

Effects of Gluten Free Substitution on  
Sensory and Objective Measurements on Brownies

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### **Abstract**

Three different variations of brownies were tested to determine the effects of substituting all-purpose flour with gluten free flour, and gluten free coffee flour. The purpose of this experiment was to test the sensory acceptability, height, and springiness of brownies. The brownies were prepared with variation one containing gluten-free flour, variation two containing a 3:1 mixture of gluten-free and coffee flour, and the control containing general all-purpose baking flour. After the brownies were baked, they were tested in a CT3 texture analyzer to test springiness, height was measured using cm on a metric ruler, and sensory data was collected on a scale of 1-5 (satisfied-dissatisfied), on overall acceptability, appearance, and flavor. Based on the ratings students gave on appearance, flavor, and overall acceptability of the brownie when compared to the control, it was statistically significantly higher than gluten free coffee flour brownies. For height, gluten free coffee flour had the highest, followed by the gluten free flour, with the control rising the least. For springiness, gluten free coffee flour was the highest, and gluten free flour was once again closest to the control. It was concluded that gluten free flour was the closest acceptable alternative when compared to the control of all-purpose flour, and gluten free coffee flour was an unacceptable substitute.

### **Introduction**

Incidence of celiac disease and gluten allergy affects an estimated one percent of the population (Nascrimento, Fiates, Anjos, & Teixeira, 2014). This may seem like a small percentage, but the United States Census Bureau estimates that there are almost 7.5 billion people in the world population (U.S. and World Population Clock, n.d.). This means that there are nearly 75,000,000 people affected by this disease.

Allen (2015), explains that it only takes about 10 to 50 milligrams (mg) per day of gluten to damage the intestinal mucosa of a person with celiac disease. That being said, a single slice of bread contains an estimated 1,600 mg of gluten (Allen, 2015). The only treatment for these individuals is to not consume gluten-containing foods (Melito & Farkas, 2012). Therefore gluten substitution can be extremely beneficial for these individuals.

The purpose of this study was to determine if there was a way to produce a gluten-free brownie using all but one identical ingredient (flour), with coffee flour or gluten-free flour, that is comparable to a gluten containing control brownie, made with all-purpose flour, in texture, height, flavor, and appearance. The variable preparations included, variation 1, a complete gluten-free flour substitution, variation 2, a 50% coffee flour 50% gluten free flour substitution, and, the control, all-purpose flour brownie.

The research questions that guided this study included 1) would varying the gluten content of the flour change the height and/ or texture of the brownies? and 2) would varying the gluten content of the flour change the satisfaction of the consumer? The objective of this study was to create an acceptable gluten-free brownie that would

give consumers who have a gluten allergy or intolerance a wider selection of dessert items to choose from.

### **Review of the Literature**

#### **Gluten Intolerance**

Gluten intolerance and wheat allergies are estimated to affect approximately one percent of the population (Nascrimento, et.al., 2014). More specifically, celiac disease, as defined by Melito and Farkas (2012), is an immune-mediated systemic disorder in which food that contains gluten cause adverse effects on the body. Currently, no medication exists to allow individuals with intolerance or allergy to gluten to consume these products. Therefore, complete avoidance is required for these patients (Melito & Farkas, 2012).

Research by Jamal and Iftikhar (2016) supports that if consumption of gluten persists in a patient with celiac disease, one could experience symptoms such as chronic diarrhea, bloating, flatulence, and abdominal pain. Other symptoms could include abnormal liver function, metabolic bone disease, arthritis, and infertility (Jamal & Iftikhar, 2016).

While many foods do naturally exist gluten free, food science has allowed researchers and product developers to explore supplemental options in order to create wheat like products that are safe for these populations to consume. The downfall of these substitutes that allow individuals to replace allergenic ingredients is that food items may suffer in quality, tenderness, acceptability, and taste to its consumers against its gluten-containing counterpart.

