# Sensory Properties of Banana Muffins Prepared by Replacing Oil with Applesauce and Greek Yogurt

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## Abstract

Sensory properties and nutrients were analyzed when testing Banana Muffin recipes formulated with variable sources of fat. The differences were found to be of no significance when compared to the vegetable oil control recipe when looking at sweetness, moistness, and overall acceptability, but were significant when looking at brownness of the muffins. These results were obtained from a sensory evaluation. The three formulations (n=3) were evaluated by an untrained panel (n=10) and statistical analysis was done using one-way analysis of variance. The highest acceptance amongst all of the recipes was the Greek-yogurt variation which contained 0 g of fat, while the control contained 9 g of fat, except when considering brownness which was rated the lowest with the control banana muffin. The Greek yogurt and applesauce variations both resulted in a muffin with 100% fat reduction, making it a perfect fat-free alternative. This difference may be due to the different reactions of the Greek-yogurt and applesauce variations and how they react with other ingredients when baked. Successful formulation of a modified recipe decreasing fat and calories in banana muffins is beneficial to preventing obesity, diabetes and cardiovascular disease among the population. Reducing caloric consumption and increasing nutrient quality can lead to weight loss and reduction in obesity related risk factors.

**Keywords:** Fat replacers; Fat-free; Applesauce; Greek yogurt; Baked products; Cardiovascular disease

## Introduction

Fat contributes to many sensory and quality properties of a food including physical, textural and olfactory factors which all influence overall palatability. Baked food products, such as crackers, cakes and biscuits, are typically high in fat. There is an increasing demand for healthy snack foods with reduced fat content. In order to maintain consumer acceptance while simultaneously reducing the total fat content, fat replacers have been accepted. Many fat replacers have been investigated in baked food products, ranging from complex carbohydrates, gums and gels, whole food matrices, and combinations thereof. Fat replacers each have different properties that affect the quality of a food product. Excess dietary fat intake, especially from snack foods, is one of the key contributors to excess energy intake resulting in weight gain. Prevalence of overweight and obesity is rising worldwide, which is cause for concern as obesity is associated with increased risk of cardiovascular disease, type 2 diabetes mellitus, and some cancers (Colla, Costanzo, & Gamlath, 2018). Another study shows that reducing the overall intake of dietary fat and gradually replacing it with other ingredients appear to be a feasible approach to control the prevalence of heart disease, obesity, and other metabolic diseases. However, simply removing fats from food may adversely affect the overall quality of products as fat contributes to the physicochemical properties, such as viscosity, texture, appearance, and flavor, of final food products (Peng & Yao, 2017). Thus, using fat replacers in foods has emerged as a promising tool to reduce fat content in the food industry. Fat replacers are classified as fat substitutes and fat mimetics depending on their chemical conformation and functionalities (Peng & Yao, 2017). Reducing total fat and energy intake by consuming low-fat low-calorie foods has emerged as one of the strategies to prevent CVD and obesity. While several health organizations have recommended that dietary fat

intake be strictly controlled, food industries have also been extensively developing and utilizing fat replacers in low- fat foods (Chen, et al., 2019).

In this experiment we examined the effects of two fat replacements on the overall quality of muffins. For this experiment we substituted oil in banana muffins with unsweetened applesauce and plain Greek yogurt. We decided to choose banana muffins because they are easy to prepare, and most people have the ingredients necessary at home already. We decided to substitute out the oil for again common household ingredients such as applesauce and Greek yogurt making a healthier alternative. The purpose of this experiment is to see how the sensory and physical properties differ from the control containing oil with the muffins containing the fat replacement ingredients. For our results, we examined the brownness, sweetness, moistness, overall acceptability, taste, and appearance of all three muffin variations. Since oil is the fat factor and plays a vital role in baked goods, it can be expected that substituting this major ingredient will alter the finished product. The end result of this experiment is to prove that you can substitute fat in baked goods with healthier alternatives and yield a similar product. (Colla, Costanzo, & Gamlath, 2018)

## Materials and Methods

### Ingredients

For this experiment, three banana muffin recipes were prepared variations of fat used. Two recipes containing fat modifications were compared to a control recipe. The control of the three muffin variations contained vegetable oil while the other two recipes substituted Greek yogurt and apple sauce for the vegetable oil. Testing was done to determine the optimal recipe for taste and appearance.

