Coconut Flour in Lieu of All-purpose Flour for Gluten Intolerant/Sensitive Individuals

Group Research Project

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Abstract

The purpose of our experiment was to create an acceptable pastry product that is gluten free and high in fiber to meet the demands of consumers who are gluten sensitive or intolerant. Given the high levels of fiber content found in coconut flour, we designed an experiment using coconut flour as a substitution. We chose a popular sugar cookie recipe and created two modifications of it by first replacing 50% of all purpose flour in the recipe with coconut flour and the second by replacing 100% of the all purpose flour in the recipe with coconut flour. We performed two objective tests on all three products, an indirect volume area test and a wettability test. In addition, we performed blind subjective testing using a duo-trio test method with 25 participants ranking each product using a hedonic scale of 1 to 5 in the following categories: texture, tenderness and flavor. The subjective results indicated that coconut flour can be used to replace all purpose flour in sugar cookies and be perceived by the public as adequate in taste and of a high overall acceptability. Nonetheless, additional research to determine the proper amount of coconut flour is needed to improve the texture and tenderness acceptability of the product.

Introduction and Purpose

Sugar cookies are a common item in modern America, especially during the holidays due their versatility. A plain sugar cookie recipe usually calls for ingredients such as all purpose flour, egg, butter, vanilla, sugar, baking soda and baking powder. In general, each of these ingredients is rather energy dense but relatively low in nutrients. In tables 1.2, 1.3 and 1.4, you can see the nutritional analysis for each sample product. Coconut flour is a delicious, healthy alternative to wheat flour. It is very high in fiber, low in digestible carbohydrates and gluten-free. It lends baked goods an incomparably rich texture and a unique, natural sweetness.

The purpose of this research project is to create a pastry product that is gluten free and high in fiber content while also making it acceptable to consumers. We strived to create a safe and healthy pastry option for our target population. Our target consumers are the general population, specifically those with gluten sensitivity and celiac disease. Coconut flour is an acceptable substitution for all purpose flour (APF) due to the absence of gluten in the flour, thus, making it an available option for gluten sensitive individuals as well as for people who are allergic to nuts, grains and/ or beans (Smith, 2006). Our hypothesis is that there will be a significant increase in fiber in the sugar cookie made from coconut flour, and that consumers will find the product acceptable in texture, tenderness and flavor.

Literature Review

Per Amy Brown, the author of Understanding Food Principles and Preparation, gluten is a protein, prominent in wheat flour, that is formed when two wheat proteins, gliadin and glutenin, are combined in water. Gluten promotes elasticity and plasticity in baked products such as bread and other wheat products (Brown, 2004). Specifically, the elasticity of gluten in wheat flour is

from glutenin, and the plasticity comes from gliadin. All-purpose flour (APF) is a type of white flour that is only made with the endosperm of the wheat grain and contains eleven percent gluten (Brown, 2004). APF is commonly used in pastries, bread and cakes, and sometimes used as a thickener or a base for thick sauces (Garlough, 2011).

According to the National Digestive Diseases Information Clearinghouse (NDDIC), celiac disease (CD) is an autoimmune digestive disease or disorder involving the small intestine that greatly affects the proper absorption of nutrients from foods that are eaten. Celiac disorder is a disease of malabsorption and an abnormal reaction to gluten, meaning that individuals who are diagnosed with CD are unable to tolerate gluten (NDDIC, 2012). All individuals diagnosed with CD have a strict gluten-free diet. As discussed in the previous paragraph, gluten is primarily found in wheat flour. However, gluten is also found in rye and barley flours (McWilliams, 2012). Because flour is used for many purposes due to its thickening ability, gluten is also found in medicines, vitamins and lip balms (NDDIC, 2012). When an individual with CD consumes food that contains gluten, the body's autoimmune response begins by obliterating the microscopic villi along the inside of the lining of the small intestine (NDDIC, 2012). These villi are necessary upon absorbing nutrients in the small intestine. Thus, without healthy and functional villi, the celiac individual may become malnourished or not properly nourished with nutrients that he or she needs to grow and thrive. In some cases, even over consumption of food will not be useful if unhealthy and nonfunctioning villi are present (NDDIC, 2012).

