The Effects of Using Flaxseed as a Fat Substitute in Banana Muffins

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ABSTRACT

Flaxseed consumption has been linked to lowering the risk for certain cancers and heart disease, which are leading causes of death in the United States. By using flaxseed in a baked product, such as muffins or bread, the nutritional value is higher and taste may be increased. Flaxseed can be used as a fat substitution or egg substitution in common recipes. To further research, this experiment used flaxseed as an oil substitution in banana muffins. Three different trials were used to compare partial and whole substitution levels. The experimental data shows that the water activity among the samples was fairly stable. Substituting 100% flaxseed for oil in the recipe produced a firmer baked product overall, while taste preferences were highly varied in each trial among the different samples. As a result, flaxseed is an inexpensive and positive way to increase the nutrition levels and lower risk for certain diseases without dramatically changing the characteristics of banana muffins.
INTRODUCTION

Many nutritional benefits have been linked to flaxseed consumption. Flaxseed comes from harvesting a flax plant. Flax plants are grown and harvesting the plant produces ground or whole flaxseeds as well as flaxseed oil. (www.ameriflax.com) According to Alpers and Sawyer-Morse, the nutritional benefits of flaxseed have been confirmed in breads, buns, and muffins. (1996) Furthermore, the Flax Council of Canada states that some of those nutritional benefits include: relief from constipation, lower risk from heart disease, and cancer prevention. (www.flaxcouncil.ca) Although consumption of flaxseed for disease prevention is a somewhat recent concept, much research has already been done. Oomah’s research shows that flaxseed is considered a functional food due to its omega-3 fatty acid and alpha-linolenic acid content. Consuming large doses of flaxseed reduces triacylglycerol levels, reduces total and LDL cholesterol levels, and also “confers beneficial renal function in patients suffering from lupus nephritis.” (Oomah 2001).

In addition to affecting the nutritional value of food, research shows that flaxseed affects the quality of food products in various ways. One experiment done by Shearer and Davies tested the batter viscosity of whole-wheat muffins made with and without flaxseed. Their results showed that batter viscosity increased with increasing flaxseed meal content. The study also claims that flaxseed meal or oil can be added to baked muffins “without detrimentally changing the freshness or storage properties.” (Shearer and Davies 2005).

According to AmeriFlax online, substituting flax for fat can and has been done, with a ratio of three to one. It is noted that products made with flax will brown more quickly as well. (www.ameriflax.com) While not yet receiving the GRAS (generally regarded as safe) title, flaxseed can be used in products up to 12% of the total product composition. (Bloedon and Szapary 2004) The goal for this experiment is to compare banana muffins with varying amounts of flax and vegetable oil to determine if flaxseed does indeed produce an equivalent product. The independent variable is the percentage of flaxseed substituted into the recipe (none, 50%, and 100%). The procedure for this experiment is slightly different than prior research in that water was not added with
increasing amounts of flaxseed. The dependent variables include texture, water activity, and taste. Texture will be evaluated by the texture analyzer, water activity using the water activity machine, and taste by using a subjective sensory taste panel.
METHODS

The overall design for this experiment was to create three different trials with the three same variables in each trial. After the recipes were prepared and baked, the objective tests and subjective test took place. After gathering data, findings could be stated and analyzed. The following is the experimental recipe and procedure used:

5 smashed ripe bananas
2.373g baking soda (½ teaspoon)
325g unbleached all-purpose flour (2 ½ cups)
165g dark brown sugar (¾ cup)
1.186g ground cinnamon (¼ teaspoon)
120mL vegetable oil (½ cup)
120mL milk (½ cup)
100g egg (2 large)
0.6g fine salt (1/8 teaspoon)
2.1g pure vanilla extract (½ teaspoon)

** Preheat oven to 425°F. Use cooking spray to grease the muffin pans and set aside. Whisk the flour, baking soda, brown sugar, and cinnamon together in a medium bowl; set aside. Whisk the banana, oil, milk, eggs, salt, and vanilla in a large measuring cup with a spout or another bowl. Make a small well in the center of the dry ingredients. Pour wet ingredients into the center; then stir with a wooden spoon until the dry ingredients are moistened but still lumpy. Do not over mix the batter or your muffins will come out dense. Divide the batter evenly into the muffin tin. Put the muffins in the oven and immediately reduce oven temperature to 375°F. Bake until golden brown, about 25 minutes, rotating the pan halfway through the cooking (insert toothpick to see if muffins are done; toothpick should come out clean). Cool muffins in the pan on a rack for a couple minutes. Turn the muffins out of the pan and cool on rack. Serve warm or at room temperature. **

The independent variable for this experiment will be substituting milled flaxseed for the vegetable oil in varying amounts. The three variations of the experiment are as follows:

1. 120mL oil (½ cup)
2. 60mL oil (¼ cup) and 39.6g ground/milled flaxseed (¼ cup)
3. 79.2g flaxseed (½ cup)

Three different trials were done in this experiment. In the first two trails, dark muffin tins were used without baking cups. In the third experiment, paper muffin cups were used to avoid burning the product. The other components of the procedure were exactly the same. To conduct the texture analysis, the cone probe as well as the muffin setting was used. The muffin was torn in two in order to get the analysis from the inside
of the muffin, not the crust. For the subject taste analysis, different subjects were used each trial due to lab time availability. For the subjective tests, randomization was used in sample numbers. The sample with 100% oil was numbered 367, 50% oil and 50% flaxseed was numbered 530, and 100% flaxseed was numbered 628. The results for these analyses can be viewed in the results section. Sample muffins were cut into fourths and placed on paper plates with the appropriate number label in front of the sample. Random 3-digit numbers were assigned to avoid bias in the data. Subjects were asked to taste a muffin and record their choice before tasting the next sample. Below is a sample sensory scorecard that was presented to subjects for the taste analysis:

Table 1: Overall Taste Analysis Scorecard
Check the box that applies for each sample:

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<td>628</td>
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DISCUSSION

Several factors contributed to the results and data obtained in this experiment. Figure 1 shows us the texture analysis of all samples. Sample 530, 50% oil and 50% flaxseed, showed the strongest force needed to probe the muffin in trial two. This force needed was 95.45g, however only 55.2g and 37g were required for trials one and three respectively. (See table 2) This inconsistency may be due to the time allowed between baking and testing or the area of the muffin used for testing. If the probe happened to go through a part of the muffin where banana was present, the force needed to probe through would be greatly decreased due to the soft texture of the cooked banana. Also seen in figure 1, the sample numbered 628, 100% flaxseed, showed the most consistency between the three trials. The forces necessary were 58.75, 79.6, and 78.75 for trials one, two, and three respectively. According to prior research, products made with complete flaxseed substitution are likely to be tougher in texture due to the absorption of water by the milled flaxseed. (Shearer and Davies 2005) This is also why www.ameriflax.com suggests using a three to one ratio of water to flax when using it in a recipe. Another source recommends using one tablespoon flax flour and three tablespoons boiling water to replace one egg in a recipe, while using one cup flax flour to replace 1/3 cup oil. (Back to Flax 2005) However, these results are not always the case as seen in Ahmed’s experiment, where water activity decreased as the amount of flax increased. This may be due to the different types of flax used, whether as flour or a seed still containing some oil. Sample 367, 100% oil, showed variable data as well according to figure 1. The first trial reported a force of 22g needed to probe the muffin. Trials two and three reported forces of 66.8g and 64.1g. Although trials two and three show some consistency, trial one may have the more accurate data considering the desired texture of a muffin baked with vegetable oil. Some sources of error for the texture analysis may be due to the slight over-doneness of muffins in trials one and two. Since they were baked in just the dark tin pans, they seemed to bake faster, while trial three was baked in a lighter colored pan with the use of a paper baking cup to avoid burning. Research has shown that the seed of the flax plant is darker in color and this may be responsible for the darker appearance of the
baked product even if the product was not burned during the baking process. (Bloedon and Szapary 2004)

Figure 2 shows the analysis of water activity among the three trials. All three samples in trial one had similar water activity levels. In trial two, the water activity of sample 628 was significantly lower than samples 530 and 367. (see table 3) Knowing that sample 628 was 100% flaxseed, this information shows accuracy in data because flaxseed has been proven to take up water in baked products where it is used. (Shearer and Davies 2005)

Figures 3, 4, and 5 show the subjective sensory taste analyses. In previous studies done, a higher amount of flax substitutions has led to a lower acceptability of taste in the final products. (Ahmed 1998) In his study, Ahmed found that the products with the greatest amount of flax had the lowest ratings for overall taste and texture. It states that the product with the greatest amount of flax is the toughest in texture. This is in agreement with the findings of this experiment as noted above and seen in figure 1. However, this experimental data shows a wide variety of taste preferences among the samples. Trials one, two, and three do not show consistency in taste preferences. This could be due to various factors. Eating prior to tasting the samples, recording preferences after tasting all samples, or sampling a certain part of the heterogeneous mixture of ingredients may lead a subject to record inaccurate data.

Further research must be done to assess whether flaxseed is an ideal fat substitution in baked products. A study done in 2005 by Souther tested the effects of different gum uses in flaxseed containing breads. Her findings state that flaxseed breads containing xanthan or guar gums showed more acceptability in taste analyses compared to the control with no added gums. This may be an area for further research in different types of baked products other than breads. Results from this study show that substituting flaxseed in baked products does not drastically alter neither physical characteristics nor overall taste preferences. Other research done shows consuming flaxseed in a regular diet has positive physiological and nutritional effects. Although much more research is necessary to move consumers to implementing these practices, it is essential to begin incorporating flaxseed into commercial products. Flaxseed is a safe and natural way to aid in digestive processes as well as lower risks for heart disease and certain cancers.
RESULTS

Table 2. Texture Analyzer Averages

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<th>Sample 367</th>
<th>Sample 628</th>
<th>Sample 530</th>
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<tr>
<td>Trial 1</td>
<td>22 g</td>
<td>58.75 g</td>
<td>55.2 g</td>
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<tr>
<td>Trial 2</td>
<td>66.8 g</td>
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<td>Trial 3</td>
<td>64.1 g</td>
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Figure 1. Texture Analysis
### Table 3. Water Activity

<table>
<thead>
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<th>Sample 530</th>
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<tbody>
<tr>
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<td>.96</td>
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<tr>
<td>Trial 3</td>
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<td>.91</td>
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![Figure 2. Water Activity Analysis](image-url)

**Figure 2. Water Activity Analysis**
Figure 3. Trial 1 Taste Analysis

Figure 4. Trial 2 Taste Analysis
Figure 5. Trial 3 Taste Analysis


