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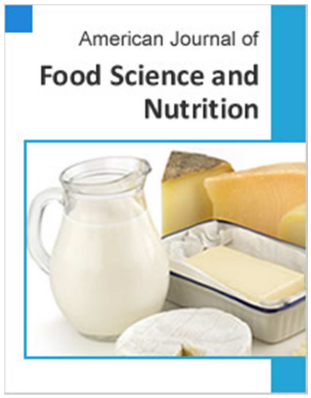

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Sensory and Nutritional Attributes of Black Bean Brownies

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Abstract

Legumes can replace fat in baked food products. Recent obesity epidemic justifies the focus on lower calorie baked product options. The use of black beans as fat replacer reduces total kcal, fat content, and improves nutritional quality of baked foods. Black beans were chosen due to their dark color which blends well with the color of brownies. This study aims to determine the taste, mouthfeel, aroma, appearance, overall acceptability, and nutrient composition of brownies made with black bean puree as replacement for shortening. Four variations of brownies were made at 0% (control), 30, 60, and 90% black bean puree replacement for shortening. Exactly 167 untrained panelists evaluated the brownies using a 9-point hedonic scale. Statistical Analysis of Variance (ANOVA) followed by Bonferroni multiple comparison post hoc tests were used to analyze the data obtained from the study. One-way ANOVA revealed significant differences (p<0.05) in appearance, odor, mouthfeel, taste, and overall acceptability when shortening was replaced with black beans. Bonferroni post hoc test for all sensory attributes indicated that 30% fat replacement was not significantly different from the control. Furthermore, 30% fat replacement compared with control showed a reduction in 12 kcal and 1.5 g fat per 34 g serving. Using an acceptability level of 20 for total score, the control, 30, 60, and 90% fat replacements were rated acceptable. This study showed that pureed black beans can replace as much as 90% of the fat (by weight) in brownies, while yielding acceptable and nutrient-rich products. Black bean fat replacement would be an effective and acceptable option, especially for brownies made with black bean at 30% fat replacement.

1. Introduction

Obesity is the second leading preventable cause of death in the United States. Obesity rates (33.8%) have risen to an all-time high of one out of every three adults [1]. Robert Wood Foundation [2] reported that after 30 yrs of marked increase in obesity rate in America, adult obesity rates remained level in every state except Arkansas in past year; where 13 states had adult obesity rates above 30%, 41 states had rates at least 25%, and every state was above 20%. In 1980 no state was above 15%; in 1991, no state was above 20%; in 2000 no state was above 25%; and in 2007 only Mississippi was above 30% (http://stateofobesity.org/files/fasinfat2013.pdf). A Robert Wood Foundation's [3] most recent data released September 2015 reported that rates of obesity now exceed 35% in three states (Arkansas, West Virginia and Mississippi), 22 states have rates above 30%, 45 states are above 25%, and every state is above 20%. Arkansas has the highest adult obesity rate at 35.9% while Colorado has the lowest at 21.3%

(http://stateofobesity.org/rates/)

Overweight and obesity due to energy imbalanced between kcal consumed and kcal expended are the 5th leading risk for global deaths [1].

Overweight and obesity increase is linked to 1) an increased intake of energy-dense foods that are high in fat, salt and sugars but low in vitamins, minerals and other micronutrients and, 2) decrease in physical activity caused by the increasingly sedentary nature of many forms of work, changing modes of transportation, and increasing urbanization [4]. These changes in dietary and physical activity patterns are often due to environmental and societal changes associated with development and lack of supportive policies in sectors such as health, agriculture, transport, urban planning, environment, food processing, distribution, marketing and education [1]. In order to prevent overweight and obesity, WHO [4] recommends a diet that limits energy intake from total fats, while decreasing saturated and trans-fat consumption; and emphasizes the consumption of fruits, vegetables, legumes, whole grains, and nuts, while added sugars and salts are not advised. Furthermore, diet recommendations to prevent chronic diseases such as overweight and obesity are designed to achieve energy balance and a healthy weight. WHO recommends limiting intake of sugars and engaging in regular physical activity to achieve energy balance and maintain a healthy weight [4]. Fat replacement in brownies using black beans may be a successful ingredient to aid in meeting these dietary recommendations.

Legumes such as black beans, a carbohydrate-based fat replacer, are high in proteins, complex carbohydrates, and fiber; and low in saturated fat. Some studies have established the health benefits of legumes [5, 6, 7, 8]. Potential health benefits from legumes include reducing risk of cancer, heart disease, and osteoporosis; and lowering blood cholesterol and management of diabetes mellitus. One study [9] showed that there is a significant inverse relationship between legume intake and risk of coronary heart disease (CHD). Legume intake may play an important part in diet therapy to prevent CHD. They can also help relieve menopausal symptoms due to their high content of is flavones [7]. More research is needed to determine the actual effect that legumes have on prevention and treatment of chronic disease. Reports on the sensory attributes of substituting fat with legumes in a baked product showed that using legumes at 25% substitution level for fat received similar sensory scores as the control product that had no fat replacement [10]. Sensory parameters assessed include appearance, color, flavor, texture and overall acceptability [11]. The study by Szafranski et al. [12] where cannellini beans substituted shortening in brownies, found that the sensory characteristics were not significantly different when comparing the control brownies (with no fat substitution) with the 50% cannellini bean substitution brownie. Using legumes as fat replacers which resembles sensory characteristics of fats can result in up to 80% reduction in cost than shortening [13]. The Legume-based fat replacers are good sources of fiber, plant sterols, beneficial oligosaccharides, antioxidants, lignans, phenolic acids, phytoestrogens and other phytochemicals, as well as a variety of vitamins and minerals [14].