### Gluten Substitution and Effects on Food

Many flour substitutions exist for gluten in recipes. A few examples of different flours present on the market include rice flour, tapioca flour, chickpea flour, buckwheat flour, ragi flour, bajra flour, and sorghum flour. A gluten free flour mixture such as buckwheat at sixty grams, ragi at forty grams, and bajra at one hundred grams can be used to as a substitute, as used in the experiment performed by Tanwar and Dhillon (2016), in lieu of its two hundred gram all-purpose flour control. Relatively new gluten free flour that has come to market is coffee flour. While there is not research on coffee flour itself, according to the manufacturer of “Coffee flour” (2015), the product does have to be combined with another type of flour. For a “Coffee flour” chocolate chip cookie, the recipe calls for forty four grams of Coffee flour, and two-hundred and sixty one grams of all-purpose or gluten free flour. (“Coffee Flour Chocolate Chip Cookies,” 2016). Sensory attributes can be affected differently depending on what type of flour is used in a recipe (Tanwar & Dhillon, 2016). Different flours can produce different qualities dependent on the product it is used for, as well as change the macro- and microelement contents (Ciesarova et al., 2016).

### Sensory Attributes of Gluten Free Substitution

In a study conducted by Melito and Farkas (2012), the physical properties of gluten-free donuts were investigated. Eight different gluten free donut recipes were tested. In the sensory evaluation, the differences among the gluten free donut scores were insignificant, but they all scored significantly lower in comparison to the wheat control (Melito & Farkas, 2012).

In another study by Perez-Carrillo, (2017), gluten-free cookies were prepared by a group of researchers. In this experiment sensory attributes were analyzed. Between the five different variations, there were significant differences that influenced panelist, such as texture, crust color, and flavor (Perez-Carrillo et al., 2017). The results were that “cookies prepared by mixing 90% NCF [nixtamalized corn flour] and 10% pregelatinized starch yielded the best gluten-free items” (Perez-Carrillo et al., 2017), which means that they had a higher acceptability rating.

Nascimento, et al., (2013), explored the perceptions of celiac consumers in products that exist as “gluten free” in the market place. Using a questionnaire, they discovered that most of their sample found moderate satisfaction in taste, texture and labeling information of gluten free foods, but felt the greatest dissatisfaction in variety, price and availability of these products in the market place (Nascimento, et.al., 2013).

It is important to keep in mind that recipe alteration can improve or negatively impact the acceptance of the food product that is being produced, as can be noted by the sensory evaluations in the study by Perez-Carrillo and colleagues (2017) on gluten free cookies. This would explain why many mass marketed gluten free products have higher acceptability ratings than, for example, the baked goods in the previous two studies.

It can also affect the cost and ability to produce and market the product as well, which could account for the dissatisfaction that exists in the celiac community.

#### Benefit of Gluten Free Substitution

Various studies examine at the acceptability, physical, and chemical properties of gluten free products. A study of millet flour substitution for kibbeh [Egyptian meat dish made with onions, spices, and cracked wheat] yielded results that stated that the

favorability of the dish was not significantly altered by the substitution (Brasil, Capitani, Takeuchi, & Ferreira, 2015). We have studies like the donut and cookie studies previously mentioned that have significant acceptability differences that were a result of gluten free substitution.

If acceptable gluten free deserts are produced for consumers, it will offer a greater variety of foods to patients who suffer from allergies, sensitivities, or have diet preferences. These people would have the opportunity to consume and enjoy foods that they have not had access to, and in turn they would potentially feel less restricted by their diet.

### **Methods**

One control group and two variations of brownies were prepared in this experiment. The control group brownies were made with 273 grams of all-purpose flour. Variation 1 replaced the all-purpose flour with 290 grams of gluten free flour, and variation 2 replaced the all-purpose flour with a mixture of 162 grams of gluten-free and 128 grams of coffee flour.

#### **Control**

Preparation of the control brownie began by preheating the oven to 350 degrees, lining a 9-by-13 inch metal baking pan with parchment paper, and gathering all of the ingredients (Appendix F). The ingredients were then placed into individual bowls and each measured using a zeroed scale. Next, 3 sticks of melted unsalted sweet cream butter were then melted on the stove at medium heat for 3 minutes and 40 seconds, stirring in 30 second increments for 10 seconds. Then 897 grams of regular granulated white sugar, the melted unsalted sweet cream butter, and 12 grams of Morton iodized salt were then

combined in a large bowl and stirred 62 times for one minute with a rubber spatula. The 6 eggs were added in, one at a time, as stirring continued with a whisk. Then 158 grams of Hyvee unsweetened baking cocoa powder and 273 grams of all-purpose flour were combined and poured into the batter in  $\frac{1}{3}$  increments. They were mixed with a rubber spatula for 25 seconds. The batter was then transferred to the baking pan and baked for 60 minutes and cooled on the counter for 2 hours. The brownies were then cut into 32 equal 1 inch x 2 inch size pieces and placed onto a paper plate for sensory and objective evaluation (Appendix F).