While many foods contain gluten, since a gluten-free diet is mandatory for individuals with celiac disease, there are still many food products that do not contain gluten. Also, celiac individuals are able to consume breads and other pastries that do not contain wheat, barley or

rye, which are now being sold in most grocery stores and natural stores. Celiac patients or individual can still enjoy a balanced, nutritious meal composed of the five main food groups: protein, grains, vegetables, fruits and dairy. They can consume grains and starches such as amaranth, arrowroot, buckwheat, corn flour, coconut flour and many more (Lacey, 2011). The gluten-free flour alternative that is used in this experiment is coconut flour.

Coconut flour is non-gluten flour used by many celiac individuals, and it contains many healthful benefits. According to the Vegetarian Journal, coconut flour is an acceptable APF alternative that may be used in a variety of baked products (Berkoff, 2010). Coconut is a tropical fruit that is used in many kinds of cooking. Individuals with gluten sensitivity, food allergies and CD individuals can safely incorporate coconut flour and oil into their daily cooking (Smith, 2012). Coconut flour is naturally gluten-free, high in fiber, low in carbohydrate and grain free. Coconut flour contains more fiber than any other non-gluten flour (Smith, 2012). According to research done in 2006 to study the food functionality of coconut flour, it was found that "the dietary fiber content of coconut flour was 60.0±1.0 g/100 g sample, 56% insoluble and 4% soluble" (Trinidad T, Mallillin A, Chua M, et al., 2006). While celiac individuals can use coconut flour, it also offers other dietary benefits and prevention of diseases such as cardiovascular disease and type 2 diabetes mellitus (Trinidad T, Mallillin A, Chua M, et al., 2006). Additionally, coconut is composed of 90% saturated fat (Willet, 2011). It is argued in Harvard Health Letter that the saturated fat in coconut oil increases the high-density lipoprotein (HDL) in the blood (Willet, 2011). This remains controversial and may be confusing to many consumers. According to the United States Department of Health and Human Services' dietary guidelines in 2010, 20% to 35% of the total calories Americans consume should be fat. Thus, nutrition intervention from a

registered dietitian (RD) is recommended for celiac patients or gluten sensitive individuals for guidelines and limitations.

Method & Design

Independent Variables: Amount of All Purpose Flour, Amount of Coconut Flour, Cooking Time.

Dependent Variables: Texture, Tenderness and Flavor of the product, Appearance of the product.

In the experiment, the original recipe was modified in its flour content. The experiment was composed of three separate trials, each trial varying in the amount and type of flour that was alternated. The control recipe followed the original recipe, using APF. The second trial consisted of 50% APF and 50% Coconut Flour, and we used 100% Coconut Flour alternation in the last trial. In consideration of consistency of our experiment, we weighed the ingredients in grams (to the tenth) instead of using household measurements (Refer to Appendices II for weights). The more precise the measurements are, the lower the chances are for errors and unexpected outcomes. By alternating the amount of APF with Coconut flour, we were able to compare the products of each trial and observe the impact of modifying the type of flour used in baking sugar cookies. By this method of experiment, we were able to observe the differences in the products' appearance, texture, consistency, tenderness, flavor and the cooking time.

Procedure for the Product

The baked products were made by the following procedures.

1. Preheat oven to 375 °F.
2. Weigh all the ingredients equally by weight, for all three sets of products (Refer to Appendices I for the list and weight of ingredients).
3. Stir flour, baking soda, and baking powder in a large bowl, set aside.

4. Mix butter and sugar and cream together in a large mixing bowl, until smooth.
5. Add in egg and vanilla extract and beat in the bowl.
6. Gradually blend in the dry ingredients with other ingredients.
7. Roll the mixed dough was into a flat surface, height measured at 1 cm.
8. Use a cookie cutter to cut out individual pieces for baking, and set on a baking sheet.
9. Bake the cookies in the oven for 6 minutes for the original recipe, and 8 minutes for the modified recipe.
10. Cool the baked products on a rack, in room temperature
11. Repeat steps 1-8 for all three samples.