The materials necessary to make the muffins are Pillsbury unbleached all-purpose flour (J.M. Smucker Company Orville, OH), Domino pure cane sugar (Domino Foods Inc. Yonkers, NY), Eggland's Best Eggs (Eggland's Best Inc. Jeffersonville, PA), Arm & Hammer Pure baking soda (Church & Dwight CO. INC Princeton, NJ), Ground Cinnamon (McCormick & Company Baltimore, MD), Calumet Baking Powder (Calumet Baking Powder Co. Chicago IL), Wesson Vegetable Oil (Richardson International Memphis, TN), Bananas (Chiquita Brands International Charlotte, NC), Unsweetened applesauce (Mott's Plano, TX), Plain Fat-Free Greek Yogurt (FAGE USA Dairy Industry Inc. Johnstown, NY), Conventional Oven (Maytag Inc., Benton Harbor, MI), Hand Mixer (Cuisinart Inc., Stamford, CT). The ingredients that were used in these recipes were proved by the Family, Nutrition and Exercise Science department of Queens College. Located in the table A below full list of ingredients for each recipe.

### Sample Formulation and Preparation

The recipe was obtained from https://thehappyhousewife.com (2020) and the fat substitutions were determined by the group. The recipes for the muffins were the same with the exception of the oil substitutions. We first gathered everything needed and preheated the oven to 350° F. Next we divided the bananas amongst three bowls for each variation and mashed them. To the bananas we added the eggs and to one bowl the vegetable oil, one the applesauce, and the last the Greek yogurt. /to each of the banana mixture bowls we added the dry ingredients the flour, baking powder, baking soda, sugar and cinnamon and mixed until combined. Next we lined three twelve cup muffin tins and scooped the batter for each variation into its own tin. We placed the tins in the preheated 350° F oven and baked for 15 minutes. At the 15-minute mark we inserted a toothpick for doneness. Once completely cooked we removed the muffins from the oven and allowed them cool.

**Table 1: Formulation for Banana Muffin Variations**

| Ingredients | Control Recipe | Applesauce Variation | Greek Yogurt Variation |
|---|---|---|---|
| **Banana** | 2 large | 2 large | 2 large |
| **Baking Powder** | 1 1/2 tsp | 1 1/2 tsp | 1 1/2 tsp |
| **Baking Soda** | 1/4 tsp | 1/4 tsp | 1/4tsp |
| **Cinnamon** | 1 shake | 1 shake | 1 shake |
| **Flour, White** | 1 1/2 Cups | 1 1/2 Cups | 1 1/2 Cups |
| **Egg, Large** | 1 egg | 1 egg | 1 egg |
| **Sugar, white** | 3/4 Cup | 3/4 Cup | 3/4 Cup |
| **Vegetable Oil** | 1/4 Cup | N/A | N/A |
| **Unsweetened Applesauce** | N/A | 1/4 Cup | N/A |
| **Greek Yogurt, Fat-Free Plain** | N/A | N/A | 4 tbsp |

**Sensory Evaluation**

Ten individuals (n=10) were selected to participate in the research experiment and consisted of two males and eight females ages 18-40 years old. This untrained panelist was informed of the general purpose of the study and was given basic instructions to taste and evaluate the samples for other sensory attributes (brownness, sweetness, and moistness), a 9-point scale was used with 1 being weak and 9 being strong. A hedonic scale was used for overall acceptability, (1=dislike extremely, 9=like extremely). The experimental recipe was prepared in the food laboratory room 300 located on the third floor in Remsen Hall building part of Queens College Campus. All sensory evaluation was conducted in this room as well. The panelist was given a sensory evaluation sheet to determine the appearance, flavor, texture and overall acceptability of the banana muffins. The evolution sheets used a 1-9 hedonic scale rating, 1 being disliked extremely and 9 being to like extremely. All lighting, temperature, and noise level was controlled for a consistent environment and ideal testing conditions.