#### Variation 1

Variation 1 was prepared in the same manner as the control. Instead of using 273 grams of all-purpose flour, variation 1 used 290 grams of gluten free flour (Appendix F).

#### Variation 2

Variation 2 was prepared in the same manner as the control. Instead of using 273 grams of all-purpose flour, variation 2 used 243 grams of gluten free flour and 64 grams of coffee flour (Appendix F).

#### Objective Evaluation

Objective evaluation was conducted using a Brookfield CT3 texture analyzer. Two measurements were taken. The first was springiness, which is defined as the height that food recovers between the first and second bite (Brookfield CT3 Measure Definitions, n.d). The second measurement was height, which is defined as the distance from the bottom of the brownie to the top (“height”, 2017).

For springiness, three samples of each variation of brownie were placed into the analyzer, one at a time, to collect data. The machine measured the distance from the



target deformation of cycle 1 to the trigger point of cycle 2 (Brookfield CT3 Measure Definitions, n.d). The median of each cycle for three samples of the control, variation 1, and variation 2 were then added together and divided by three to find the median springiness score.

Height was measured using a standard metric ruler in centimeters. Researchers hand measured three different cuts of each variation, in order to calculate median height. Adding each height measurement of the three samples of the control, variation 1, and variation 2, and dividing by three collected the median height.

#### Sensory Evaluation

After being cut into equally sized rectangular pieces, the samples were placed into small paper plates for sensory evaluation. A random three-digit number was assigned to each variation and these numbers were used to identify each variation on the ballot.

The brownies were then stored on a cart, individually wrapped in plastic wrap on sample plates for two hours prior to evaluation. They were then unwrapped as they were distributed to participants who signed the informed consent waiver.

The sensory analysis was a convenience sample taken from one class on campus at a Midwestern public university that contained twenty five students. Twenty two of these students choose to participate in our study.

The appearance, flavor, and overall acceptability perceptions of panelists were rated using a hedonic scale (Appendix G). Panelists were not trained for sensory evaluation, and the sample was not representative of the campus or the general area population as a whole.

Each panelist signed a consent form, and then ballots were distributed. Each panelist was given one sample of each variation of brownie, as well as water, which acted as a palate cleanser to prevent carryover tastes (Choi, 2014). Panelists were requested to refrain from speaking to each other during sensory evaluation. After testing, panelists filled out their ballots and evaluated each variation of brownie for appearance, flavor, and overall acceptability.

## **Results**

### **Nutrient Evaluation**

Nutrient evaluation was determined for the control and its variations, and documented.

For the control, all-purpose flour, the calorie content was 245 calories, fat content was eleven grams, six of which were saturated fats. Carbohydrate content was 32.5 grams, fiber was one gram, protein was four grams, sodium was 165 grams, and calcium was eight mg (Appendix A).

For variation 1, gluten free flour, the calorie content was 249 calories, fat content was eleven grams, six of which were saturated fats. Carbohydrate content was 33.5 grams, fiber was two grams, protein was four grams, sodium was 165 mg, and calcium was eight mg (Appendix A).

For variation 2, gluten free coffee flour, the calorie content was 156 calories, fat content was eleven grams, six of which were saturated fats. Carbohydrate content was 33 grams, fiber was three grams, protein was four grams, sodium was 195 grams, and calcium was eight grams (Appendix A).

### **Objective Results**

In objective evaluation of the effects of gluten substitution on brownies, data for springiness was collected using the Brookfield CT3 texture analyzer.

Springiness is the measure of the height in which food recovers between the first and second bite (“Brookfield CT3 Measure Definitions”, n.d.). This is measured by taking the “distance from the target deformation of cycle one to the trigger point of cycle two” (“Brookfield CT3 Measure Definitions”, n.d.).

The median result for springiness of the control brownie was 2.51 mm. The median result for springiness of brownie variation 1 was 2.33 mm. The median result for springiness of brownie variation 2 was 2.78 mm (Appendix B & C)

Height, the distance from the bottom of the brownie to the top (“height”, 2017), was measured using a ruler, and the metric measurement of centimeters.