Results and Discussion

Objective Evaluations

Two objective evaluations were performed in testing each sample of the experiment in addition to the nutrition analysis done using the myfitnesspal.com database (Table 1.2, 1.3 and 1.4). The first method performed is where we calculated the indirect volume area of the baked product (Table 1.0). We have chosen this method in lieu of the line-spread test for the dough due to the dry nature of the dough for each of the samples (control, 100% coconut flour, and 50% coconut flour). The second method is the wettability test (Table 1.1). This method was performed by first weighing each sample. We then soaked each sample in water for ten seconds, and then weighed each one again. The weight difference of each sample was then calculated. The wettability is the ability of the baked product to absorb moisture during a controlled period of time, with high moisture retention indicating that the baked product is sufficiently moist (McWilliams, 2012). After the first objective evaluation, the control and sample 415 had very

similar volume, whereas sample 707 differed by 76% in volume. This could be due to the amount of the APF that is incorporated in sample 707, as it was half of the amount in sample 415. As for the second objective evaluation, it is found that sample 707 is 20% more moist than sample 415. The control and sample 707 has a wettability difference of 1.3 grams (g). Thus, sample 707 is a much more acceptable product than sample 415. However, sample 707 is not 100% gluten free as it still contains 50% APF. Per the nutrition analysis for all three samples, sample 707 has lower calorie content than sample 415. Sample 707 and Sample 925 had a difference of 2 calories.

Table 1.0 Indirect Volume Area

	Height	Diameter	Area	Volume (area x height)
Control (925)	0.3 cm	7.2 cm	40.72 cm^2	12.22 cm^3
100% coconut flour (415)	0.8 cm	4.5 cm	15.90 cm^2	12.72 cm^3
50% coconut flour 50% APF (707)	0.6 cm	4.5 cm	15.90 cm^2	9.54 cm^3

Table 1.1 Wettability Test

	Weight Before (dry product)	Weight After (wet product)	Difference (wettability)
Control (925)	17.8 g	34.3 g	16.5 g
100% coconut flour (415)	16.8 g	20.5 g	3.7 g
50% coconut flour 50% APF (707)	16.5 g	34.3 g	17.8 g

Table 1.2 Nutrition Analysis for Sample 925

Number of Servings: serves 48 people

Ingredients	Calories	Carbs	Fat	Protein	Sodium	Sugar

APF	1155	242	3	33	6	1
Granulated Sugar	1080	300	0	0	3	300
Butter	1575	0	178	2	1265	0
Baking Powder	0	2	0	0	220	0
Baking Soda	0	0	0	0	1067	0
Egg	357	2	24	31	340	2
Vanilla Extract	12	1	0	0	0	1
Total	4179	547	205	66	2901	304
Per Serving	87	11	4	1	60	6

Table 1.3 Nutrition Analysis for Sample 415

Number of Servings: serves 48 people

Ingredients	Calories	Carbs	Fat	Protein	Sodium	Sugar
Coconut Flour	1360	181	45	45	680	23
Granulated Sugar	1080	300	0	0	3	300
Butter	1575	0	178	2	1265	0
Baking Powder	0	2	0	0	220	0
Baking Soda	0	0	0	0	1067	0
Egg	357	2	24	31	340	2
Vanilla Extract	12	1	0	0	0	1
Total	4384	486	247	78	3575	326
Per Serving	91	10	5	2	74	7

Table 1.4 Nutrition Analysis for Sample 707

Number of Servings: serves 48 people

Ingredients	Calories	Carbs	Fat	Protein	Sodium	Sugar
Coconut Flour	680	91	23	23	340	11
APF	578	121	2	16	3	0

Granulated Sugar	1080	300	0	0	3	300
Butter	1575	0	178	2	1265	0
Baking Powder	0	2	0	0	220	0
Baking Soda	0	0	0	0	1067	0
Vanilla Extract	12	1	0	0	0	1
Egg	357	2	24	31	340	2
Total	4282	517	227	72	3238	314
Per Serving	89	11	5	2	67	7

Blind Sensory/Subjective Evaluation (Public Tasting)

As for the subjective evaluation, 25 untrained individuals tested each sample cookie. Per the Mean Blind Sensory Evaluation (Figure 1.0), it shows that the control recipe (sample 925) has the highest scores for each characteristic. Sample 415 had the lowest scores for each characteristic. The 25 untrained sensory panels rated the products by their texture, tenderness and flavor. Samples 925 and 707 both have a higher acceptability rating than sample 415. Per our observation during the trial, we noticed that some individuals did not seem to be pleased with sample 415 because of how hard the bite was. However, many tasters enjoyed sample 925.

Table 1.5 Sample 925 Subjective Evaluations

Testers	Texture 1=poor; 5=good	Tenderness 1=too tender; 5=good tender	Flavor 1= poor flavor; 5=good flavor
1	4	4	5
2	4	3	4
3	3	4	5
4	5	5	5
5	4	4	4
6	5	5	5
7	5	5	4

8	4	3	4
9	4	3	4
10	4	5	4
11	1	2	3
12	4	4	4
13	5	5	5
14	4	1	2
15	5	5	5
16	4	3	4
17	3	3	4
18	5	5	5
19	5	3	5
20	2	2	4
21	3	2	4
22	5	3	0
23	4	3	2
24	3	3	4
25	5	5	5
Total:	100	90	100

Table 1.5 Sample 925 Mean, Median and Mode

Sample 925	Texture	Tenderness	Flavor
Mean	4	3.6	4
Median	4	4	4
Mode	4	3	4

Table 1.6 Sample 707 Subjective Evaluations

Testers	Texture 1=poor; 5=good	Tenderness 1=too tender; 5=good tender	Flavor 1= poor flavor; 5=good flavor
1	1	4	5
2	5	4	5

3	2	2	2
4	3	4	3
5	1	2	2
6	4	3	3
7	4	3	4
8	2	1	5
9	2	2	4
10	2	2	5
11	4	4	4
12	1	1	7
13	1	1	5
14	3	2	3
15	2	1	5
16	5	5	5
17	3	3	4
18	5	3	1
19	5	3	2
20	2	3	4
21	4	3	4
22	2	1	3

