Sensory Characteristics, Acceptability and Dietary Fiber of Brownies Produced from *Theobroma Cacao* Shell Flour

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Abstract: According to statistics, around 4,000,000 tons of cocoa mass is produced annually for the mass production of cocoa, and about 114,000 tons are the wastes incurred from cacao shells. Several studies have found high contents in certain nutrients in these shells. Particularly for its fiber content, it has been found that around 50-60% of the cacao shells consists of the total dietary fiber. This study reconciles the wastes produced from cocoa production, specifically shell wastes, and its high significant dietary fiber levels. It further aims to produce brownies with flour from pulverized cacao shells which would then be evaluated for acceptability and analyzed for dietary fiber content. In doing so, a recipe was tried thrice applying the modifications of predetermined ratio of 25%, 50%, 75% and 100%. Sensory Characteristics Evaluation and Acceptability was conducted to 41 conveniently sampled panelists. Results were statistically analyzed using One-Way Analysis of Variance (ANOVA) to determine significant differences among ratings, and if significant, was further analyzed through Tukey's Honest Significant Difference Test. The Dietary Fiber content was measured through the AOAC and AACC Methods which was statistically analyzed through ANOVA and Linear Regression. Results for sensory evaluation showed that 25% was the most preferred ratio, followed by 75%, 50% and then 100% as the least preferred while the dietary fiber content was found to be increasing as the percentage of cacao shell flour increases. Overall, 75% was the most acceptable due to its relatively high preference and high dietary fiber content.

1 INTRODUCTION

1.1 Research Background

Chocolate industry has been on the rise for many years and demands does not seem to fluctuate, and cocoa made it possible for chocolate products to flourish in the market. Chocolate is produced from the *Theobroma cacao* (cacao) tree. The beginning of chocolate or cacao domestication has been discovered around 3000 years ago, predominant in areas with warm climates and high humidity (Gibson, 2018). For the past decade, the total worldwide production of cocoa can roughly be estimated around 4 million tons according to statistics (Statista, 2019 & International Cocoa Organization, 201). Production of cocoa is abundant in tropical countries all around the world but more significantly in the areas of South America, Africa and Southeast Asia.

The cacao fruit houses the seed of the plant covered in mucilaginous pulp[4]. In the production of cocoa used in chocolate industry, harvesting, fermenting, drying, roasting and winnowing are parts of the process of obtaining the cocoa mass used. The harvesting of the fruit is identified through the color of its pod husk which is the first waste in this process. Then, it is followed by fermenting the cacao seed with its pulp in which the pulp will be separated from the seeds. Seeds are dried usually under the sun, roasted, and then winnowed. Roasting maintains the intrinsic flavor developed from fermentation. After winnowing, cacao nibs are obtained leaving behind wastes in form of cacao shells. (Gibson, 2018 & de Souza et. al., 2018)

1.2 Related Literature

Cocoa and its parts consist of many nutrients unknown to even exist in them. Several studies found that cocoa actually has high levels for dietary fiber. The compounds that give cocoa this property is present in all parts of the cocoa (Azizah et. al., 1997). However, the different parts of cocoa vary in the nutrient content that they possess. Cocoa beans are

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the widely used part of the cacao plant. Lecumberri et. al. (2006) identified in their study that the cocoa beans has 60% dietary fiber content of the dry weight-- where approximately 17% of this is soluble dietary fiber (SDF) while the remaining 83% is the insoluble dietary fiber (IDF). In a separate study on the chemical comparison between cocoa beans and coffee beans, it was discovered that cocoa beans contain the about 17% crude fiber (Oyeyemi, 2017). In addition, Martinez et. al. (2012) determined in their study that the total dietary fiber (TDF) in the cocoa pod husk is approximately at 56%, and that around 95% consists of IDF while the remaining 5% consists of the SDF.

Cocoa production especially those catered for mass-production entails a lot of process which involves unusable losses or wastes. In cocoa processing and chocolate production, excellent quality of cocoa beans depends on the extent that the shell is removed from the cocoa nib as it contributes to undesirable taste and texture to the final product (Okiyama et. al., 2016). Indonesia is considered as one of the tops producers of cocoa globally. With this, a research computed that waste from cocoa bean shells accounted in Indonesia alone for the year of 2009 was around 1700 to 1800 tons, based on the data percent composition of cocoa products as related to statistical values (Djali, 2017). In the Philippines, about 6,200 tons of cocoa mass is produced (Gibson, 2018) meaning that the shell waste from this amounts to roughly 155 tons. According to the International Cacao Organization (2018), the cocoa production estimates in 2016 to 2017 peaked to around 4,400,000 tons which means that around 114,000 tons should constitute the wastes from cocoa shells.