The result of the height of the control brown was 2.6 cm, 2.5 cm, and 2.4 cm, with a median of 2.5 cm, and a standard deviation of 0.082 cm. The result of the height of brownie variation 1 was 3.3 cm, 2.6 cm, and 2.8 cm, with a median of 2.9 cm, and a standard deviation of 0.294 cm. The result of the height of brownie variation 2 was 2.9 cm, 3.0 cm, and 3.1 cm, with a median of 3.0 cm, and a standard deviation of 0.082 cm (Appendix C & D).

### Sensory Evaluation

In sensory evaluation of brownie variations and the effects of gluten substitution, data was collected from an evaluation panel. Twenty two panelists participated in a single blind evaluation and were asked to rate the appearance, flavor, and overall acceptability of the brownie variations using a hedonic scale of one through five, one being satisfied and five being dissatisfied. Randomized numbers were used in order to avoid bias.

Number 405 represented the control, 391 represented variation 1, gluten free, and 286 represented variation 2, gluten free coffee flour (Appendix G).

During testing, it was clear that panelists were experience dissatisfaction with one of the variations.

Mean, and standard deviation were calculated from the data collected from the evaluation results (Appendix H).

For the control, the mean of appearance was 1.39 out of five, the mean of flavor was 1.59 out of five, and the mean of the acceptability was 1.55 out of five. Standard deviation of the control of the appearance was 0.733, standard deviation of flavor was 0.98, and standard deviation of acceptability was 0.94 (Appendix E).

For variation 1, gluten free flour, the mean of appearance was 1.24 out of five, the mean of flavor was 1.55 out of five, and the mean of the acceptability was 1.64 out of five. Standard deviation of the gluten free flour variation of appearance was 0.53, standard deviation of the flavor was 0.72, and standard deviation of acceptability was 0.77 (Table 5).

For variation 2, gluten free coffee flour, the mean of appearance was 1.41 out of five, the mean of flavor was 2.82 out of five, and the mean of acceptability was 2.68 out of five. Standard deviation of the gluten free coffee flour variation of appearance was 0.58, standard deviation of the flavor was 1.19, and standard deviation of the acceptability was 1.33 (Appendix E).

## Discussion

### Nutrient Analysis

In the nutrient analysis, it can be seen that there is a minimal nutrient difference between all-purpose flour, gluten free flour, and gluten free coffee flour (Table 1).

Sodium content of the gluten free coffee flour is slightly higher than the coffee flour and all purpose flour. Other than this, all three flours are very nutritionally similar.

Given that all other ingredients were equal, nutrient differences can be attributed to the flour variations. This is supported by the nutrient facts panel on the coffee flour brand Coffee Flour, and King Arthurs gluten free flour (CoffeeFlour™, 2017), (“King Arthur Gluten Free Flour”, 2017).

### Objective Results

Objective results for this experiment indicate that the mean springiness index of the control, variation 1, and variation 2 were all within .5 mm of each other. Variation 2, coffee flour had a higher springiness index, than the control, all-purpose flour, and the gluten free flour had the least springiness index.

While there is not much research on coffee flour, it can be noted that in ratings on this product found on sites that sell coffee flour, it has been made mention that coffee flour made their bread products “denser” and “heavier” (“Customer Reviews”, 2017). While this is just a review from a customer, it is evidence that other users of this product are also experiencing similar results.

The control brownie had the smallest height, the gluten free brownie was in the middle, and the gluten free coffee flour brownie was the tallest when measured. This

research is not fully supported because according to Melito and Farkas (2013), gluten free baked goods have been found to have lower volumes than their wheat counterparts.

Given this information, what should be seen is a denser product that takes up less space.

Explanation for the low volume of the all-purpose flour variation could be over preparation of gluten in mixing for experiment, ending with a harder product.

### Sensory Result

Sensory results showed a difference in the satisfaction of the control and gluten free brownies, against the coffee flour brownies. For all three variables, appearance, flavor, and overall acceptability, all-purpose flour and gluten free flour exhibited similar scores, and have higher satisfaction ratings, while coffee flour brownies did not.

These results can be attributed to the ratio of coffee flour to gluten free flour. In early preparations of this experiment, coffee flour was used in a 1:1 ratio with gluten free flour. There mixture was one cup gluten free flour, one cup coffee flour. The product was unpalatable, which caused researchers to change ratio to 3:1 of one and a half cups gluten free flour, and half a cup coffee flour.

Further adjusting the ratio from 3:1 of gluten free flour to coffee flour, respectively, to an even more palatable ratio could potentially increase acceptability scores.

Coffee and flour have distinct flavors. Coffee is bitter (“Tongue Maps for Coffee”, 2006), and flour can have a sweeter taste. This could also account for why the flavor was undesirable, because it was not the expected taste of a brownie.

This experiment helps show that those who are required to eat a gluten-free diet, are still able to have desserts, such as brownies, with the use of suitable gluten

replacements. The results shown in this experiment also benefit food service companies who are looking to find ways to increase their gluten free products. Research could also be expanded into other gluten free flour substitutes that were not experimented with in this research.

### **Conclusion**

Based on the outcome of the experiment, gluten free flour (variation 1) was an acceptable alternative when compared to the control of all-purpose flour. This was shown by the ratings students gave based on appearance, flavor, and overall acceptability when compared to the control, and was higher than the undesirable variation 2, which was made with coffee flour. For height, variation 2 had the highest, followed by variation 1, being more closely related to the control. For springiness, variation 2 was the highest, and variation 1 was also closest to the control.

It can be concluded that manipulation of gluten content in brownies has an effect on sensory and objective evaluation. There is a sensory deficit between the control and the gluten free coffee flower variation in both flavor and acceptability.

With panelists comments like “did not like 405 [coffee flour]”, and had clear dissatisfaction when tasting it. It is evident that this study did not find an acceptable recipe to use the coffee flour in.

Gluten free coffee flour may not be a suitable replacement for all-purpose flour, but gluten free can. With objective and subjective test scores that support it’s desirability in comparison to the all-purpose flour control, gluten-free flour has a high potential to succeed in the market as a gluten-free desert flour substitution.

Future research should focus on evaluating the ratio of coffee flour to gluten free flour to make recipes more desirable to appearance, flavor, and overall acceptability.



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**Appendices**

Appendix A.....	Nutrient Analysis of Brownies
Appendix B .....	Springiness Median Scores
Appendix C .....	Brownie Height Data
Appendix D.....	Objective Testing Mean and Standard Deviation
Appendix E.....	Sensory Evaluation Mean and Standard Deviation
Appendix F.....	Brownie Variation Recipes
Appendix G.....	Sensory Evaluation Hedonic Scale
Appendix H.....	Sensory Panel Data

**Appendix A***Table 1. Nutrient Analysis of Brownie Variations*

	Control	Variation 1	Variation 2
Calories	123 kcal	125 kcal	124 kcal
Fat	5.5 g	5.5 g	5.5 g
Saturated Fat	3 g	3 g	3 g
Carbohydrates	16.25 g	16.75 g	16.5 g
Fiber	0.5 g	1 g	1.5 g
Protein	2 g	2 g	2 g
Sodium	82.5 mg	82.5 mg	97.5 mg
Calcium	4 mg	4 mg	4 mg

Each total represents one 1'' by 1 ½' slice of brownie

Control- Brownie prepared with all-purpose flour

Variation 1- Prepared with gluten free flour

Variation 2- Prepared with a combination of gluten free and coffee flour

**Appendix B***Table 2. Effects of Gluten Variation on Springiness of Brownies*

Springiness	Control	Variation 1	Variation 2
Median	2.51 mm	2.33 mm	2.78 mm

**Appendix C***Table 3. Effects of Gluten Variation on Height of Brownies*

Height	Control	Variation 1	Variation 2
A	2.6 cm	3.3 cm	2.9 cm
B	2.5 cm	2.6 cm	3.0 cm
C	2.4 cm	2.8 cm	3.1 cm

**Appendix D***Table 4: Mean and Standard Deviation for Height of Brownies*

Variable	Mean N=3	SD
Height		
Control	2.5 cm	0.082 cm
Variation 1	2.9 cm	0.294 cm
Variation 2	3.0 cm	0.082 cm

*Table 5: Mean for Springiness of Brownies*

Variable	Mean N=3
Springiness	
Control	2.51 mm
Variation 1	2.33 mm
Variation 2	2.78 mm

**Appendix E**

*Table 6: Sensory Analysis for Appearance, Flavor, and Overall Acceptability of Brownie Variations*

Variable	Mean (n=22)	SD
Appearance		
Control	1.36	0.773
Variation 1	1.24	0.53
Variation 2	1.41	0.58
Flavor		
Control	1.59	0.98
Variation 1	1.55	0.72
Variation 2	2.82	1.19
Acceptability		
Control	1.55	0.94
Variation 1	1.64	0.77
Variation 2	2.68	1.33

Control- Brownie prepared with all-purpose flour

Variation 1- Prepared with gluten free flour

Variation 2- Prepared with a combination of gluten free and coffee flour.