23	2	2	2
24	1	2	4
25	2	2	3
Total:	68	52	92

Table 1.7 Sample 707 Mean, Median, and Mode

Sample 707	Texture	Tenderness	Flavor
Mean	2.7	2.1	3.6
Median	2	2	4
Mode	2	2	5

Table 1.8 Sample 415 Subjective Evaluations

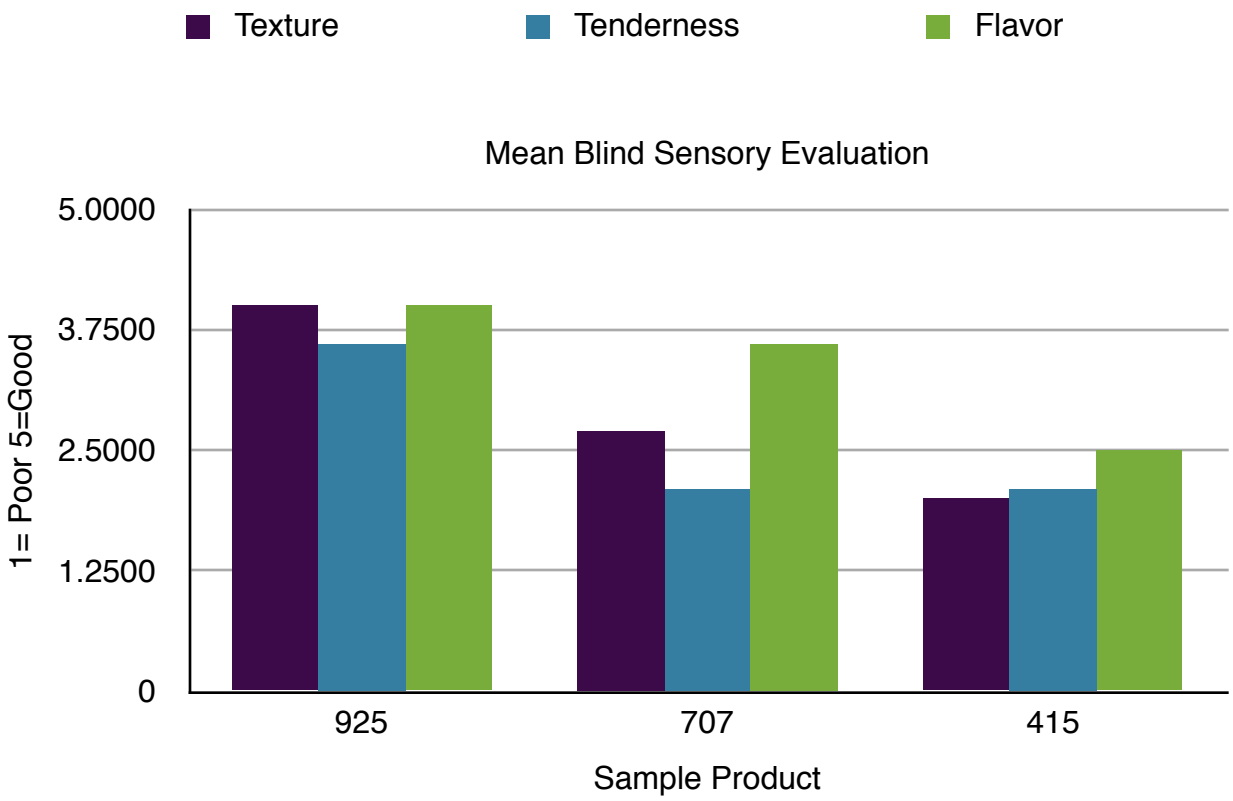
Testers	Texture 1=poor; 5=good	Tenderness 1=too tender; 5=good tender	Flavor 1= poor flavor; 5=good flavor
1	5	3	3
2	3	3	4
3	1	2	3
4	1	3	2
5	3	1	1
6	1	3	2
7	3	2	4
8	1	1	2
9	1	1	2
10	1	1	5
11	2	3	2
12	2	1	1
13	2	1	1
14	3	2	3
15	1	1	3

16	5	5	5
17	1	1	3
18	0	5	1
19	3	2	4
20	1	2	1
21	3	2	3
22	1	1	1
23	1	1	2
24	4	4	5
25	1	1	3
Total:	51	52	63

Table 1.9 Sample 415 Mean, Median, and Mode

Sample 415	Texture	Tenderness	Flavor
Mean	2.0	2.1	2.5
Median	1	1	3
Mode	1	1	3

Figure 1.0 Mean Blind Sensory Evaluation Graph



Procedure for Volume Test

The volume test proceeded with the following directions.

1. Measure the height of the baked product.
2. Measure the diameter of the baked product.
3. Calculate the Area of the surface (Pi multiplied by r^2).
4. Multiply the Area by the height.
5. Repeat steps 1-4 for all three samples, and record the measurements and calculations.

Procedure for Wettability Test

The wettability test was preceded by the following instructions.

1. Weigh the baked product on a scale in grams, record the weight.

2. Prepare a medium bowl filled with enough cold water to sink the whole product.
3. Drop the product into the water bowl for ten seconds.
4. Remove the product from the water and remove excess water.
5. Weigh the product on a scale in grams, record the weight.
6. Calculate the wettability; subtract the first recorded weight from the weight of the wet product, and record the subtraction in grams.

Conclusion

The purpose of this research experiment was to bake and observe modified sugar cookies that have high fiber content and have low amount of digestible carbohydrates while remaining acceptable to consumers. With specific attention to Celiac disease patients and gluten-sensitive population, the motive of the research was aimed at providing a nutritious, healthy, yet enjoyable product. The hypothesis of the experiment is that there will be a significant increase in the amount of fiber in the sugar cookie made from coconut flour, and that consumers will find the product acceptable.