The samples were served once completely cooled to room temperature. The samples were taken from each of the three variations and cut evenly into four pieces. Each of the three samples were assigned the random numbers 574, 307, and 129 for control, applesauce, and Greek yogurt respectively to reduce any bias, and set on a paper plate with the corresponding code. Panelists were given templates with the coded muffin sample pieces and a cup of water to cleanse their palate between tastings. Panelists were asked to circle a number 1-9 on the evaluation sheet for how much they liked or disliked the samples, 1 being “dislike extremely” and 9 being “like extremely”. The panelist evaluated four different sensory attributes of appearance brownness, sweetness, moistness and overall acceptability of the sample (refer to Table 2 for full definitions). There was a significant difference ($P< 0.05$) in the brownness of muffins baked using Greek Yogurt and applesauce compared to the control. This is due to the increased protein in the Greek yogurt variation which increases the Maillard reaction. The increased sugar in the applesauce recipe also increases the maillard reaction. There was no significant difference found in the moistness of the muffins baked using vegetable oil, Greek yogurt, or applesauce ($P < 0.05$). There was no significant difference found in the sweetness of the muffins baked using vegetable oil, Greek yogurt, or applesauce ($P < 0.05$). There was no significant difference found in the overall acceptability of the muffins baked using vegetable oil, Greek yogurt, or applesauce ($P < 0.05$).

**Table 2: Sensory Attributes Evaluated**

| Sensory | Attribute | Definition |
|---|---|---|
| **Appearance** | Brownness | 1 means “light brown” and 9 means “dark brown” |
| **Flavor** | Sweetness | 1 means "not sweet, bland" and 9 means "very sweet" |
| **Texture** | Moistness | 1 means “it is less tender (hard to chew)” and 9 means “it is very tender (easy to chew)” |
| **Overall Acceptability** | Liking | The degree of overall liking, 1 means “dislike extremely” and 9 means “like extremely” |

**Data Analysis**

All data collected in this evaluation was measured in rations and measured using SPSS for windows (version 25.0, 2017, IBM Inc., Armonk, NY). One-way analysis of variance (ANOVA) was used and a Tukey test set at a level of significance of $P < 0.05$ was also used to analyze the data. Mean values were determined for each of the attributes and were compared amongst the three variations. The ingredients were analyzed using the Food Processor software for Windows (version 10.7.0., ESHA Research, Salem, OR). Nutrient analysis of macronutrients, dietary fiber, saturated fat, monounsaturated fat, magnesium, potassium, and vitamins E and K were analyzed. Nutrient facts were analyzed using recipal.com and the serving size that was used for nutrient analysis is a 2-inch diameter cookie, which is a common serving size for cookie’s nutrition label. Serving sizes and ingredient amounts were based on the recipe from https://thehappyhousewife.com.

**Results and Discussion**

Analysis of data indicates that there is only a significant difference in the sensory attribute of brownness. The Greek yogurt and applesauce variations had significantly higher values (P=.02) than the control sample using oil. The trend favored the Greek yogurt variation with the highest values for brownness 5.60, sweetness 5.30, moistness 5.50, and overall acceptability 5.90 (refer to table 3). The control was rated the lowest for both brownness and moistness when compared to both modified variations. The brownness may not be an important physical characteristic because color difference may be hard to decipher. The brownness was evaluated as being the lowest in the control at 3.90 and the two modified variations although had no significant results of 5.60 for the Greek yogurt and 5.90 for the applesauce making it the highest sample. The extent of the Maillard reaction can cause gentle sweet flavors or result in a strong burnt or bitter flavor. A study looking at strategies to control the Maillard reaction indicates the extent of the Maillard reaction affecting overall changes in product acceptability (Lund, 2017). The color mostly comes from the type of fat used in baking. The texture of the muffins was evaluated through its moistness and both the Greek yogurt and applesauce variations were ranked 5.50 for moistness. The control muffin ranked the lowest with 4.60.

The control muffin was highest in sweetness with a mean of 5.73 ( refer to table 3). In another study, the use of fruit purees in baked goods can also dull the natural flavors of the baked goods and/or produce off-flavors or add undue Sweetness to the baked goods (Greenland, Lynch III, Mitchell, Mitchell, & Myers, 1997). The applesauce muffin was ranked lowest in sweetness with a mean of 4.70 and the Greek yogurt with a mean of 5.30.

The overall acceptability was highest in the Greek yogurt muffin at a mean of 5.90 when compared to the control and applesauce variations, 5.70 and 4.80 respectively. This was not surprising based on another study that showed using Greek yogurt in baked products in place of oil will yield a very similar product. The final products produced using the yogurt base also yield similar or superior appearance, texture, and taste to their full fat counterparts while providing substantially less calories, fat, and cholesterol (Krzeminski, et al., 2013).