\*Each aspect of each variation was rated on a scale of 1 to 5, with 1 representing being Satisfied and 5 representing being Dissatisfied



## Appendix F

Table 7: Brownie Variation Recipes

Recipe Name: Brownies Made with All-Purpose Flour

Category: Dessert  
(i.e., entrée, breads)

Recipe #1

Ingredients	For 27 Servings		Directions: Include <i>step by step</i> instructions, the <i>critical control points</i> (CCP-specific points at which a hazard can be reduced, eliminated or prevented) and <i>critical limit</i> (time and/or temperature that must be achieved to control a hazard).
	Weight	Measure	
All-purpose flour Granulated white sugar Eggs Unsalted butter Salt Unsweetened cocoa powder	273 grams 897 grams 6 large 3 sticks 12 grams 158 grams	2 cups 4 cups 6 large 3 sticks 1 tsp 2 cups	1. Preheat oven to 350°F 2. Line 9 x 13 inch metal baking pan with parchment paper. 3. Melt butter on the stove at medium heat for 3 minutes and 40 seconds, stirring every 30 seconds for 10 seconds. 4. In a large bowl, combine sugar, butter, and salt. 5. Stir for one minute with a rubber spatula. 6. Whisk in eggs, one at a time. 7. Stir in cocoa powder and flour in 1/3rd increments, and mix with a rubber spatula for 25 seconds for each instrument. 8. Transfer batter to baking pan, bake for 50-60 minutes, until just set. 9. Let cool for 2 hours and serve.

Serving Size 1' by 1 1/2' slice Pan Size 9 x 13 inch

### Oven Temperature & Baking Time:

Yield: 64 servings Number of Pans: 1

	Temperature	Minutes
Conventional	350°F	60

If available, **Nutrition Analysis:** **Serving Size:** 1' by 1 1/2' slice  
 123 Calories 3g Saturated Fat 0 mg Vitamin C  
 2g Protein 82.5 mg Sodium 169 IU Vitamin A  
 5.5g Total Fat (g) 0.5g Fiber (g) 4 mg Calcium  
 0 mg Iron

Recipe Name: Brownies Made with Gluten-Free Flour

Category: Dessert  
(i.e., entrée, breads)

Recipe #2

Ingredients	For 27 Servings		Directions: Include <i>step by step</i> instructions, the <i>critical control points</i> (CCP-specific points at which a hazard can be reduced, eliminated or prevented) and <i>critical limit</i> (time and/or temperature that must be achieved to control a hazard).
	Weight	Measure	
Gluten-Free Flour Granulated white sugar Eggs Unsalted butter Salt Unsweetened cocoa powder	290 grams 897 grams 6 large 3 sticks 12 grams 158 grams	2 cups 4 cups 6 large 3 sticks 1 tsp 2 cups	1. Preheat oven to 350°F 2. Line 9 x 13 inch metal baking pan with parchment paper. 3. Melt butter on the stove at medium heat for 3 minutes and 40 seconds, stirring every 30 seconds for 10 seconds. 4. In a large bowl, combine sugar, butter, and salt. 5. Stir for one minute with a rubber spatula. 6. Whisk in eggs, one at a time. 7. Stir in cocoa powder and flour in 1/3rd increments, and mix with a rubber spatula for 25 seconds for each increment. 8. Transfer batter to baking pan, bake for 50-60 minutes, until just set. 9. Let cool for 2 hours and serve.

