies and the original or “break and bake” cookies all with p-values of >0.10. The null hypothesis was not rejected. The a values which show the hue of the cookies came up with a significant difference between the almond flour cookies and the original cookies with a p-value of <0.05, but no significant difference between the “break and bake” cookies and the original, as well as no difference between the “break and bake” cookies and the almond flour cookies. The b values which measure the saturation of color in the cookies showed a significant difference between the almond flour cookies with the original cookies, as well as a significant difference between the almond flour cookies and the “break and bake” cookies both with a p-value of <0.05. The null hypothesis was rejected for the b and a values. The almond flour cookies did not brown as the “break and bake” and original cookies did which attributes to the variation in color, as well as the fact that the almond flour cookies fell apart before measurements were taken causing inconsistencies in the side of the cookie that the measurement was taken from; i.e. the side of the cookie that was touching the pan while baking or the top side.

The subjective data gathered from participants reflects that the overall favored cookie by 63% of the participants being the original cookie recipe. 30% preferred the “break and bake” cookie, while only 7% preferred the almond flour cookie. The overall appearance was also tested subjectively and the most favored by a small percentage was the almond flour cookie by 38% of the participants. The appearance was a much closer test than the overall liking of the cookies
split between 27%, 38%, and 35%. This shows that appearance doesn’t have as much of an impact on the cookie varieties as texture and palatability did.

Overall the substitution of almond flour rejected the null hypothesis of there being no difference in texture, color, and palatability in replacing all-purpose flour. The healthy alternative could be partially substituted in future work to incorporate more fiber and less gluten and carbohydrates. Other possibilities for future work could be changing variables such as adding more leavening agents that may aid in gluten-free products texture since without the gluten the cookies didn’t rise. The overall composition of almond flour differs in the fact that it is as mentioned, gluten-free, low carbohydrate, it also has a low heat conductivity causing it to be baked at 20 degrees less than the other varieties. A variable should also be looked for to lessen the sticky texture of the almond flour cookies to make their texture more desirable such as in an article from the *Journal of Food Science* in which the researchers substituted gums into the recipe to make a more desirable texture in French breads. The substitution of almond flour in our cookies did not turn out as a perfect substitute for all-purpose flour, but more work can be done to get closer to the right results.

References:


