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Effects of Chickpea Flour Replacement on Physical and Sensory Characteristics of Brownies

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Abstract

Due to health concerns and adding more nutritional value to foods, many consumers have started to incorporate nutrient-dense functional foods into their everyday diet. Chickpeas (*Cicer arietinum* L.) are an important globally consumed legume and pulse crop. They are utilized in foods due to their higher protein quality compared to other types of pulses grown around the world as they contain all the essential amino acids. Chickpeas are a great source of carbohydrates, dietary fiber, vitamins, and minerals. Another important factor is that it can be used as a supplement for protein for vegetarians and as a grain substitute for consumers who have celiac disease and cannot consume gluten. The main purpose of this study was to determine the effects of complete and partial substitution of all-purpose flour with chickpea flour on the physical and sensory attributes of brownies. The physical properties that were measured were pH, moisture content, and volume index. Sensory characteristics were also measured as well. All-purpose flour at a 100% ratio was used as the control variable while chickpea flour at 50% and 100% ratios were used as the experimental variables. A sensory evaluation was conducted from 23 participants using a 9-point hedonic scale and was used to assess appearance, color, flavor, texture, taste, and overall acceptability. Both sensory and physical characteristics were measured and entered in IBM SPSS Statistics (version 27) software. One-Way ANOVA and post-hoc tests, Tukey HSD and LSD were performed. The data was assessed using a $p < 0.05$ and the results presented as mean ± standard deviation. The results revealed that there were no significant changes in the pH, moisture content, and sensory characteristics. However, there was a significant difference in volume index between the control group and the experimental groups. There was no significant difference through sensory attributes meaning that a consumer would not be able to tell the difference between a baked good using chickpea flour or all-purpose flour. The use of chickpea flour in food such as baked goods would help add nutritional value back into everyday meals. The consumers who would greatly benefit from this conclusion would be vegetarians, health-conscious individuals, and those who have celiac disease.

Introduction

Chickpeas (*Cicer arietinum* L.) are one of the most widely consumed legumes in the world and known as an important pulse crop, especially in tropical and subtropical areas (Bulbula & Urga, 2018). As stated in the review article by Hirdyani (2014), chickpeas are excellent sources of carbohydrates and protein, as they are considered to have a better quality of protein compared to other types of pulse crops. They are highly utilized in foods to add nutritional value, such as adding the use of chickpeas to create nutritional food for low-income socioeconomic groups and people who suffer certain lifestyle diseases like celiac disease (Hirdyani, 2014).

The chickpea is also known as garbanzo beans or Bengal gram, an Old-World pulse (Hirdyani, 2014). Currently, chickpeas are grown in over 50 countries around the world from North Africa to the Americas, and globally they rank third as the most important pulse crop to be produced; along with field pea and dry beans (Hirdyani, 2014). However, India is the world's largest chickpea-producing country accounting for 66 percent of all global chickpea production. Other countries that also produce mass amounts of this special crop are Turkey, Ethiopia, Iran, Mexico, United States, and Australia (Hirdyani, 2014).

As for the nutritional composition of chickpeas, they are loaded with a nutritious amount of carbohydrates, proteins, dietary fiber, minerals, and vitamins. About 80% of the total dry seed mass of the chickpea stems from carbohydrates and protein alone (Hirdyani, 2014). Starch is the major form of carbohydrate storage and its content makes up 41% to 50% of the chickpea seed, followed by dietary fiber, oligosaccharides, and simple sugars such as sucrose and glucose (Hirdyani, 2014). There is a low amount of lipids present in chickpeas, about 6%, but they are rich in nutritionally valuable unsaturated fatty acids such as oleic and linoleic acids (Hirdyani, 2014). The high protein quality in chickpeas is utilized the most compared to other legumes and pulse crops. Chickpeas have a significant amount of all the essential amino acids which is what makes them so important as a source of protein, except for the sulfur-containing amino acids (Hirdyani, 2014). The notable minerals of calcium, magnesium, phosphorus, selenium, potassium, and iron are contained within chickpea seeds (Hirdyani, 2014). Chickpeas are also a good source of fundamental vitamins such as folate, riboflavin (B_2), niacin (B_3), thiamine (B_1), and the vitamin A precursor β-carotene (Hirdyani, 2014). Also, chickpeas have many health benefits from their nutritional composition factors and in combination with other cereals and pulses due to their high antioxidant activity. They have beneficial effects on diseases such as cardiovascular disease (CVD), type 2 diabetes, digestive diseases, and some cancers such as colon and lung cancer (Hirdyani, 2014). "Thanks to the essential amino acids, vitamins, minerals and food fibers contained in chickpeas, it is rightfully considered a "health grain" and recommended for use in therapeutic and preventive nutrition" (Sadigova et al., 2018).