Serving Size: 1' by 1 1/2' slice Pan Size 9 x 13 inch

### Oven Temperature & Baking Time:

Yield: 64 servings Number of Pans: 1

	Temperature	Minutes
Conventional	350°F	60

If available, **Nutrition Analysis:** **Serving Size:** 1' by 1/2' slice  
 125 Calories 3g Saturated Fat 0 mg Vitamin C  
 2g Protein 82.5 mg Sodium 169 IU Vitamin A  
 5.5 g Total Fat 1g Fiber 4 mg Calcium  
 0 mg Iron

Recipe Name: Brownies Made with Gluten-Free and Coffee Flour

Category: Dessert  
(i.e., entrée, breads)

Recipe #3

Ingredients	For 27 Servings		Directions: Include <i>step by step instructions</i> , the <i>critical control points (CCP)</i> -specific points at which a hazard can be reduced, eliminated or prevented) and <i>critical limit</i> (time and/or temperature that must be achieved to control a hazard).
	Weight	Measure	
Gluten-Free Flour Coffee Flour Granulated white sugar Eggs Unsalted butter Salt Unsweetened cocoa powder	243 grams 64 grams 897 grams 6 large 3 sticks 12 grams 158 grams	1.5 cup 0.5 cup 4 cups 6 large 3 sticks 1 tsp 2 cups	1. Preheat oven to 350°F 2. Line 9 x 13 inch metal baking pan with parchment paper. 3. Melt butter on the stove at medium heat for 3 minutes and 40 seconds, stirring every 30 seconds for 10 seconds. 4. In a large bowl, combine sugar, butter, and salt. 5. Stir for one minute with a rubber spatula. 6. Whisk in eggs, one at a time. 7. Stir in cocoa powder, gluten-free flour, and coffee flour in 1/3rd increments, and mix with a rubber spatula for 25 seconds for each increment. 8. Transfer batter to baking pan, bake for 50-60 minutes, until just set. 9. Let cool for 2 hours and serve.

Serving Size: 1" by 1 1/2" slice

Pan Size 9 x 13 inch

Oven Temperature & Baking Time:

Yield: 64 servings

Number of Pans: 1

Temperature

Minutes

Conventional 350°F60

If available, Nutrition Analysis:

Serving Size: 1" by 1 1/2" slice

124

Calories

3g

Saturated Fat

0 mg

Vitamin C

2g

Protein

97.5 mg

Sodium

169 IU

Vitamin A

5.5 g

Total Fat

1.5g

Fiber

4 mg

Calcium

0 mg

Iron

**Appendix G***Table 8. Control Brownie Sensory Evaluation Hedonic Scale*

Instructions: For each sample, circle the number that best applies to each characteristic.

Sample 286

Characteristics	Satisfied	Moderately Satisfied	Neutral	Moderately Dissatisfied	Dissatisfied
Appearance- The color is dark brown throughout, and appears flakey on top.	1	2	3	4	5
Flavor- Brownie has a sweet, rich chocolate flavor, with no unpleasant aftertaste.	1	2	3	4	5
Overall Acceptability- How satisfied are you with this product?	1	2	3	4	5

*Table 9. Variation 1 Brownie Sensory Evaluation Hedonic Scale*

Instructions: For each sample, circle the number that best applies to each characteristic.

Sample 391

Characteristics	Satisfied	Moderately Satisfied	Neutral	Moderately Dissatisfied	Dissatisfied
Appearance- The color is dark brown throughout, and appears flakey on top.	1	2	3	4	5
Flavor- Brownie has a sweet, rich chocolate flavor, with no unpleasant aftertaste.	1	2	3	4	5
Overall Acceptability- How satisfied are you with this product?	1	2	3	4	5

*Table 10. Variation 2 Brownie Sensory Evaluation Hedonic Scale*

Instructions: For each sample, circle the number that best applies to each characteristic.

Sample 405

Characteristics	Satisfied	Moderately Satisfied	Neutral	Moderately Dissatisfied	Dissatisfied
Appearance- The color is dark brown throughout, and appears flakey on top.	1	2	3	4	5
Flavor- Brownie has a sweet, rich chocolate flavor, with no unpleasant aftertaste.	1	2	3	4	5
Overall Acceptability- How satisfied are you with this product?	1	2	3	4	5

**Appendix H***Table 11. Control Sensory Panel Data*

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

*Table 12. Gluten Free Sensory Panel Data*

Participant	Appearance	Flavor	Overall Acceptability
1	1	1	2
2	1	3	3
3	1	2	1
4	1	1	1
5	1	2	2
6	1	1	1
7	1	2	3
8	1	1	1
9	1	2	2
10	1	1	1
11	1	2	2
12	1	1	1
13	3	1	1
14	2	2	2
15	1	1	1
16	1	1	1
17	2	3	3
18	X	3	3
19	1	1	1
20	1	1	1
21	1	1	1
22	1	1	2

*Table 13. Gluten Free Coffee Flour:*

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