The idea of using coconut flour in place of APF is considerable, knowing that it can be a healthy option for those diagnosed with Celiac disease or those who have gluten sensitivity. However, the results were not aligned with the hypothesis of the experiment. Although the modified sugar cookies are higher in fiber content, the hedonic scale showed a negative feedback when compared to the control products. While goods using the original recipe were rated with a 3.9 mean average overall (for texture, tenderness, flavor), the 50% recipe products were given a score of 2.8, and the 100% recipe products a 2.2. The hedonic scale rating is crucial in showing the correlation of using coconut flour and the decrease of acceptability by the evaluators. Making

sugar cookies with coconut flour may result in a nutritious product that is nutritious and gluten free, but it takes away the goodness of a cookie that makes it enjoyable.

The research experiment was unsuccessful, as results were negative by replacing APF with coconut flour. The results of using the modified recipe showed a significant decrease in acceptability of the product, which is not what we hoped for. The hypothesis was proven to be wrong, in that the consumers will not find the product acceptable.

Despite the unexpected outcome of the experiment, there is still hope for producing nutritious, gluten-free products. It was observed in the trials that the sugar cookies with coconut flour were much denser when compared to the original cookies. These characteristics may have kept the heat from transferring so easily, preventing the product from being baked thoroughly. Perhaps shaping the dough in different physical forms may increase the acceptability by the consumers.

Appendices

Original Recipe

Sugar Cookies Recipe

http://allrecipes.com/recipe/easy-sugar-cookies/

Original recipe makes 4 dozen

- 2 3/4 cups all-purpose flour
- 1 teaspoon baking soda
- 1/2 teaspoon baking powder
- 1 cup butter, softened
- 1 1/2 cups white sugar
- 1 egg
- 1 teaspoon vanilla extract

Directions

- Preheat oven to 375 degrees F (190 degrees C). In a small bowl, stir together flour, baking soda, and baking powder. Set aside.
- In a large bowl, cream together the butter and sugar until smooth. Beat in egg and vanilla. Gradually blend in the dry ingredients. Roll rounded teaspoonfuls of dough into balls, and place onto ungreased cookie sheets.
- Bake 8 to 10 minutes in the preheated oven, or until golden. Let stand on cookie sheet two minutes before removing to cool on wire racks.

Table 1.10 Weighed Ingredients

Products	Control (925)	100% Coconut Flour (415)	50% Coconut Flour / 50% APF (707)
Ingredients	Weight of ingredient (g)	Weight of ingredient (g)	Weight of ingredient (g)
Baking Soda	3.9	3.9	3.9
Baking Powder	1.4	1.4	1.4
Butter, softened	219.7	219.7	219.7
Egg	1 count	1 count	1 count
All Purpose Flour	317.4	0	158.7
Coconut Flour	0	317.4	158.7
White sugar	294.9	294.9	294.9
Vanilla Extract	4.2	4.2	4.2

Lab Work Documentation for Friday, November 8, 2013

Purpose: The purpose of today's experiment is for each group member to make a sample for the day of the trial. There are three group members. Therefore, the first person will make the control, the second person will do sample 2 and the third person will do sample 3. We have designated a specific sample product for each group member to make in today's experiment and for the day of the trial, for consistency and accuracy.

Documented Procedures:

For the control recipe, the first person did the following:

- Weighed all ingredients (Table 1.10) and started preheating the oven to 375 degrees Fahrenheit.
- Followed the recipe.
- Baked for 6 minutes.

For the sample 2, the second person did the following:

- Weighed all ingredients. Note: 25% APF, 75% coconut flour.
- Followed the recipe.
- Baked for 8 minutes at 375 degrees Fahrenheit.
- Attempted to go all the way to 100% coconut flour to execute the purpose of the experiment: gluten-free product and high fiber content.
- Weighted all ingredients with 100% coconut flour (Table 1.10).
- Followed the recipe.
- Baked for 8 minutes at 375 degrees Fahrenheit.

For the sample 3, the third person did the following:

- Weighed all ingredients (Table 1.10).
- Followed the recipe.
- Baked for 8 minutes at 375 degrees Fahrenheit.