Using chickpeas to add nutritional value to food products allows for a great improvement of the quality of diets, due to increasing the availability and consumption of foods being made or added with chickpeas compared to normal grains such as wheat or barely, in order to address cost in food, lifestyle diets, and nutrient deficiencies in some

cases. Chickpeas allow for beneficial results when added to food products because of the nutrients encased within them. The legume is also a cheap source of high-quality protein, especially for low-income families and for developing countries that may not be able to afford animal protein for adequate nutrition (Bulbula & Urga, 2018). Chickpeas are an important crop to utilize for their mass production, nutritional composition, ease of cost, and nutritional availability to be used in baked products for consumers who have a lifestyle diet of not consuming gluten due to celiac disease, vegetarians, or even for preference. Therefore, the purpose of this study was to determine the effects of complete and partial substitution of all-purpose flour with chickpea flour on the physical and sensory attributes of brownies. Moisture content, pH, volume index, and sensory evaluations were measured to compare any difference between groups.

Materials and Methods

All the ingredients for the brownie batter were purchased from a local grocery store. The control group was made with 100% all-purpose flour and one experimental group was made with 50% all-purpose flour and 50% chickpea flour, while the other experimental group was made with 100% chickpea flour. The ingredients that were used to make the brownie batter were ½ cup salted butter (melted), 2 eggs, ⅓ cup Hershey's unsweetened cocoa powder, 1 cup of white sugar, 1 teaspoon of vanilla extract, ¼ teaspoon of salt, ¼ teaspoon of baking powder, and either a ½ cup of all-purpose flour, ½ cup of chickpea flour, or a ¼ cup chickpea flour and ¼ cup all-purpose flour combined. All the ingredients were gathered into large mixing bowls and mixed until homogenized with a KitchenAid mixer (KitchenAid, St. Joseph, Michigan, USA). After the batter was mixed, the control batter and the experimental chickpea flour batters were poured into their respective baking pans. Disposable tin pans were sprayed with non-stick canola oil spray. The brownies were then placed in the oven for approximately 30 minutes at 350 degrees Fahrenheit.

Physical Measurements

The process of making the brownie batters was then repeated in order to take the objective measurements. The objective measurements that were recorded were pH, moisture content, and volume index. The data collected for pH was done so by using the brownie batter while it was still in its wet state before baking. The pH was recorded by placing the pH electrode (Sper Scientific, Environmental Measurement Instruments, Scottsdale, AZ, USA) directly inside the room temperature brownie batter. Each measurement was done twice. The pH electrode was washed with distilled water in between each reading.

Moisture content was obtained by using a moisture HC103 analyzer (Mettler Toledo, Toledo, OH, USA). Each measurement was done twice. Approximately 4g of the baked brownie was placed in an aluminum pan and set at 120 degrees Celsius. Volume index was recorded next using a Vernier caliper (Nortools International LTD, China) to measure 5 points on a single brownie piece. The volume index was obtained by measuring the height on each corner of a brownie slice, along with the middle point. This was done 3 times per each brownie group, the control and the two experimental groups, using 3 different corner slices on each group to measure. The volume index was taken three times in order to gather more data on the different groups of brownies.