Different fat replacers are used in baking; however, few fat replacers yield a comparable result to non-modified foods while reducing calories and increasing nutritional value. Legumes have been shown as effective fat replacers in baked products that decrease fat and increase nutritional value [10]. USDA states that black beans have a high carbohydrate (62.36%) content which gives the potential for being a successful fat replacer. Black beans are low in fat (1.41%), and high in protein (21.60%), dietary fiber (15.5%), B vitamins, zinc, potassium, magnesium, calcium, and iron [15]. An additional benefit is that dietary fat absorption is reduced in the presence of considerable dietary fiber. Black beans are inexpensive, and readily available. Moreover, the dark color of black beans blends well with the color of brownies. It is hypothesized that chocolate brownies prepared with 30, 60 and 90% black bean puree (as fat replacers) will yield a baked product with acceptable sensory attributes when compared with a traditional chocolate brownie made with shortening. This study aims to 1) assess the acceptability of chocolate brownies prepared with black bean puree as a replacement for 30, 60, and 90% of shortening; and 2) compare sensory characteristics of modified brownies with traditional brownies made with 100% shortening. It was assumed that all participants could read and understand instructions & survey materials; and that they responded in an open and honest manner.

2. Materials & Methods

Table 1. *Chocolate Brownie Formulas*.*

Variable	Control	30%	60%	90%
Ingredient				
Shortening	255.2 g	178.6 g	102.1 g	25.5 g
Black Bean Puree	0 g	76.5 g	153.1 g	229.6 g
Sugar	737.1 g	737.1 g	737.1 g	737.1 g
Salt	7.1 g	7.1 g	7.1 g	7.1 g
Vanilla	7.1 g	7.1 g	7.1 g	7.1 g
Fresh, Large Eggs	7	7	7	7
Enriched all-purpose flour	425.2 g	425.2 g	425.2 g	425.2 g
Cocoa	170.8 g	170.8 g	170.8 g	170.8 g
Baking Powder	14.2 g	14.2 g	14.2 g	14.2 g

*Recipe formulation was performed as described by USDA [16].

Four variations of brownies made with black beans were analyzed and ranked on a 9-point hedonic scale based on six sensory characteristics. Chocolate brownies that were analyzed included a control (0% shortening replacement), 30, 60 and 90% shortening replacement with black bean puree. Compositions of the four brownie samples are shown in Table 1 as described by USDA [16].

2.1. Formulas and Procedures

The formulation of the black bean brownies was adapted

from the USDA website [15]; http://www.fns.usda.gov/tn/Resources/all_numerical.pdf). The original recipe was used as the control without fat replacement; then altered by percentage to accommodate black bean puree as a fat replacer at three different concentrations. The recipe was originally expressed in ounces but was converted to grams to be more accurate as well as adhere to international metric system requirement [17].

2.2. Procedure for Preparing Control and Variations

The brownies were prepared on Tuesday afternoon before the sensory evaluations which took place the following Wednesday, Thursday, and Friday of the same week. All ingredients, except the eggs, were held at room temperature until use. Eggs were held in the refrigerator. For preparation of the brownies, all ingredients were gathered and the oven was preheated to 350° F. To prepare the black bean puree, canned black beans were strained-off the liquid and rinsed twice to remove excess sodium. To begin the batter preparation, shortening and/or black bean puree were creamed with the sugar, salt, and vanilla in a mixer for 2 min on medium speed. Then the eggs were added and beaten for 3 min on medium speed. The flour, cocoa, and baking powder was then added and mixed at medium speed until completely incorporated. Batter was then spread into 2 disposable aluminum pans (11-3/4"L × 9-3/8"W × 2-5/16"H) which had been previously lightly coated with pan release spray and labeled with the appropriate three-digit sample identification number representing the brownies proportions. Brownies were then baked in a conventional oven at 350° F for 20-30 minutes. Each pan of brownies was tested with a tooth pick to reassure that they were cooked through before removing. The tooth pick came out clean when done. Each pan of brownies was left out to cool at room temperature and then cut into 100 pieces and placed in cups on tables labeled with their corresponding three-digit numbers. Water was provided to the panelists to cleanse palates in-between tasting of each sample. Brownies were stored at room temperature in plastic wrap covered containers until the tasting period.

2.3. Nutritional Composition of Brownies

Nutritional information of each chocolate brownie product was gathered from the USDA database [15]. Each ingredient of the control brownie variations was entered separately into the database to obtain its nutritional composition. Then the nutrients were added together to get the total content for that brownie. This step was repeated with each black bean brownie formula used for comparison (Table 2). After the nutritional information was calculated, a two-tailed T-test was done for the combined samples of the control and 30% brownies as well as the combined samples of the 60% and 90% brownies, using the Statistical Package for the Social Sciences Software PASW Student Version 18 (SPSS) [18].

Table 2. *Nutritional Profile of Chocolate Brownies (adapted from USDA, 2011).*

Variable	Control	30%	60%	90%
Nutrient Content				
Calories	152	140	128	117
Protein	2.43 g	2.56 g	2.70 g	2.83 g
Carbohydrate	23.35 g	23.72 g	24.08 g	24.44 g
Total Fat	6.98 g	5.46 g	3.99 g	2.42 g
Cholesterol	26.04 mg	26.04 mg	26.04 mg	26.04 mg
Vitamin A	37.8 IU	37.9 IU	38.0 IU	38.1 IU
Iron	1.03 mg	1.06 mg	1.10 mg	1.13 mg
Calcium	26.58 mg	26.98 mg	27.36 mg	27.79 mg
Sodium*	96.58 mg	96.54 mg	96.50 mg	96.46 mg
Dietary Fiber	1.36 g	1.50 g	1.63 g	1.77 g

*Sodium content may be less than indicated amount due to canned black beans being rinsed prior to use.

2.4. Testing

Overall acceptability and palatability of the control and three variations of brownies were evaluated by 167 untrained panelists after approval from the Institutional Review Board (IRB). The brownies (made on Tuesday) were tasted by five different sets of panelists on Wednesday, Thursday, and Friday. To determine whether the freshness of the brownies had any effect on the sensory properties of the brownie, score sheets were labeled one through five to represent the time that they were tasted. Tasting periods took 15-20 minutes each depending on how long the panelists spent analyzing the brownies. During the tasting periods, panelists evaluated the brownies blindly by using a three-digit number. Panelists were asked to taste the brownies in random order to minimize positional error [19]. Panelists were also asked to carefully match the three-digit number of the brownie with the corresponding column on the scoring sheet. Three-digit numbers were used to eliminate biases that could potentially be associated with certain numbers [19]. The scoring sheet allowed panelists to rank each brownie using a 1-9 scale relating to key characteristics such as appearance, odor, mouthfeel, taste and total score. The total score represents each sensory characteristic added together. A 1-9 point hedonic scale has been used in similar studies to show acceptability and palatability of similar products [20, 21, 22, 10, 11, 12]. This study used a rating scale of 1-9 which consists of 9 (like extremely), 8 (like very much), 7 (like moderately), 6 (like slightly), 5 (neither like nor dislike), 4 (dislike slightly), 3 (dislike moderately), 2 (dislike very much), 1 (dislike extremely). Panelists were asked to remain silent during the tastings and not to discuss opinions or

ratings about the brownies with other panelists. Based on the 9-point hedonic scale, an acceptability level was generated using a score of five or higher (neither like nor dislike) for each individual sensory characteristic. For total score, an acceptability level of twenty or higher (average of neither like nor dislike) has been generated. The acceptability levels represent the point at which the product is liked enough to be used on average in everyday baking without yielding a product that is disliked. Additionally, the higher the value of the acceptability level the more the product is liked for either the individual characteristic or the overall liking (total score).

2.5. Statistical Analysis

Data was analyzed using analysis of variance (ANOVA) to determine the differences in the means of the groups. Alpha level for statistical significance was set a priori at $p<0.05$. ANOVA was also used in similar studies to analyze results [12, 11, 10]. This was followed by the Bonferonni multiple comparison post hoc test which compared specific pairs of means (Tables 4, 5, 6, 7, 8). Statistical analysis was executed with a PC computer by using the Statistical Package for the Social Sciences Software PASW Student Version 18 (SPSS) [18].

Table 3. *Analysis of Variance (ANOVA) for the Sensory Characteristics and Total Score of Chocolate Brownies made with Different Levels of Black Bean Fat Replacement.*

		Sum of Squares	df	Mean Square	F	Sig.
Freshness of Brownies	Between Groups	0.000	3	0.000	0.000	1.000
	Within Groups	1350.419	664	2.034		
	Total	1350.419	667			
Appearance	Between Groups	48.107	3	16.036	5.504	0.001*
	Within Groups	1919.950	659	2.913		
	Total	1968.057	662			
Odor (Aroma)	Between Groups	193.239	3	64.413	22.258	0.000*
	Within Groups	1918.707	663	2.894		
	Total	2111.946	666			
Mouthfeel (Texture)	Between Groups	471.539	3	157.180	37.165	0.000*
	Within Groups	2803.993	663	4.229		
	Total	3275.532	666			
Taste (Flavor)	Between Groups	670.234	3	223.411	54.567	0.000*
	Within Groups	2714.497	663	4.094		
	Total	3384.732	666			
Total Score	Between Groups	4555.849	3	1518.616	46.332	0.000*
	Within Groups	21600.097	659	32.777		
	Total	26155.946	662			

*Statistically Significant, $p<0.05$

Table 4. *Bonferroni Multiple Comparisons Post Hoc Analysis for Appearance.*

Fat Replacement	Fat Replacement	Mean Difference	Std. Error	Sig.
Control	30%	-0.016	0.188	1.000
Control	60%	0.478	0.188	0.066
Control	90%	0.575*	0.188	0.014
30%	60%	0.494	0.187	0.051
30%	90%	0.590*	0.187	0.010
60%	90%	0.096	0.187	1.000

*Statistically Significant, $p<0.05$

Table 5. *Bonferroni Multiple Comparisons Post Hoc Analysis for Aroma (Odor).*

Fat Replacement	Fat Replacement	Mean Difference	Std. Error	Significance
Control	30%	0.387	0.186	0.231
Control	60%	0.836*	0.186	0.000
Control	90%	1.447*	0.186	0.000
30%	60%	0.449	0.186	0.097
30%	90%	1.060*	0.186	0.000
60%	90%	0.611*	0.186	0.007

*Statistically Significant, $p<0.05$

Table 6. *Bonferroni Multiple Comparisons Post Hoc Analysis for Mouthfeel (Texture).*

Fat Replacement	Fat Replacement	Mean Difference	Std. Error	Significance
Control	30%	0.152	0.225	1.000
Control	60%	1.787*	0.225	0.000
Control	90%	1.721*	0.225	0.000
30%	60%	1.635*	0.225	0.000
30%	90%	1.569*	0.225	0.000
60%	90%	-0.066	0.225	1.000

*Statistically Significant, $p<0.05$

Table 7. *Bonferroni Multiple Comparisons Post Hoc Analysis for Taste (Flavor).*

Fat Replacement	Fat Replacement	Mean Difference	Std. Error	Sig.
Control	30%	0.381	0.222	0.516
Control	60%	2.160*	0.222	0.000
Control	90%	2.196*	0.222	0.000
30%	60%	1.778*	0.221	0.000
30%	90%	1.814*	0.221	0.000
60%	90%	0.036	0.221	1.000

*Statistically Significant, $p<0.05$

Table 8. *Bonferroni Multiple Comparisons Post Hoc Analysis for Total Score.*

Fat Replacement	Fat Replacement	Mean Difference	Std. Error	Significance
Control	30%	0.940	0.629	0.814
Control	60%	5.296*	0.629	0.000
Control	90%	6.000*	0.629	0.000
30%	60%	4.355*	0.628	0.000
30%	90%	5.060*	0.628	0.000
60%	90%	0.705	0.628	1.000

**Statistically Significant, p<0.05*

3. Results & Discussions

3.1. Nutritional Composition of Brownies

Results of the two-tailed T-test of the nutritional profile of four brownie variations (Table 2) showed no significance among the four samples at $p=0.1$ possibly due to the fact that the values were estimates from the USDA nutrient database. A different outcome may be obtained between each set of two groups (control and 30% brownies; and 60% and 90% brownies) if exact values with more precise means and standard deviations were determined in the lab. Overall, the total calories and fat per serving decreased as the percentage of black bean puree increased (Table 2). Furthermore, the nutritional value in protein, vitamin A, iron, calcium, and dietary fiber increased as the percentage of black bean puree increased. Nutritionally, the brownie with 90% black bean replacement is the healthiest option of the brownies. A similar report by Asif et al. [23] stated that legumes are valued for their nutrient density.

The nutritional composition of brownies improved by substituting pureed black beans for shortening. The greatest improvements were seen in the reduction of kcal and fat. A decrease of 12 kcal and 1.52g total fat were seen in the 30% black bean brownie compared to the control and a decrease of 24 kcal and 2.99 g total fat were seen in the 60% black bean brownie compared to the control for a 1.2 oz (34 g) serving. The use of legumes as fat replacers in food products probably leads to a reduced saturated fat consumption recommended by WHO [4]. A recent study on the nutritional properties and consumer acceptability of a yellow split pea cracker made with inulin and maltodextrin showed the cracker had reduced fat content (≤25% than reference food) based on the Australian Food Standards Code [24] – which requires that products must contain at least 25% less fat than in the same quantity of a reference food to claim that the product is reduced fat [25].

3.2. Brownie Freshness

Effect of brownie freshness was measured since brownies were tasted in five different sessions which was based on when each set of panelists was available. Tastings were labeled 1-5 with one being the first and having the freshest brownies. There was no significant difference ($F=0.000$, $p>0.05$) in all brownie scores relating to the freshness of the brownies; therefore, no post hoc analysis was conducted.

3.3. Appearance

Analysis with One-way ANOVA (Table 3) indicated significant differences in appearance between fat replacement groups ($F=5.504$; $p<0.05$). Post hoc analysis (Table 4) showed a significant difference in the comparisons between

the control and 90% variations (μ_d = 0.575, p<0.05) and between the 30% and 90% variations (μ_d=0.590, p<0.05). However, no significant differences were indicated between the i) control and 30% variations (μ_d= -0.16, p>0.05), control and 60% variations (μ_d = 0.478, p>0.05), 30% and 60% variations (μ_d = 0.494, p>0.05), or 60% and 90% variations (μ_d=0.096, p>0.05). This suggests that appearance does not differ in brownies at a fat replacement of up to 60%. Similar results were found in another study using legumes where appearance was not affected by percent of fat replacement [12]. In another study using legumes as fat replacers, no significant difference was found at 25% fat replacement [10].