Cocoa shells are found to be consisted mostly of dietary fiber. In a study on different chemical component of the cocoa waste products, it was determined that cocoa shell is composed of 51-55% TDF (Martinez et. al., 2012). Approximately 74% of it is IDF and approximately 26% consists of SDF. Okiyama et. al. (2016) compared several studies on the identification of dietary fiber content of the cocoa shell, and confirmed that in three studies, it was consistent that a kilogram of cocoa shells contains a range of 500 to 600 grams of dietary fiber which means at least half to more than half of the cocoa shells is composed of the dietary fiber. However, in a study conducted by Redgewell and colleagues, showed indication of overestimation of the TDF in cocoa shells due to presence of “Klason Lignin” although they have identified through the AOAC method that TDF, IDF and SDF is 63.6%, 51.9% and 11.7% of the dry weight of the cocoa shell, respectively. Additionally, according to the *in vitro* model systems study conducted, the fiber from cocoa beans shells has the capacity to diffuse and adsorb glucose, hydrolyze starch, and bind sodium cholate, oil and cholesterol (Nsor-Atindana, 2012). In a similar study, Sanchez et. al. (2012) discovered in their study that rats fed with 5% cocoa shell-enriched diet showed decreased risks for cardiometabolic diseases as manifested by less weight associated with low food intake, lower values of total cholesterol, triglycerides and blood pressure, and lower insulin resistance.

Application of the utilization of the wastes incurred from cocoa are very diverse. Most of these applications focus on the well-known characteristics which high fiber content of cocoa wastes particularly cocoa shells. Other applications revolve around its antioxidative properties, and cocoa wastes were also used as food additive. One study took advantage of the cocoa shell and made a fat replacer from the extraction of the soluble fibers and was used in baking chocolate muffins (Martinez-Cervera, 2011). This study showed positive results with feedback mostly focused on the texture that the cocoa shell brings into the product. Only a certain amount of oil should be replaced with the extracted soluble fiber to ensure nutritional content which then results to overall acceptability. In their comparison of the different cocoa shell applications, Okiyama et. al. (2016) mentioned another study which concluded that about 6% of the added soluble fiber from cocoa shells is the acceptable considering all aspects. Currently, in the University of the Philippines Los Baños (UPLB), scientists have found a way to turn cocoa pod husk into a nutritious food supplement (de Jesus, 2017) since cocoa wastes have been found to contain high nutritional value especially for dietary fiber (Nsor-Atindana et.al., 2012 & Sanchez, et. al., 2010). UPLB National Institute of Molecular Biology and Biotechnology further focused on addressing this concerns as large amounts of these waste products tend to be put away and disposed. Other application of the cocoa wastes include use as food additive for additional food flavoring and intermediate ingredients in functional foods. In the non-human application of the cocoa wastes, it is currently being used as additive to feeds of certain animals, natural fertilizer for the crops and biomass and biogas support. Indeed, it has been shown that there are lots of potential for the utilization of wastes of the cocoa industry.

1.3 Research Objectives

In this study, the concerns regarding waste product from cocoa production shall be addressed in such way that it will tackle how such by-products could be transformed as a consumable food item. Another point is that a dietary fiber food source is not optimized due to the lack of ways to convert cocoa production wastes, particularly cacao shell, into a more acceptable food product. With this, cacao shells can then become a possible cheap source of dietary fiber. The research aims to produce flour from pulverized cacao shell which will then be used as an ingredient in baking brownies, and to measure the acceptability of these brownies along with its dietary fiber content. Specifically, this study aims to (1) bake brownies using cacao shell flour at different percentage variations; (2) determine which cacao flour percentage variation is the most acceptable through sensory evaluation; and (3) compare differences of dietary content between the brownies made with cacao shell flour than those of made with ordinary flour.

1.4 Scope and Limitations

The study was conducted from March to May 2019 at the Bio-Assay Laboratory of the Institute of Human Nutrition and Food at the University of the Philippines Los Baños in Laguna. Cacao shell samples were collected from Lipa City, Batangas. The research focused on producing flour from cocoa food waste, used it in baking brownie, and measured its dietary fiber content. It aimed to address cocoa waste production from a barangay in the city of Lipa, Batangas, Barangay Bolbok, since this specific community has *tablea* (native cocoa nibs) production as one of their main livelihood job. Since the study is only limited to a specific community in Lipa City, it covered *Theobroma cacao* variety available in that area. In addition to that, this study only focused on producing one baked product- brownie. It also aimed to measure the nutrient content of the brownie but only limited to within dietary fiber content. In terms of methodology for product development, the steps performed were lacking. Instead of having a formal sensory evaluation for each trial of the recipe trial, the evaluation was informally done by providing characteristic comments for each product. With this, the acceptability for the successful recipe have no quantitative gauge since it relies more on qualitative basis.

2 METHODOLOGY

2.1 Sample Collection and Processing

The raw material to be used in the production of the cocoa flour came from the barangay of Bolbok in Lipa City, Batangas. This community has *tablea* production as one of their livelihoods, which means that as they produce cocoa mass for *tablea,* they incur waste from cocoa shells. Cocoa shells are obtained as by-product from roasting cacao beans before it is grinded. These were obtained from the small-scale cocoa roasters.

The cocoa shells' raw material was washed to get rid of physical contaminants and then dried using the dehydrator to remove the additional moisture caused by washing procedure. The shells were grinded finely to achieve powder-like flour samples using a grinder. A commercial grinder was used to grind large amounts of cocoa shell. After that, the obtained flour was sifted, and the large particles were further pulverized by the spice and herb grinder to achieve the flour-like powder form. The mentioned equipment was available at Bio-Assay Laboratory in the Institute of Human Nutrition and Food.

2.2 Brownie Production

The flour from the cacao shell was then used to make a bakery product particularly a brownie since it was accounted that cacao shell produced a bitter taste. Therefore, incorporating it in a chocolate-flavored product can bask in that undesirable taste. In making the baked product, a recipe was adopted and modified. Five predetermined setups were utilized in the study: control setup with no modifications; first setup was substituted with 25% shell flour; second setup was substituted with 50% shell flour; third setup was substituted with 75% shell flour; and fourth was substituted with 100% shell flour. All the recipes of the setups were standardized first to test out the palatability of the setups. After three recipe trials, the final recipe for the brownie was generated, applying the necessary adjustments. The brownie then underwent sensory evaluation for its characteristics and acceptability.

2.3 Sensory Evaluation of Brownies

2.3.1 General Procedure

The brownies produced from shell flour was tested for evaluation of sensory characteristics and acceptability. This measured the acceptability of the

characteristics of the product in comparison to percentage of shell flour that it contains and identify which percentage variation is the most acceptable. Forty-one students were randomly selected through convenience sampling to participate in the study, and they were asked to accomplish informed consent forms. The sensory evaluation forms used a 7-point hedonic scale for the general attributes such as taste, appearance, aroma and texture. The best and least sample were also asked in the latter part of the questionnaire along with recommendations and suggestions. After collating the responses, the results were statistically analyzed through the appropriate statistical analysis.

2.3.2 Statistical Analysis of Sensory Evaluation

The following statistical analyses were performed to answer the objectives of the study in determining the acceptability of the brownies made from cacao shell flour. Two statistical analyses were done for this to be possible-- namely the One-way Analysis of Variance (ANOVA) and Tukey's Honest Significant Difference (HSD) Test.

One-way Analysis of Variance is a statistical analysis which aims to determine if there is difference in the response variables across a pre-determined set of treatments through observation of means and variances. This statistical analysis tests the null hypothesis that there is no difference in the means of the response variable across treatments. In this study, one-way ANOVA will be used to determine if there is difference in the mean rating of the brownies' characteristics across the percentage of flour used. If the p-value obtained for the characteristics is less than 0.005, it was concluded that the mean rating for each characteristic among variations was significant.

Tukey's HSD Test is a test for pairwise mean difference. This is a consequent test to the one-way Analysis of Variance in which it is performed if the one-way ANOVA is found to be significant. It determined which of the treatment(s) used tend(s) to yield the most desirable values of the response variable. The Tukey's HSD Test was used to identify which brownies from a specific percentage of flour used obtained the highest characteristic rating. These two analysis techniques were used for each characteristic that was asked to the respondents. Subsequently, the treatment which were found to have the highest rating in each characteristic was recorded. The results from this test was summarized to identify which garnered the highest points and was then ranked accordingly.

2.4 Dietary Fiber Analysis of Brownie

For the analysis of the dietary fiber content of the Brownie, the control was compared to the rest of the modified Brownie product. This was aimed to validate the increase in dietary fiber in brownies when the cacao shell flour percentage was increased. The moisture content of the treatments was first determined by measuring the weight of the samples before and after drying them using the hot air oven overnight for about 18 hours. In analyzing the dietary fiber content of the product, AOAC Method was utilized to determine the insoluble dietary fiber, soluble dietary fiber and eventually the total dietary fiber. Calculations were based on the Assay Procedure of the *Megazyme* Kit in which the sample underwent series of filtration, washing and precipitation to obtain the weight for the fiber (Megazyme, 2017). To test if data obtained is statistically sound, the data will undergo ANOVA and HSD Tukey's Test to identify significance, and Linear Regression to further determine the differences.

3 RESULTS

3.1 Flour Amount Identification

In the brownie production, three trials were done to account different comments and suggestions from evaluators. The use of the all-purpose flour and cacao shell flour ratio was also identified from predetermined percentages. The needed amount for the recipe is one-fourth cup, which is equivalent to 4 tablespoons, so the amount of substitution is identified using this unit. The control needed four tablespoon of AP flour and no cacao flour; 25% treatment needed three tablespoon of AP flour and one tablespoon of cacao flour; 50% treatment needed two tablespoon AP flour and two tablespoon cacao flour; 75% treatment needed one tablespoon AP flour and three tablespoon cacao flour; and 100% treatment needed no AP flour and four tablespoon cacao flour (Table 1).

Table 1: Amount of modification of different flour ratio according to setup.

Treatment	All-Purpose Flour (Tbsp)	Cacao Flour (Tbsp)
Control	4	0
25%	3	1

Table 1: Amount of modification of different flour ratio according to setup. (Cont.)

Treatment	All-Purpose Flour (Tbsp)	Cacao Flour (Tbsp)
50%	2	2
75%	1	3
100%	0	4

3.2 General Profile of Population

The Sensory Characteristics and Acceptability was done through an evaluation with a total of 41 respondents which were identified to be all students of the University of the Philippines Los Baños. Out of these 41 people, 31 were female and their mean age was 20.42 years, while 10 were male and their mean age was 20.10 years. Overall, the mean age of the 41 participants was 20.34 years.

The number of votes for different variations as the least preferred and most preferred were counted. The highest preference with 16 votes was for the control variation; followed by the 25% and 50% variations with 7 votes each; followed by 75% variation with 6 votes; and lastly by 100% variation with 5 votes. The least preference with 18 votes was for 100% variation; followed by 50% variation with 12 votes; followed by the control variation with 5 votes; followed by 75% variation with 4 votes; and lastly by 25% variation with 2 votes.

3.3 General Characteristics and Acceptability

The evaluation of the sensory characteristics and general acceptability of the brownie product variations computed for the mean ratings for each characteristics and acceptability among variations (Table 2). Disregarding the control setup who garnered the most points, 25% variation ranked as the most acceptable with a rating of 6.14 while 100% ranked as the least acceptable with a rating of 5.20. Also, the standard deviation was shown to depict discrepancies and 25% treatment showed less varied response while 100% treatment showed most varied response.

3.4 Statistical Results of Sensory Evaluation

In the statistical analysis of the sensory characteristics of different brownie products, the total mean squares and their p-values were obtained to show which characteristics have shown significant differences. Aroma showed insignificant differences with a P-value of 0.3268 which is within the significance limit (<0.05). On the other hand, appearance, texture and flavor have P-values of 0.0050, 0.0412 and <0.0001, respectively which are all within the significance limit (Table 3).

Table 2: Mean and standard deviation of ratings for sensory characteristics and general acceptability evaluation.

CHARACTERISTICS	Control	25%	50%	75%	100%
Appearance	5.83 ± 0.97	5.59 ± 1.12	5.59 ± 0.87	5.39 ± 1.12	5.44 ± 1.98
Aroma	5.95 ± 0.95	5.78 ± 0.79	5.54 ± 1.03	5.68 ± 1.06	5.12 ± 1.25
Texture	6.05 ± 0.89	5.71 ± 0.90	5.71 ± 0.90	5.63 ± 1.09	5.44 ± 1.12
Flavor	6.12 ± 0.78	5.51 ± 0.98	5.51 ± 0.98	5.51 ± 1.05	4.90 ± 1.16
General Acceptability	6.14 ± 0.69	5.78 ± 0.72	5.78 ± 0.98	5.56 ± 0.90	5.20 ± 1.17

Table 3: P-values of sensory characteristics and their rankings based on Tukey's HSD Test.

TREATMENT	RANKING PER CHARACTERISTICS				OVERALL TOTAL	OVERALL RANK
	Aroma (0.3268)	Appearance (0.0050)	Texture (0.0412)	Flavor (<0.0001)		
Control	3.0	1.5	1.0	1.0	6.5	1
25%	3.0	1.5	3.0	3.0	10.5	2
50%	3.0	3.5	5.0	3.0	14.5	4
75%	3.0	3.5	3.0	3.0	12.5	3
100%	3.0	5	3.0	5.0	16.0	5

The sensory characteristics with significant figures were subjected to Tukey's Honest Significant Difference (HSD) Test. Results for appearance showed that 25% treatment is the most preferred followed by 75% and 50% treatment while the least preferred is the 100% treatment. As for the results for texture, it showed that all treatments were highly preferred except for the 50% treatment. The result for flavor showed that 50% showed the highest preference followed by 25% and 75% treatment while the least preferred is the 100% treatment. As summarized (Table 3), it can be observed that upon considering all characteristics of the different brownie variation while also disregarding the control setup, 25% cacao shell flour treatment ranked the highest followed by the 75% treatment then by the 50% treatment while the 100% treatment remain the lowest.

For the moisture and dietary fiber composition of the brownie products, it was found that moisture content decreases while dietary fiber content increases as the percentage of cacao shell flour is also increased (Table 4). The insoluble dietary fiber content for the control, 25%, 50%, 75% and 100% treatments are at 0.58%, 0.82%, 1.04%, 1.30% and 1.41%, respectively. The soluble dietary fiber content for the control, 25%, 50%, 75% and 100% treatments are at 1.34%, 182%, 2.34%, 2.92% and 3.49%, respectively. With this, it is obvious that there is an apparent increasing pattern as well for the total dietary fiber. This model was determined to be significant using the ANOVA as it has shown a p-value within the limit (<0.0001) and was further verified by Tukey's Test for Honest Significance in which no percentages were identified similar.

In summary for the total dietary fiber content (Table 5), the coefficients for different cacao shell flour variations were identified. This value indicates the increase in total dietary fiber content across different cacao shell flour variation assuming the setup with no cacao shell flour is the baseline. This means that compared to the pure all-purpose flour brownie, an increase of 25% cacao shell flour would mean an increase in total dietary fiber by 0.7467%. The same goes with the following variations; 50% variation will have a 1.4633% increase; 75% variation will have a 2.3033% increase; and 100% variation will have a 2.9833% increase. This model was considered significant as supported by the p-value of less than 0.001 (<0.001) which is within the <0.05 limit. Indeed, this shows that cacao shells contain quite significant amounts of dietary fiber as seen in the increase that occurs with its presence in the recipe.

In this study, the average weight for a serving (9-sq. inch) of brownie is computed to be approximately 92 grams. Given the weight and computed dietary fiber percentage content of a brownie, the actual weight of the dietary fiber in the brownie was computed (Table 6). In here, the base treatment which was the control was identified to contain only 1.77 grams of total dietary. The 25% treatment contained 2.46 grams while 50% treatment contained 3.11 grams of total dietary fiber. Furthermore, the 75% treatment contained 3.88 grams dietary fiber while the 100% treatment contained 4.51 grams of dietary fiber. The values of each brownie were then compared to the different recommended nutrient intake (RNI) for dietary fiber per age group to identify its contribution to daily intake. For 6-9 years old, the 25%, 50%, 75% and 100% treatments have percent daily values of 12.6%, 17.5%, 22.2%, 27.7% and 32.2% respectively. For 10-12 years old, the 25%, 50%, 75% and 100% treatments have percent daily values of 10.4%, 14.5%, 18.3%, 22.8% and 26.5% respectively. For 13-15 years old, the 25%, 50%, 75% and 100% treatments have percent daily values of 8.9%, 12.3%, 15.6%, 19.4% and 22.6% respectively. For 16-18 years old, the 25%, 50%, 75% and 100% treatments have percent daily values of 7.7%, 10.7%, 13.5%, 16.9%, 19.6% respectively. For Adults and Elderly, the 25%, 50%, 75% and 100% treatments have percent daily values of 7.1%, 9.8%, 12.4%, 15.5% and 18.0% respectively. From this data, it can be observed that the treated setups have relatively higher percentages of dietary fiber compared to the normal product in the form of the control. Specifically, most of them are considered high since their values range from 10% and above.

Overall, the brownies from cacao shell flour have acceptable characteristics while its dietary fiber are higher than a brownie produced purely from all-purpose flour.

4 DISCUSSION

The sensory evaluation was the first part done to determine as to whether the brownie product has acceptable characteristics. Participants of the evaluation were found to be around 18 to 29 years (average age of 20.34) which implies that respondents are within the young adult age group. The results from the evaluation generally showed that as cacao shell flour increased, the preference for the brownie decreases. However, given the values of the mean ratings per characteristics (Table 2), it can be further noted that the products are within the range of

Table 4: Percentage content for moisture and the dietary fiber across different brownie variations.

TREATMENT	Moisture Content (%)	Insoluble Dietary Fiber (%)	Soluble Dietary Fiber (%)	Total Dietary Fiber (%)
Control	12.61±1.14	0.58±0.01	1.34±0.02	1.97±0.02
25%	10.40±1.05	0.82±0.02	1.85±0.02	2.67±0.03
50%	10.27±1.09	1.04±0.22	2.34±0.02	3.38±0.02
75%	8.86±0.45	1.03±0.02	2.92±0.03	4.22±0.05
100%	9.53±0.80	1.41±0.23	3.49±0.03	4.90±0.25

Table 5: Summary of the coefficients and p-values of the dietary fiber content across the different cacao shell flour percentage variations of the brownies.

Variables Control as the baseline	Coefficient	Standard Error	t-statistics	P-value
25%	0.7467	0.0930	8.02	<0.001
50%	1.4633	0.0930	15.73	<0.001
75%	2.3033	0.0930	24.75	<0.001
100%	2.9833	0.0930	32.06	<0.001
(Intercept)	1.9200	0.0658	29.18	<0.001
P-value of the model: <0.001 (F statistic: 327.13)				

"slightly like" to "like". This means that although there is a decreased preference for the increasing cacao shell flour ratio, all brownie variations are acceptable but with 25% treatment with less varied response while 100% treatment with the most varied responses. In the statistical analysis, a slightly different ranking was obtained since all aspects were considered.

These results can be better explained by associating the sensory characteristics with the age group of the respondents. The age range of the study are within the young adult age group. According to the comments from the evaluators, the product is characterized by a mixture of sweet, bitter and sour taste with a bit of residual texture. A study showed that texture or the mouthfeel contributes to picky eating behaviors of young adults just like among children (Nederkoorn et. al., 2019). In another perspective, it was determined that among adolescents and young adults, bitter taste is the least preferred taste while sour taste is perceived as an unpleasant taste (Hoffman et. al., 2016) which can gradually turn into liking as adulthood progresses. The age group of the population of this study may have explained the reason behind the low preference for the increased percentage of cacao shell flour. However, it is important to note that this population was accidentally determined. Given this information, it can be assumed that preference for high cacao shell flour brownie was not as favorable due to the flavor and texture of the product.

On the other hand, the dietary fiber determination was the second part of this study. From the results, there is an increasing pattern with increasing cacao shell flour percentage. With this, it can be assumed that the total dietary fiber of the different brownie variations consists more of the soluble dietary fiber rather than the insoluble dietary fiber (Table 4). This differs from the studies conducted on dietary fiber composition of cacao shells[8]. Although this difference may be attributed to the presence of other food ingredients in the brownie, it is also important to note that no changes in proportion occurred even if the other flour component is decreased which can mean that the cacao shell itself may have contributed to the brownie as well. As for the statistical analysis of these results, it was determined that it showed significant values which means that the increase in dietary fiber across variations were indeed different from one another (Table 5).