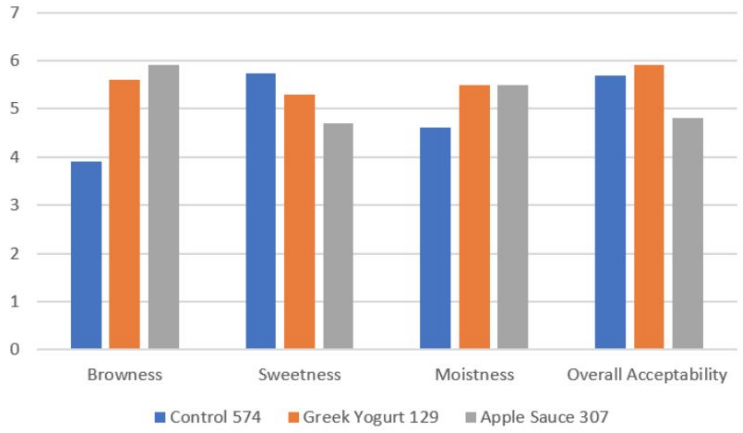
Table 3 below shows the sensory attributes for each of the banana muffin samples. Although none of the results were significant (P <0.05) in this experiment, the muffins made with the applesauce ranked highest for brownness (5.90 ± 1.60) compared to the other two variations. The control ranked highest in sweetness (5.70 ± 1.83). Both the applesauce muffin (5.50 ± 1.18) and Greek yogurt muffin (5.50 ± 1.27) ranked the highest in moistness. The overall acceptability muffin with the highest score was the Greek yogurt ( 5.90 ± 1.37) variation. There is no significant difference among three samples in sweetness, moistness and overall acceptability (P>.05) However in brownness (P=.02) Greek yogurt and applesauce samples had significantly higher values than the control sample using oil.

**Table 3: Sensory attributes for banana muffins prepared by replacing oil with Greek yogurt and applesauce (Mean ± SD)**

| | **Control 574** | **Greek Yogurt 129** | **Apple Sauce 307** |
|---|---|---|---|
| **Brownness** | $3.90^{a}$ ±1.91 | $5.60^{b}$ ±1.23 | $5.90^{b}$ ±1.56 |
| **Sweetness** | $5.73^{a}$ ±1.83 | $5.30^{a}$ ± 1.95 | $4.70^{a}$ ± 2.21 |
| **Moistness** | $4.60^{a}$ ± 1.51 | $5.50^{a}$ ±1.23 | $5.50^{a}$ ±1.18 |
| **Overall Acceptability** | $5.70^{a}$ ±1.16 | $5.90^{a}$ ± 1.27 | $4.80^{a}$ ±1.87 |