Sensory Measurements

Sensory evaluations were also conducted using a 9-point hedonic scale. The 9-point hedonic scale is commonly used in the food industry to measure the acceptability of food. The scale ranges from 1 being “dislike extremely” to 9 being “like extremely”. There were 23 participants, male and female ranging from the ages of 20 to 29, that participated in the sensory evaluations. Appearance, color, flavor, texture, taste, and overall acceptability were all evaluated. Samples of the brownies were cut into fourths and placed on to a white plate for the participants to try. Each group was given a three digital random number. Participants were given a score sheet to evaluate the samples and were instructed to take a sip of water before and after consuming each sample.

Statistical Analysis

Statistical analysis was performed using the IBM SPSS Statistics Version 27 (IBM, Armonk, NY, USA) to compare the differences and similarities between three groups. A One-Way ANOVA test was performed, along with a post-hoc test using LSD (Least Significant Difference). Data in are shown as mean ± standard deviation (SD). Significant differences between groups were determined at the significance level of $p < 0.05$.

Results

From the sensory characteristics data in Table 1, there were no significant differences in appearance, color, flavor, texture, taste, and overall acceptability. The control brownies ranked slightly higher than the other chickpea variations in overall acceptability, taste, and flavor. The 100% chickpea flour brownies were slightly scored higher than the other groups in appearance, color, and flavor. However, none of the differences in evaluations were drastic enough to indicate significance. These findings suggest that total and partial replacement of all-purpose flour with chickpea flour in the making of brownies would be an acceptable substitution as indicated by the participant’s high, positive ratings and likeability, which are mostly the same as the control brownies. That means a consumer would not suspect much of a difference in a baked product that completely or partially substituted a normal all-purpose flour for chickpea flour.

Adding chickpea flour and using it as a substitute to all-purpose flour in brownies showed slight variance. From the physical properties data in Table 2, it was found that there was a significant difference ($p < 0.05$) in volume index between the control brownies and both the chickpea flour brownies at ratios 50% and 100%. The data collected showed that the height averages of the brownies that used chickpea flour were significantly higher compared to the control brownies that used the normal all-purpose flour.

Discussion/Conclusion

After analyzing the results, it was concluded that there were no significant changes in the pH, moisture content, and sensory characteristics of brownies made with all-purpose flour compared to brownies made with 50% chickpea flour and 100% chickpea flour substitutions. The only significant change that was identified from the research was in the volume index or height of the brownies after baking. From the

sensory evaluations, the control brownies and the chickpea flour brownies in partial and whole substitutions were similar in shape, color, size, and taste.

In the Wiley Journal of Texture Studies, a similar study was conducted using chickpea flour in muffins compared to wheat flour. They found that in the muffins made with chickpea flour alone, they ". . . had lower hardness, springiness, cohesiveness, chewiness, and resilience than the control ones." (Alvarez et al., 2017). This result was due to the difference in protein concentrations of the two types of flours. Compared to the data found with the brownies that used chickpea flour, the texture was found to be slightly better than that of the control brownies made with all-purpose flour. Similar to our study they also found that there were no other significant changes in the muffins and that they expected a "high ranking for consumer acceptance" (Alvarez et al., 2017). This is of importance for the sales of baked good made with chickpea flour instead of a normal all-purpose flour. That way a baked food item can appeal to those who live healthy lifestyles or gluten-free ones.

The only significant difference found was in the height of the brownies and how much they raised during baking, but this would not be a detrimental factor to consumer appeal and acceptance. Since there were no significant changes in the sensory characteristics it can be concluded that chickpea flour can be used as a good substitute, fully and partially, for all-purpose flour in brownies and/ or baked goods for consumers. The use of chickpea flour would help overcome the problem of low nutritional value as most consumers find in everyday foods, but the substitution with chickpea flour shows to be the solution to add nutritional value back into food as there is no significant differences compared to foods made with normal all-purpose flour. The consumers who would benefit from this conclusion would be health-conscious people who want to add nutritional value to their foods such as increased protein content or zero gluten, and patients who suffer lifestyle diet diseases such as celiac disease.