3.4. Aroma (Odor)

Analysis with one-way ANOVA (Table 3) indicated significant difference in odor between fat replacement groups (F=22.258, p<0.05). Post hoc analysis (Table 5) showed significant differences between the control and 60% groups (μ_d = 0.836, p<0.05), control and 90% groups (μ_d = 1.447, p<0.05), 30% and 90% groups (μ_d = 1.060, p<0.05), and 60% and 90% groups μ_d = 0.611, p<0.05). However, no significant differences were indicated between the control and 30% groups (μ_d = 0.387, p>0.05), or the 30% and 60% groups (μ_d = 0.449, p>0.05). This suggests that odor is not significantly different from the control at 30% black bean fat replacement.

3.5. Mouthfeel (Texture)

Analysis with One-way ANOVA (Table 3) indicated significant differences in mouthfeel between fat replacement variations (F=37.165, p<0.05). Post hoc analysis (Table 6) showed significant differences between control and 60% variations (μ_d = 1.787, p<0.05), control and 90% variations (μ_d = 1.721, p<0.05), 30% and 60% variations (μ_d = 1.635, p<0.05), and 30% and 90% variations (μ_d = 1.569, p<0.05). However, no significant differences were indicated between the control and 30% variations (μ_d = 0.152, p>0.05) or 60% and 90% variations (μ_d = -0.066, p>0.05). This suggests that mouthfeel is not significantly different from the control at 30% black bean fat replacement. Similar results were found in a study using legumes as fat replacement where no significant differences were found until 75% fat replacement [12]. Another study showed that at 25% fat replacement with legumes, there were no significant differences [10]. Several authors noted that increased hardness as fat replacement level increased is a critical flaw in reduced fat baked products [26, 27, 28, 29].

3.6. Taste (Flavor)

Analysis with one-way ANOVA (Table 3) indicated significant differences in taste between fat replacement groups (F=54.567, p<0.05). Post hoc analysis (Table 7) showed significant differences in the control and 60% groups (μ_d = 2.160, p<0.05), control and 90% groups (μ_d = 2.196, p<0.05), 30% and 60% groups (μ_d = 1.778, p<0.05), and the 30% and 90% groups (μ_d = 1.814, p<0.05). However, no significant differences were indicated between the control and 30% groups (μ_d = 0.381, p>0.05) and the 60% and 90% groups (μ_d = 0.036, p>0.05). This suggests that taste is not significantly different from the control at 30% black bean fat replacement. Similar results were found in another study [10] using legumes as fat replacement where significant differences were found in the 50% and 75% bean brownies but not in the 25%. Another study showed no significant difference until 75% bean replacement [12].

3.7. Total Score

Analysis with One-way ANOVA (Table 3) indicated significant differences in total score between fat replacement groups (F=46.332, p<0.05). Post hoc analysis (Table 8) showed significant differences in the control and 60% groups (μ_d = 5.296, p<0.05), control and 90% groups (μ_d = 6.000, p<0.05), 30% and 60% groups (μ_d = 4.355, p<0.05), and 30% and 90% groups (μ_d = 5.060, p<0.05). However, no significant differences were indicated between the control and 30% groups (μ_d = 0.940, p>0.05) or the 60% and 90% groups (μ_d = 0.705, p>0.05). This suggests that the total score of black bean brownies is not significantly different at 30% compared with the control chocolate brownie. A study using legumes found that significant differences occurred with as little as 25% fat replacement [10]. Another study using legumes as fat replacement did not indicate significant differences between brownies until 75% [12].

3.8. Acceptability Level

The control brownie was favored for appearance, odor, mouthfeel, taste, and total score. Brownies prepared with 30% fat replacement did not differ significantly when compared the control brownie. On all measurements except appearance, the brownies with less or no black bean replacement are liked on average more than brownies with greater levels of black bean replacement. All four brownies would be considered acceptable for appearance and odor, using a minimum hedonic score of 5 (neither like nor dislike) as acceptable (Figs 1, 2). Using the same score for acceptability, the control and 30% brownies would be considered acceptable for mouthfeel and taste. Both the 60% and 90% brownies were not considered acceptable for mouthfeel and taste but were close candidates with means from 4.49 to 4.65 (Figs 3, 4). A hedonic score of a minimum of 20 was considered acceptable for total score and showed that all four brownies would be considered acceptable (Fig. 5). Therefore, this study showed that it is possible to substitute up to 90% pureed black beans for fat in chocolate brownies and still yield an acceptable product. However, the control brownie was preferred by tasters over the black bean substituted brownies and as the percent of black bean fat replacement increase the total score decreased. These results were similar to those found in another legume fat replacement studies [10, 12]. Further studies are needed to determine the effects of substituting black beans for fat in other baked products.

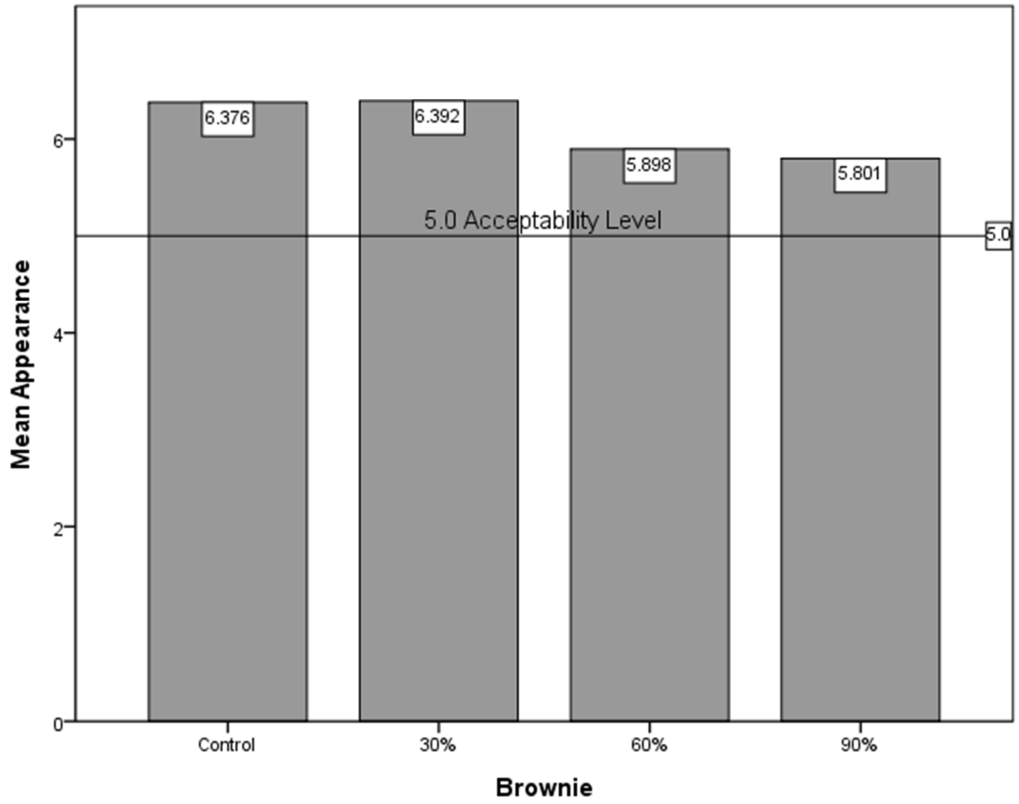

Figure 1. *Comparison of Mean Scores for Appearance of Chocolate Brownies Made with Black Bean Puree Fat Replacement.*

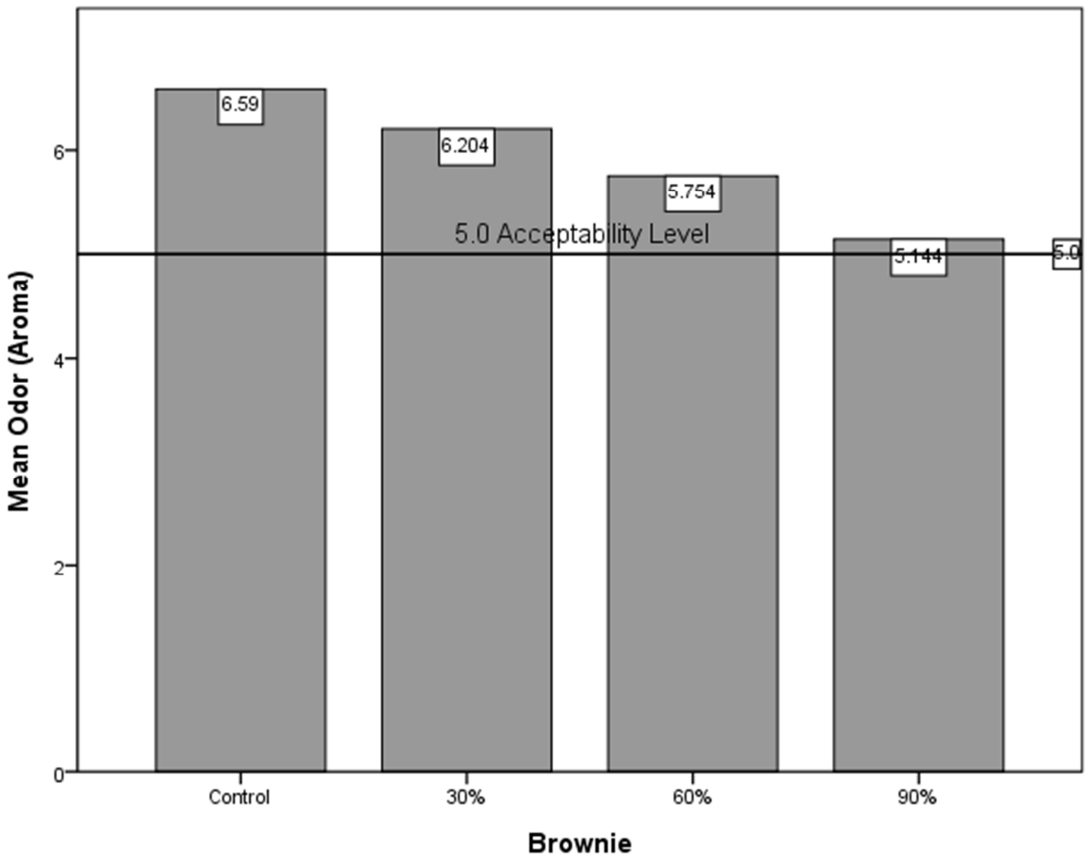

Figure 2. *Comparison of Mean Scores for Odor of Chocolate Brownies Made with Black Bean Puree Fat Replacement.*

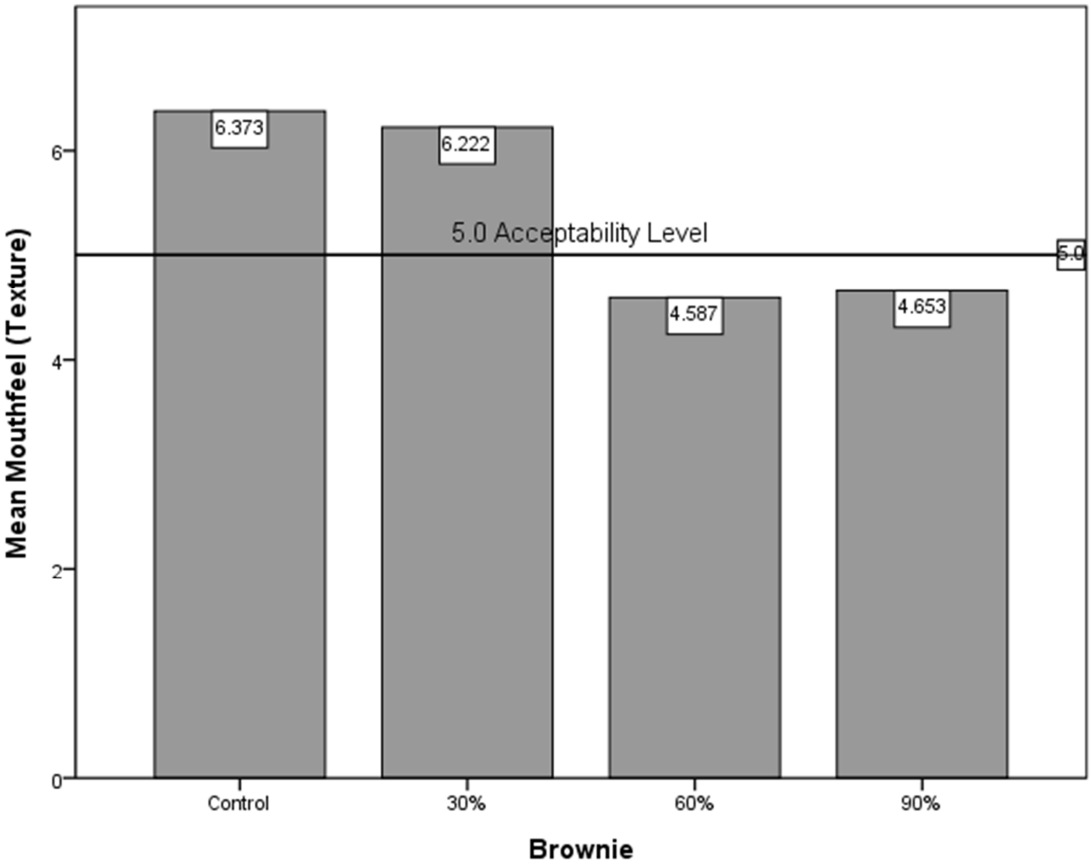

Figure 3. *Comparison of Mean Scores for Mouthfeel of Chocolate Brownies Made with Black Bean Puree Fat Replacement.*