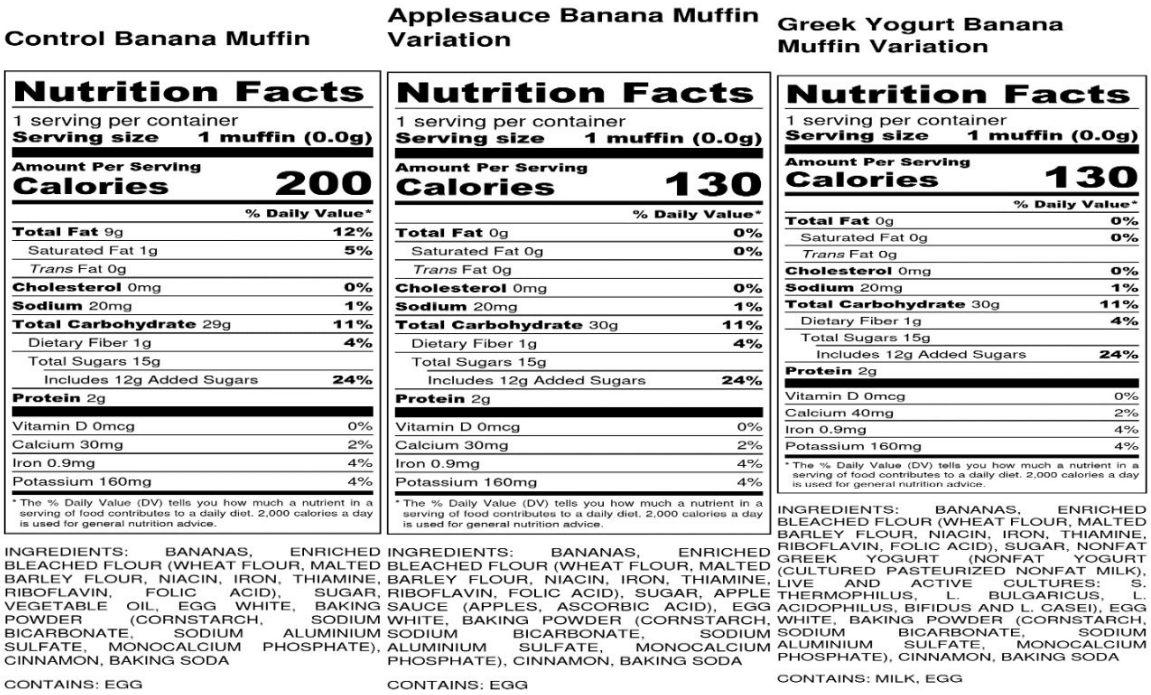
*Mean and Standard deviation of 10 panelists using a 9-point scale (1: weak, 9: Strong; overall acceptability- 1: dislike extremely, 9: Like extremely)*
**Means that the same subscripts in rows indicate no significance in difference (Tukey test, p<0.05)*

**Figure 1: Bar Graph for Sensory Attributes and Overall Acceptability of Banana Muffin Formulations**




*Mean of 10 panelists using a 9-point scale (1: Weak, 9: Strong; overall acceptability- 1: dislike extremely, 9: like extremely). Sample formulations found in Table 1.*

**Figure 2: Nutrition Facts of Banana Muffin Formulations**



**Control Banana Muffin**

**Nutrition Facts**

1 serving per container
**Serving size** **1 muffin (0.0g)**

**Amount Per Serving**
**Calories** **200**

| | % Daily Value* |
|---|---|
| **Total Fat** 9g | **12%** |
| Saturated Fat 1g | **5%** |
| *Trans* Fat 0g | |
| **Cholesterol** 0mg | **0%** |
| **Sodium** 20mg | **1%** |
| **Total Carbohydrate** 29g | **11%** |
| Dietary Fiber 1g | **4%** |
| Total Sugars 15g | |
| Includes 12g Added Sugars | **24%** |
| **Protein** 2g | |
| Vitamin D 0mcg | 0% |
| Calcium 30mg | 2% |
| Iron 0.9mg | 4% |
| Potassium 160mg | 4% |

* The % Daily Value (DV) tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.

INGREDIENTS: BANANAS, ENRICHED BLEACHED FLOUR (WHEAT FLOUR, MALTED BARLEY FLOUR, NIACIN, IRON, THIAMINE, RIBOFLAVIN, FOLIC ACID), SUGAR, VEGETABLE OIL, EGG WHITE, BAKING POWDER (CORNSTARCH, SODIUM BICARBONATE, SODIUM ALUMINIUM SULFATE, MONOCALCIUM PHOSPHATE), CINNAMON, BAKING SODA

CONTAINS: EGG

**Applesauce Banana Muffin Variation**

**Nutrition Facts**

1 serving per container
**Serving size** **1 muffin (0.0g)**

**Amount Per Serving**
**Calories** **130**

| | % Daily Value* |
|---|---|
| **Total Fat** 0g | **0%** |
| Saturated Fat 0g | **0%** |
| *Trans* Fat 0g | |
| **Cholesterol** 0mg | **0%** |
| **Sodium** 20mg | **1%** |
| **Total Carbohydrate** 30g | **11%** |
| Dietary Fiber 1g | **4%** |
| Total Sugars 15g | |
| Includes 12g Added Sugars | **24%** |
| **Protein** 2g | |
| Vitamin D 0mcg | 0% |
| Calcium 30mg | 2% |
| Iron 0.9mg | 4% |
| Potassium 160mg | 4% |

* The % Daily Value (DV) tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.

