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Sensory and Objective Evaluation of Pumpkin Bars using Ground Flaxseed or Sweet Potato Baby Food as Egg Replacers

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Abstract The purpose of this study was to produce an acceptable dessert product that met the dietary needs of an individual with an egg allergy. Three variations of pumpkin bars were analyzed to determine sensory and objective differences in taste, mouthfeel, overall acceptability, batter viscosity, and springiness that resulted due to the elimination of eggs in the recipe. The experimental variations consisted of a replacement of eggs with ground flaxseed, a replacement of eggs with sweet potato baby food, and a control recipe utilizing eggs. Samples of each variation's batter were subjected to viscosity testing using a Bostwick Consistometer. The distance that each 30mL batter sample travelled was recorded at two and four minutes. Once the pumpkin bars were baked and cooled, they were cut into 1"x1" squares for sensory analysis. A total of thirty-nine participants completed a randomized taste test of the pumpkin bars and filled out a ballot to rate the samples on a four-point Likert scale for taste, mouthfeel, and overall acceptability. Data collected from the sensory ballots was entered into SPSS, and paired sample *t*-tests were completed to compare each of the three variations. The variation made with sweet potato baby food had the highest average ratings for taste and overall acceptability; however, statistical analysis concluded that there was no significant difference between the control and either variation for taste, mouthfeel, or overall acceptability. The pumpkin bar samples were subjected to a springiness test using a Brookfield Texture Analyzer, with the Control producing the springiest final product. It was concluded that acceptable dessert products, specifically pumpkin bars, can be produced without the use of eggs, and that certain egg replacers may even create products of greater acceptability to consumers.
Keywords *Dessert Product; Egg Allergy; Sensory Analysis*

1. Introduction

Food allergy prevalence is increasing within the population, with eggs being one of the top eight allergens found in foods [1]. This makes it necessary to develop effective ways to replace eggs in food products and discover egg alternatives made with ingredients that consumers readily have access to. A major category of foods that frequently incorporate eggs are baked products. The

diverse function of eggs as leavening agents, binders, thickeners, and emulsifying agents makes it difficult to create a universal substitute [2].

Ground flaxseed when mixed with water will form a gel comparable to the consistency of eggs. The literature revealed limited research studies using flaxseed as a flour replacer [3, 4], but not distinctively as an egg replacer. Borneo, Aguirre, & Leon [5] concluded that a similar gel produced with chia seeds could be utilized as an effective egg or oil replacer, but no research could be found that specifically used flaxseed as an egg replacer in baked products. The effectiveness of this flaxseed gel in replicating the baking properties found in eggs was evaluated.

Previous studies have created appealing dessert products by replacing eggs with pureed fruits or vegetables, however little information could be found on the use of sweet potatoes in this area. One study attempted to utilize sweet potatoes as a fat replacer in brownie products and reported that the variation with 100% replacement of fat strongly correlated with overall acceptability [6]. Sweet potatoes were chosen as the second variation in this study because of the rich orange color that would blend nicely with the canned pumpkin in the Control recipe and the lack of research evaluating the use of sweet potatoes as effective egg substitutes.

The main objective of this study was to create an acceptable dessert product that eliminated the use of eggs for individuals with an egg allergy. The purpose of this specific experiment was to test the overall acceptability of pumpkin bars prepared using ground flaxseed or sweet potato baby food as a replacement for eggs. The following research questions were addressed through the experiment: i) Is there a statistically significant difference in desired sensory properties of taste, mouthfeel, and overall acceptability for pumpkin bars made with a) Ground flaxseed, b) Sweet potato baby food, and c) Control recipe using eggs? ii) Is there a statistically significant difference in desired objective variables of batter viscosity and cake springiness for pumpkin bars made with a) Ground flaxseed, b) Sweet potato baby food, and c) Control recipe using eggs? It was predicted that pumpkin bars made with ground flaxseed would have an equal taste rating, denser mouthfeel, thinner batter viscosity, and decreased springiness. Pumpkin bars made with sweet potato baby food were predicted to have a higher taste rating, denser mouthfeel, thicker batter viscosity, and decreased springiness.

2. Materials and Methods

2.1. Ingredients

Three variations of pumpkin bars were prepared to test quality characteristics of dessert products produced with eggs, flaxseed gel, or sweet potato baby food. Each variation contained the same ingredients except for the substitution of eggs with an egg replacer. The ingredients used in each variation can be found in Table 1. The ingredients utilized in each pumpkin bar recipe were entered into Food Processor (Version 10.12.0), a nutrient analysis software, to determine the total Calories, fat, carbohydrate, fiber, and protein found in one serving size of pumpkin bars. It was determined that one batch of pumpkin bars yielded thirty-five 2.1”x2.2” servings.

Table 1: *Ingredients Incorporated into Each Pumpkin Bar Variation*

Ingredient	Control Recipe – Eggs	Variation #1 – Ground Flaxseed	Variation #2 – Sweet Potatoes
Sugar	392.0g	392.0g	392.0g
Vegetable Oil	118mL	118mL	88.5mL
Canned Pumpkin	425.3g	425.3g	425.3g
Eggs, beaten	200.0g	-	-
Water	-	88.8g	-
Ground Flaxseed	-	16.2g	-

Sweet Potato Baby Food	-	-	168.0g
All Purpose Flour	252.0g	252.0g	252.0g
Baking Powder	7.0g	7.0g	7.0g
Baking Soda	4.7g	4.7g	4.7g
Salt	2.3g	2.3g	2.3g
Cinnamon	4.6g	4.6g	4.6g
Ground Cloves	0.6g	0.6g	0.6g

2.2. Procedure

Three jelly-roll pans with dimensions of 10.5”x15.5” were obtained for the Control and two variation recipes of pumpkin bars. Each pan was greased with one tablespoon of margarine and one tablespoon of flour to prevent the product from sticking to the pan after the bars had cooked and cooled. After the pans were greased, the oven was preheated to 350^{o}F (177^{o}C).

For the Control recipe, all ingredients were obtained and precisely measured. To create consistency in measurements, each individual ingredient was measured by the same researcher throughout the preparation of the variations. The eggs were measured by cracking four eggs into a single bowl and beating them together with a fork. A portion of 200.0g was then measured from the beaten egg mixture.

For Variation 1, using flaxseed and water, the same ingredients and mixing procedure were followed, except for the addition of eggs. Each egg was replaced with one tablespoon (8.1g) of ground flaxseed and three tablespoons (44.4g) of water. The Control recipe required the use of four eggs; however the equivalent of only two eggs were replaced with the ground flaxseed gel. Therefore, a total of 16.2g of ground flaxseed and 88.8g of water were utilized in replacement. The two ingredients were mixed in a small bowl with a metal fork with the flaxseed added first followed by the addition of water. The flaxseed mixture was placed in the refrigerator for twenty-five minutes in order for the mixture to effectively set and thicken. The gel mixture was stirred intermittently throughout the refrigeration period.

Variation 2 also followed the same ingredient and mixing preparations as the Control recipe, except that sweet potato baby food was used in replacement of the eggs, and the amount of oil utilized was decreased to 88.5mL. Each egg was replaced with ¼ cup (56g) of sweet potato baby food; however, the equivalent of only three eggs was replaced with the pureed sweet potatoes. Therefore, a total of 168.0g of sweet potato baby food was utilized in replacement.

After all of the ingredients had been accurately measured, they were combined into a large glass bowl. The ingredients were mixed with an electric hand mixer at a medium speed for three minutes. At this point, volumes of 90mL were removed from each batter preparation to be used for objective testing using a Bostwick Consistometer. The remaining batter was then poured into one of the jelly roll pans and placed in an oven to bake. The bars were allowed to cook for thirty minutes at 350°F (177^{o}C), or until a toothpick inserted in the center came out clean.

The products were prepared in the same room and on the same day to eliminate extraneous environmental variables. Oven temperature remained constant over all variations; however multiple ovens were utilized for preparation. Once removed from the oven, the pumpkin bars were allowed to cool to room temperature while sitting on the counter for thirty minutes. The bars were then covered with plastic wrap and foil and stored on the counter until it was time to cut and serve.

Using a medium sized chef's knife, a 1.25" border was removed from the perimeter of the bars to create uniformity in all samples and to remove the portion of the bars subjected to greater heat at the edge of the pan. The remaining bars were cut into 1"x1" squares for sensory analysis and objective testing using a Brookfield Texture Analyzer.

2.3. Objective Testing

After the ingredients were mixed with an electric hand mixer, volumes of 90mL were removed from each batter preparation. Each batter sample was tested for viscosity using a Bostwick Consistometer. Viscosity specifically measures the resistance to flow of matter [7]. Individual samples of 30mL were poured into the closed gate of the leveled device, and the chamber was opened when the timed trial began. The force applied was the gravitational pull on the batter sample itself. The distance the batter traveled over a two minute and four minute period was recorded. Three trials of each variation were completed, and all results were averaged for comparison.

Three 1"x1" pumpkin bar samples of each variation were reserved for objective analysis. These samples were tested for springiness using a Brookfield Texture Analyzer. This machine applies force to samples using different probes to simulate a variety of stresses. The number two attachment was utilized to complete a springiness test. Springiness refers to how well a product physically springs back after it has been deformed from compression [7]. The spring back is measured at the down stroke of the second compression from the device. Three trials of each variation were subjected to testing, and their results were averaged.

2.4. Sensory Testing

The three samples provided for each sensory analysis were taken from the same location in each pan using a template. Samples were placed on white paper plates that were equally divided into thirds. A random three digit number was assigned to each sample and these codes were transcribed onto the plates prior to starting the experiment. After cutting the bars, samples were placed into their respective portions on the plate.

The sensory analysis was conducted at a large Midwestern public university. The panelists participating in the study were a convenience sample and were not trained for this sensory test analysis. Individuals who had any form of food allergy were not permitted to participate in the study.

The test began by reading an individualized experiment synopsis and handing out a consent form for each panelist to sign. After having all participants sign and date the waiver, sensory ballots and samples were distributed. Sample plates were slightly rotated when presented to panelists to help prevent positional bias. The panelists were encouraged not to speak during the analysis of the pumpkin bars to eliminate suggestive error. The ballot asked the test subjects to rate the three pumpkin bars on their taste, mouthfeel, and overall acceptability on a four-point Likert scale (Table 2). The four choices on the scale ranged from one being very dissatisfied to four being very satisfied. The goal was to test the acceptability of the products and to determine if there was a statistically significant difference among the three variations.

Table 2: *Pumpkin Bar Sensory Evaluation Ballot*

Sample Characteristics	Very Satisfied	Satisfied	Dissatisfied	Very Dissatisfied
Taste- Should experience a rich pumpkin flavor accompanied by a nice balance of spices	4	3	2	1
Mouthfeel- Should feel moist and fluffy, not dry or dense	4	3	2	1
Overall Acceptability- How well would you rate this pumpkin bar when considering both taste and mouthfeel?	4	3	2	1

2.5. Statistical Analysis

The sensory data recorded from panelist ballots was compiled and entered into an Excel spreadsheet. The data was then downloaded into SPSS (Version 19) for statistical analysis to calculate the overall flavor, mouthfeel, and overall acceptability of each pumpkin bar variation. Descriptive and inferential statistics were used to calculate the ratings recorded by the panelists. A paired-sample *t*-test was performed for the variables of flavor, mouthfeel, and overall acceptability for each variation. Descriptive statistics were used to analyze objective data from the batter viscosity and springiness tests.

3. Results and Discussion

3.1. Results

3.1.1. *Nutritional Analysis*

The nutritional analysis values were generated using Food Processor and represent a single pumpkin bar serving. The Control contained the greatest amount of Calories, while Variation 2 contained the least amount of Calories per serving. Variation 2 also contained the least amount of fat at 2.52g. The Control contained the greatest amount of protein and was the only recipe to contribute any cholesterol. The sweet potato variation contained the greatest amount of carbohydrates per serving, while the flaxseed variation contained the greatest amount of fiber. Complete nutritional analysis of the pumpkin bars is found in Table 3.

Table 3: *Nutritional Analysis of Pumpkin Bar Variations*
Totals are Representative of One Serving Size of Pumpkin Bars—2.1"x2.2"

	Control Using Eggs	Ground Flaxseed	Sweet Potatoes
Total Calories	109.87 kcal	103.84 kcal	98.25 kcal
Fat	3.86g	3.48g	2.52g
Cholesterol	21.26mg	0.00mg	0.00mg
Carbohydrates	17.85g	17.95g	18.56g
Fiber	0.77g	0.91g	0.84g
Protein	1.67g	1.06g	1.02g

3.1.2. *Sensory Testing*

Table 4 presents the results from the sensory analysis testing. A total of thirty-nine subjects participated in the study and completed a sensory ballot. For all variables tested, there was no significant difference ($p<0.05$) between any of the three variations. All samples were rated as acceptable on the four-point Likert scale. The lowest average score was given to the taste of the

Control at 3.15, while the highest scores were given to the average mouthfeel of the Control and Variation 2—both at 3.54. Variation 2 scored the highest in acceptability, while Variation 1 scored the lowest.

Table 4: *Paired-Sample t-Test for Taste, Mouthfeel, and Acceptability of Pumpkin Bar Variations*

Variable	Mean n=39	SD
Taste		
Control	3.15	0.670
Variation 1[a]	3.28	0.647
Variation 2[b]	3.33	0.092
Mouthfeel		
Control	3.54	0.505
Variation 1[a]	3.51	0.644
Variation 2[b]	3.54	0.682
Acceptability		
Control	3.31	0.614
Variation 1[a]	3.23	0.627
Variation 2[b]	3.41	0.595

[a]Variation 1 – Ground Flaxseed
[b]Variation 2 – Sweet Potato Baby Food

3.1.3. *Objective Testing*

Table 5 shows the results of the objective testing for all pumpkin bar variations. Three trials were completed for each variation and results were averaged. For the springiness test, the Control had the greatest springiness at 3.57mm while Variation 1 had the least springiness at 3.06mm. For the batter viscosity testing using the Bostwick Consistometer, the Control travelled the furthest throughout the duration of the test. Variation 2 was the most viscous and travelled the shortest distance in the device.

Table 5: *Mean and Standard Deviation for Objective Testing of Pumpkin Bars*

Variable	Mean N=3	SD
Springiness (mm)		
Control	3.57	0.025
Variation 1[a]	3.06	0.012
Variation 2[b]	3.23	0.215
Distance Spread at 2 min (cm)		
Control	0.53	0.076
Variation 1[a]	0.12	0.029
Variation 2[b]	0.02	0.029
Distance Spread at 4 min (cm)		
Control	0.63	0.116
Variation 1[a]	0.22	0.029
Variation 2[b]	0.17	0.289

[a]Variation 1 – Ground Flaxseed
[b]Variation 2 – Sweet Potato Baby Food

3.2. Discussion

3.2.1. *Nutritional Analysis*

The results from the nutritional analysis show that the sweet potato variation would be the best option for individuals concerned with total Caloric intake. Although the difference in total Calories is relatively small, this difference is most likely the result of decreased fat content in Variation 2. The observation

of overly moist pumpkin bar products was observed in pilot trials utilizing both sweet potatoes and ground flaxseed. This is why equivalents of eggs were not replaced in a one-to-one ratio in the final recipes. In attempt to lower the proportion of wet ingredients in Variation 2, the equivalent of three eggs were replaced with sweet potato baby food and the total amount of vegetable oil was reduced by 29.5mL. Findings of overly moist pumpkin bars were unexpected in Variation 1 since findings by Koca and Anil [4] showed bread products made with ground flaxseed to have increased water absorption due to the high fiber content. The discrepancy of egg equivalents was a variable that was not effectively controlled in the methodology of the experiment and can optimistically be perfected in future studies.

Both Variation 1 and Variation 2 contained zero grams of cholesterol as a result of the elimination of the eggs. This would make these alternatives better options for individuals concerned with their total cholesterol levels and risk for cardiovascular disease and additionally allows vegans, who eliminate all animal products from their diet, to consume this specific baked product. It was also noted that the flaxseed and sweet potato variations had over a half a gram less of protein per serving. With protein as such a focus in food products as of late, this may be seen as a negative factor; however, other benefits such as decreased fat, decreased cholesterol and increased fiber may be of greater concern to consumers.

3.2.2. *Sensory Analysis*

Between the Control, Variation 1, and Variation 2 there was no statistically significant difference over all variables tested. The data from the sensory analysis responses supports the main study objective that acceptable variations of pumpkin bars can be made without the use of eggs. The data suggests that the variations prepared without the use of eggs are just as acceptable as the Control. This contradicts previous findings stating that eggs are essential for cake products to meet quality standards [8].

Even though there was no statistically significant difference between the variations, Variation 2 was rated higher in taste and overall acceptability than the Control. This finding suggests that the addition of the substitute ingredients in replacement of eggs added unique flavor profiles that improved the taste of the final product. The results matched the findings of Forrester et al., [6] who concluded that acceptable baked products can be produced by replacing ingredients with sweet potatoes.

The high proportion of canned pumpkin in this recipe may have compensated for the elimination of egg products due to its moisture and binding qualities. Thus, the addition of ground flaxseed or sweet potato baby food may have had little to no effect on the final product. One avenue for future research would be to produce a variation eliminating the use of eggs with no additional ingredients to compensate for the exclusion. This would test how large of an impact the canned pumpkin played in reproducing the quality characteristics of the eggs.

It was expected that the samples containing flaxseed would have a lower mouthfeel rating due to the grainy texture that the seeds added to the batter. This variation was also perceptibly different because the seeds were visible in the final baked product. These factors may have resulted in Variation 1 having the lowest overall acceptability rating. The findings do support that the gel produced when combing water with ground flaxseed does create pumpkin bar products of high acceptability. Further research should be conducted to determine if this substitution could be generalized to all baked products using eggs.

3.2.3. *Objective Analysis*

Since only three samples of each variation were subjected to each objective test, indication of significance cannot be assumed due to small sample size. Future studies with the resources to conduct objective tests in greater depth are needed to strengthen the findings in this study.

Variation 1 was the least springy of all the samples, which was supported by previous research that found decreased springiness in muffins using ground flaxseed [3]. Previous research conducted using chia seeds as egg replacers in cakes also found similar results. The gel formed from chia seeds mixed with water was comparable to how the flaxseed gel was prepared in this study. Cakes prepared with chia seeds were denser than the Control and had a decreased volume [5]. This recurring finding suggests that foods made with flaxseed gel will have denser qualities that decrease the overall height and airiness of the final product.

The decreased quantity of protein found in Variations 1 and 2 may have hindered the overall structure of the pumpkin bars while baking. While eggs would denature and coagulate in response to the prolonged heat in the oven, neither the flaxseeds nor the sweet potatoes would be able to reproduce these stability and structural qualities. This may have contributed to the pumpkin bar products being more compact and less springy upon testing.

Measurements of batter viscosities illustrated apparent differences between the variations. The Control contained the greatest amount of liquid ingredients, which most likely contributed to its decreased viscosity and increased spread. Modifications in the amount of liquid ingredients in the variations likely caused the variance when testing this variable.

4. Conclusion

The purpose of this experiment was to create an acceptable dessert product that eliminated the use of eggs for individuals with an egg allergy. The production of acceptable pumpkin bars can be achieved without the use of eggs, as supported by the experimental data. Ground flaxseed and sweet potato baby food appear to be quality egg substitutes in the production of pumpkin bars; however further research should be conducted to see if these specific egg substitutions can be applied to other baked products.

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