Table 6: Recommended nutrient intake (RNI) across different ages and percent daily values (%DV) of the treated brownies.

Brownie Setup	Dietary Fiber Content (g)	6-9 years old % DV	10-12 years old % DV	13-15 years old % DV	16-18 years old % DV	Adults & Elderly % DV
		RNI: 14.0 g	RNI: 17.0 g	RNI: 20.0 g	RNI: 23.0 g	RNI: 25.0 g
Control	1.77	12.6	10.4	8.9	7.7	7.1
25%	2.46	17.5	14.5	12.3	10.7	9.8
50%	3.11	22.2	18.3	15.6	13.5	12.4
75%	3.88	27.7	22.8	19.4	16.9	15.5
100%	4.51	32.2	26.5	22.6	19.6	18.0

Table 7: Percent daily values of different variations across age groups and their classification.

SETUP	6-9 years old		10-12 years old		13-15 years old		16-18 years old		Adults & Elderly	
	%DV	Class	%DV	Class	%DV	Class	%DV	Class	%DV	Class
Control	12.6	Good	10.4	Good	8.9	-	7.7	-	7.1	-
25%	17.5	Good	14.5	Good	12.3	Good	10.7	Good	9.8	-
50%	22.2	Rich	18.3	Good	15.6	Good	13.5	Good	12.4	Good
75%	27.7	Rich	22.8	Rich	19.4	Good	16.9	Good	15.5	Good
100%	32.2	Rich	26.5	Rich	22.6	Rich	19.6	Good	18.0	Good

As for the nutritional significance of the product, the percent daily values of each variations showed significant results (Table 6). According to the guide for Nutrition Labelling of the Food and Drug Administration in the United States (2013), a food serving containing at least 10% of the daily values for a nutrient are considered as good sources while at least 20% of the daily values are considered for rich sources. With this assumption, the claims for the brownie product are observed. Results shows that compared to the normal brownie (control), a modified (cacao shell flour) brownie are better sources of dietary fiber as evidenced by good and rich sources classifications according to the FDA. Indeed, the product made from cacao shell flour are better when it comes to dietary fiber content.

5 CONCLUSION

Overall, the study on the sensory characteristics and general acceptability of the brownie from cacao shell flour was able to (1) produce brownies from predetermined percentages of cacao shell flour; (2) evaluate the sensory characteristics and general acceptability of the product from 41 respondents which were identified to be within the young adult age group; and (3) identify significant differences in dietary content of the brownies across the percentages. The brownies are identified as acceptable since the general ratings for the variations of brownies were determined to range from “slightly like” to “like”. More specifically, disregarding the control, the descending acceptability of the variations are as follows: 25%, 75%, 50% and then 100%. As for the differences in dietary content of the brownies, the increase in dietary fiber were 0.7467%, 1.4633%, 2.3033% and 2.9833% for flour variation increase by 25%, 50%, 75% and 100%, respectively.

In conclusion, considering all factors, the most acceptable cacao shell flour percentage is the 75% variation. Even though it ranked second for the sensory evaluation, its high dietary fiber content contributed the most since it ranked to have the second highest dietary fiber while 25% variation only ranked fourth. For a 90-gram serving of a brownie, this percentages can be classified as rich source of dietary fiber for school-aged children (6 to 12 years old), and as good source of dietary fiber for the older groups. From this study, cacao shell flour is a feasible flour substitute with higher content of dietary fiber. Preferences for the cacao shell flour are varied but is within acceptable levels as evidenced by mean ratings

of all variations. Consumers may benefit from this since dietary fiber functions in several health maintenance mechanisms especially in the nutrient digestion and absorption, and in preventing occurrence of certain cardiovascular diseases (Riccioni et. al., 2012 & Carlson, et. al., 2011).

6 RECOMMENDATION

In the future, this study can serve as basis for studies on usability of cacao shell flour. It can specifically target more about its nutrient content aside from the dietary fiber itself. Other than that, for baking, its gluten content can be determined to identify its capabilities and quality as flour for other pastries or baked product. Furthermore, cacao shells can be explored more as studies in this aspect are rare. Cacao shell has shown great potential for dietary fiber which might be beneficial in the future. Research on its toxicity is feasible as well to balance out its benefits with probable harmful effects.

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