Table 2.0 Acceptability: 1= unacceptable; 3=acceptable with comments

Random Testers	Control	100%	50%
1	3 (sugary, golden brown, melts in mouth)	2 (very coconut, sweet, dark golden brown, some resistance)	3 (sweet, good, light golden brown)
2	3 (good color, very sweet)	3 (delicious coconut flavor)	2 (nice color, good bite)
3	3 (acceptable, very sweet)	2 (coconut, some bite, warm)	2 (crumbles, sweet)
4	3 (original sugar cookies)	2 (very powdery, some bite)	2 (little powdery, okay with flavor)
5	3 (good color, good texture)	2 (grainy, coconut flavor)	2 (little grainy, little bite)
6	3 (great consistency, good flavor)	1 (hard, very powdery, high coconut flavor)	2 (some grainy, coconut aftertaste)

Table 2.1 Indirect Volume Area

	Height	Diameter	Area	Volume (area x height)
Control (925)	0.3 cm	7.2 cm	40.72 cm^2	12.22 cm^3
100% coconut flour (415)	0.8 cm	4.5 cm	15.90 cm^2	12.72 cm^3
50% coconut flour 50% APF (707)	0.6 cm	4.5 cm	15.90 cm^2	9.54 cm^3

Table 2.2 Wettability Test

	Weight Before (dry product)	Weight After (wet product)	Difference (wettability)
Control (925)	17.8 g	34.3 g	16.5 g
100% coconut flour (415)	16.8 g	20.5 g	3.7 g
50% coconut flour 50% APF (707)	16.5 g	34.3 g	17.8 g

Summary

Outcome of Testing

In order to get a better idea of what our two modification would be for our project, we decided to play around with a couple of figures. During our first sugar cookie test trials, we experimented with a combination of 50% APF and 50% coconut flour, and 25% APF and 75% coconut flour. The flavor results were encouraging but the appearance, texture and tenderness of the 50% and 75% substitutions were unsatisfactory. Compared to the control sample product, our two modified variations did not spread and stayed in a ball shape which resulted in an undercooked product. In addition, since we wanted to create a product high in fiber but gluten free as well, we needed to completely substitute the APF needed in the recipe with 100% coconut flour. As a consequence, we decided to modify the recipe to 50% and 100% coconut flour instead

of 75%. We also needed to develop another method to attempt to make all three sample products appear the same. In order to remedy the appearance, texture and tenderness of the sample products, we decided to roll the dough to one centimeter thick and used a two-inch round cookie cutter to make all three samples appear the same. In doing so, we were able to produce two modified samples that looked very similar and the control just slightly different. In addition, we were able to produce a pastry high in fiber and gluten free that both tasted great and looked delicious.

Possible Errors

One of the errors we encountered during our test trials was that the 50% and 100% sample products had little or no gluten, thus making the dough denser, crumbly and harder to work with because it lacked elasticity. Our first trial using 50% and 75% of coconut flour did not work well because we assumed the cookies would spread like the control sample and they did not. Since the two modified samples lacked gluten, they were unable to spread like the control sample, thus resulting in a thick, unshaped, undercooked product that had poor appearance as well as texture and tenderness. Although the appearance and consistency of the two modified products didn't provide the result we had hoped for, the flavor did and we just needed to find a way to make it work. On our second trial run, we continued with 50% but eliminated the 75% and instead went all the way to 100% of APF replaced with coconut flour. We came to the conclusion that we needed to flatten the dough first to be able to cut it into shapes that were the same size in order for all sample products to be uninformed. We then cooked both modified samples for the same amount of time as the control sample, which was 8 minutes. As a consequence, the 50% and 100% samples were undercooked and lacked the nice golden brown

color we desired. On our third trial, we determined we needed the 50% sample to be baked for 10 minutes and the 100% sample for 12 minutes in order for them to bake all the way through. Unfortunately, the lack of gluten and the high content of fiber made the modified sample products harden once cooled. In order to compensate for this, we needed to bake the cookies and serve them right away or seal them in an airtight container to preserve their freshness.

Conclusion

The purpose of the experiment was to determine how much all purpose flour could be substituted for coconut flour in a standard sugar cookie recipe in order to produce a gluten-free product also high in fiber content. We found that flavor acceptability was comparable between all three sugar cookie samples, but additional research is needed in order to improve the texture and tenderness of both modified products.

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