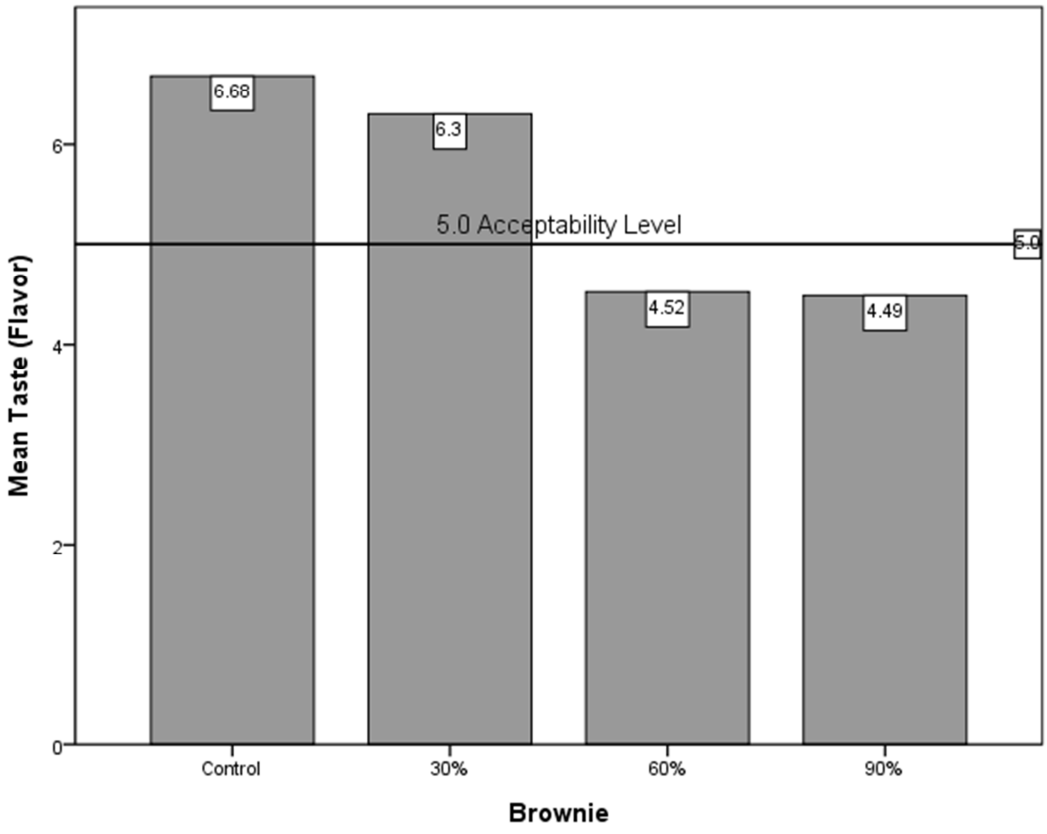

Figure 4. *Comparison of Mean Scores for Taste of Chocolate Brownies Made with Black Bean Puree Fat Replacement.*

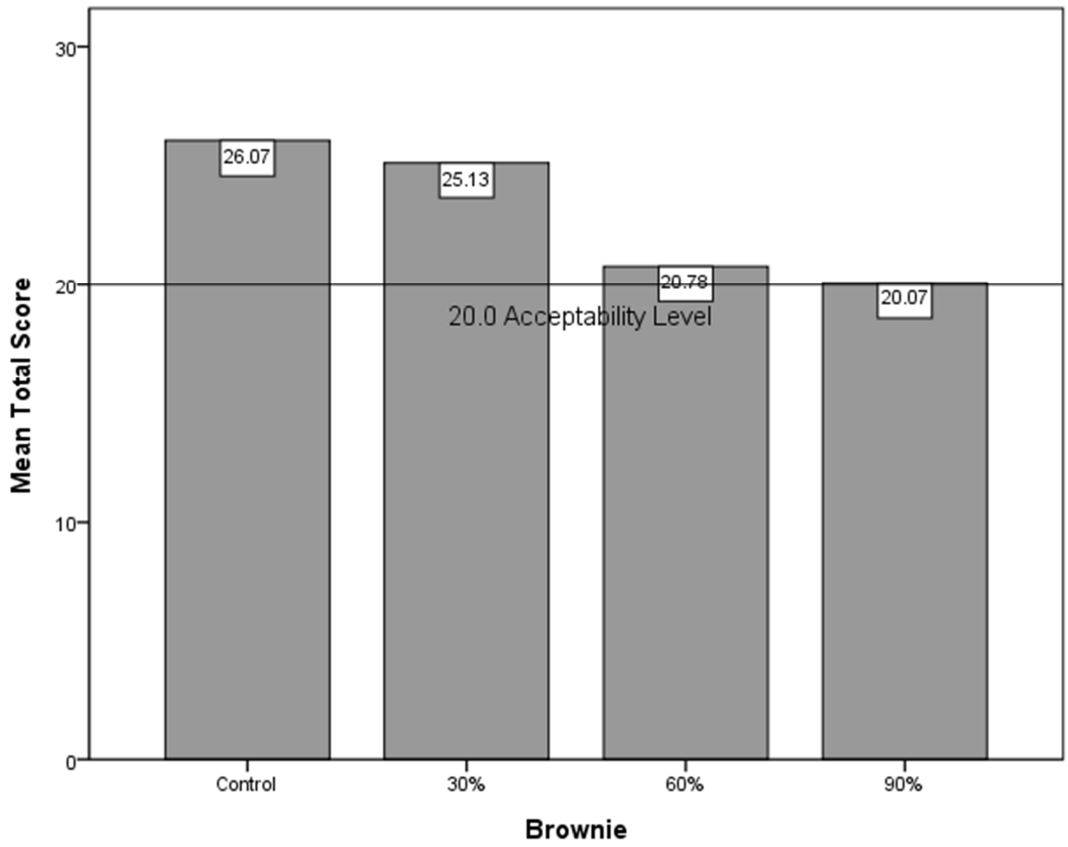

Figure 5. *Comparison of Mean Scores for Total Score of Chocolate Brownies Made with Black Bean Puree Fat Replacement.*

4. Conclusions

Findings of this study demonstrate that black bean puree is acceptable at 30, 60 and 90% replacement for shortening. This is supported by reports from other published studies.

However, substituting a smaller concentration of black beans with shortening may be a viable option for fat replacement in brownies given that they yield a product that is easy to make (simply drain, rinse, and puree), have an improved nutritional composition, and cost about the same (compared to shortening). Black bean puree should be considered as a viable option for fat replacement in brownies both at home and in the foodservice industry.

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