References

Alvarez, M. D., Herranz, B., Fuentes, R., Cuesta, F. J., & Canet, W. (2016). Replacement of wheat flour by chickpea flour in muffin batter: Effect on rheological properties. *Journal of Food Process Engineering, 40*(2). https://doi.org/10.1111/jfpe.12372

Alvarez, M. D., Herranz, B., Jiménez, M. J., & Canet, W. (2017). End-product quality characteristics and consumer response of chickpea flour-based gluten-free muffins containing corn starch and egg white. *Journal of Texture Studies*, *48*(6), 550–561. https://doi.org/10.1111/jtxs.12263

Bulbula, D. D., & Urga, K. (2018). Study on the effect of traditional processing methods on nutritional composition and anti nutritional factors in chickpea (Cicer arietinum). *Cogent Food & Agriculture*, *4*(1), 1422370. https://doi.org/10.1080/23311932.2017.1422370

Guardado-Félix, D., Lazo-Vélez, M. A., Pérez-Carrillo, E., Panata-Saquicili, D. E., & Serna-Saldívar, S. O. (2020). Effect of partial replacement of wheat flour with sprouted chickpea flours with or without selenium on physicochemical, sensory, antioxidant and protein quality of yeast-leavened breads. *LWT*, 129, 109517. https://doi.org/10.1016/j.lwt.2020.109517

Herranz, B., Canet, W., & Alvarez, M. D. (2017). Cornstarch and egg white enriched gluten-free chickpea flour batters: Rheological and structural properties. *International Journal of Food Properties*, *20*, S489–S506. https://doi-org.ezproxy.uakron.edu:2443/10.1080/10942912.2017.1299760

Hirdyani, H. (2014). Nutritional composition of Chickpea (Cicerarietinum-L) and value added products—A review. *Indian Journal of Community Health*, *26*(Supp 2), 102–106.

Sadigova, M. K., Buhovets, V. A., Belova, M. V., & Rysmuhambetova, G. E. (2018). Technology solutions in case of using chickpea flour in industrial bakery. *Scientific Study & Research. Chemistry & Chemical Engineering, Biotechnology, Food Industry*, *19*(2), 169–180.

Xiao, Y., Huang, L., Chen, Y., Zhang, S., Rui, X., & Dong, M. (2016). Comparative study of the effects of fermented and non-fermented chickpea flour addition on quality and antioxidant properties of wheat bread. *CyTA: Journal of Food*, *14*(4), 621–631. https://doi-org.ezproxy.uakron.edu:2443/10.1080/19476337.2016.1188157

Appendix

Table 1. Sensory attribute scores from consumer evaluations

	Appearance	Color	Flavor	Texture	Taste	Overall Acceptance
Control	7.09 ± 1.70	7.35 ± 1.53	7.04 ± 1.26	6.87 ± 1.60	7.22 ± 1.28	7.39 ± 0.99
50% Chickpea	7.17 ± 1.53	7.17 ± 1.43	6.48 ± 2.15	7.17 ± 1.59	6.65 ± 2.19	6.67 ± 2.23
100 % Chickpea	7.78 ± 1.56	7.52 ± 1.50	6.52 ± 2.02	7.04 ± 2.12	6.43 ± 2.11	6.78 ± 2.02

Data presented as mean ± standard deviation

Table 2. Quantitative measurements of physical characteristics

	pH	Volume Index	Moisture Content
Control	5.60 ± 0.04	17.53 ± 1.25[#]	11.02 ± 0.95
50% Chickpea	5.64 ± 0.05	20.69 ± 1.40	9.96 ± 0.24
100% Chickpea	5.71 ± 0.06	20.69 ± 1.46	10.53 ± 0.04

Data presented as mean ± standard deviation

[#] Indicates significant difference ($p < 0.05$)