INGREDIENTS: BANANAS, ENRICHED BLEACHED FLOUR (WHEAT FLOUR, MALTED BARLEY FLOUR, NIACIN, IRON, THIAMINE, RIBOFLAVIN, FOLIC ACID), SUGAR, APPLE SAUCE (APPLES, ASCORBIC ACID), EGG WHITE, BAKING POWDER (CORNSTARCH, SODIUM BICARBONATE, SODIUM ALUMINIUM SULFATE, MONOCALCIUM PHOSPHATE), CINNAMON, BAKING SODA

CONTAINS: EGG

**Greek Yogurt Banana Muffin Variation**

**Nutrition Facts**

1 serving per container
**Serving size** **1 muffin (0.0g)**

**Amount Per Serving**
**Calories** **130**

| | % Daily Value* |
|---|---|
| **Total Fat** 0g | **0%** |
| Saturated Fat 0g | **0%** |
| *Trans* Fat 0g | |
| **Cholesterol** 0mg | **0%** |
| **Sodium** 20mg | **1%** |
| **Total Carbohydrate** 30g | **11%** |
| Dietary Fiber 1g | **4%** |
| Total Sugars 15g | |
| Includes 12g Added Sugars | **24%** |
| **Protein** 2g | |
| Vitamin D 0mcg | 0% |
| Calcium 40mg | 2% |
| Iron 0.9mg | 4% |
| Potassium 160mg | 4% |

* The % Daily Value (DV) tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.

INGREDIENTS: BANANAS, ENRICHED BLEACHED FLOUR (WHEAT FLOUR, MALTED BARLEY FLOUR, NIACIN, IRON, THIAMINE, RIBOFLAVIN, FOLIC ACID), SUGAR, NONFAT GREEK YOGURT (NONFAT YOGURT (CULTURED PASTEURIZED NONFAT MILK), LIVE AND ACTIVE CULTURES: S. THERMOPHILUS, L. BULGARICUS, L. ACIDOPHILUS, BIFIDUS AND L. CASEI), EGG WHITE, BAKING POWDER (CORNSTARCH, SODIUM BICARBONATE, SODIUM ALUMINIUM SULFATE, MONOCALCIUM PHOSPHATE), CINNAMON, BAKING SODA

CONTAINS: MILK, EGG

*The reduced fat modified recipes had 100% decreased fat compared to the control recipe. The calories decreased by 65% for both the Greek yogurt substituted recipe and the apple sauce substituted recipe. Both ingredients used for the fat substitution contained 0 grams of fat.*

**Nutrient Analysis for Muffin Formulations**

The three recipes when analyzed indicated significant differences in fat content per serving when compared to the control. The applesauce and Greek yogurt both have 0g total fat compared to the control containing 9g total fat. There are also 65% less calories in the applesauce and Greek yogurt versions with a total of 130 calories for 1 muffin compared to the control containing 200 calories per muffin. With modification of the recipe the fat and calories both decreased. Something else affected by these changes were the total carbohydrates with the control containing 29g and the two modified versions containing 30g. The calcium increased for the muffin containing the Greek yogurt to 40mg while the control and applesauce variations contain 30mg. Refer to Figures 3 to see that both the Greek Yogurt and the applesauce fat modified recipes reduced the fat content of 1 muffin by 100%. The amount of fat in the control recipe was 9g of total fat and 1g of saturated fat. Both the applesauce modified recipe and the Greek yogurt modified recipe had 0g of total fat and 0g of saturated fat, resulting in a 100% reduction in fat.

**Conclusion**

After performing a sensory evaluation and nutrient analysis on the various muffin formulations, we are able to conclude that the substitution of Greek yogurt and applesauce is a palatable replacement and can reduce fat content without affecting overall acceptability. This study demonstrated that the overall acceptability and physical properties of fat alternatives can be successfully used in healthier versions of banana muffins. We determined that the Greek-yogurt muffin variation was actually more accepted in taste and had no significant difference to the control since it had a similar palatability. We found that applesauce and Greek yogurt can be adequately substituted for oil as well as have an increased preference in a taste test. These healthier versions of banana muffins should be incorporated into manufactured recipes of banana muffins to offer a tasty yet reduced fat version that should appeal to

consumers. These alternatives also provide additional nutrition to the muffins making them more beneficial and marketable for a healthier alternative. Further research should be done on determining the best oil/fat alternatives to use when used in different recipes and techniques. Also, sensory analysis should be done with a larger panel for more statistically significant results.

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