Abstract

Different amounts of flaxseed meal were added to muffins batters using boxed muffin mixes with no other modifications in the original formula. The texture and water activity of the baked muffins as well as the viscosity of the batters were analyzed. The experiments yield conflicting results but it could be concluded that the muffins with and without flaxseed meal differ significantly in their physiochemical properties. The possible sources of error were discussed. Future work in this area was suggested.

Introduction

For centuries, flaxseed has been consumed throughout the world. Today, flaxseed is recognized as a good source of $\alpha$-linolenic acid (ALA, an essential omega-3 fatty acid), dietary fiber, mucilage, lignans (potent plate-activating factor receptor antagonists) and phenolic compounds, all of which are probably beneficial in reducing the risk factors for both coronary vascular disease and cancer. Edible flaxseed products include the whole seed, ground meal and extracted oil or mucilage (Shearer & Davies 2005). Research documenting the health benefits of flaxseed has increased its potential as an ingredient for bread, muffins and other baked goods. Research conducted on the effect of incorporating flaxseed meal into foods, however, yields conflicting results.

Flaxseed has been promoted as an egg replacer in home-baked goods for vegans (Shearer & Davies 2005), but this use has not been the focus of most researches. Flaxseed’s favorable lipid profile was employed to replace shortening in cakes (Lee, Inglett & Carriere, 2004). Some trials replaced part of the flour in the original formula with ground flaxseed meal (Alpers & Sawyer-Morse 1996) while some simply added flaxseed meal to the original formula (Shearer & Davies 2005). The water binding capacity of flaxseed due to its mucilage content has been characterized. This feature calls
for an increase in the amount of liquid when flaxseed is used in a formula (Payne 2000). Since
about 41 per cent of flaxseed is oil, many trials called for a reduction in the added oil from the
original formula when flaxseed is added. One study suggest that bulk density and breaking strength
of corn snack increased while expansion ratio decreased with increasing flaxseed meal
content((Shearer & Davies 2005), but another study found the density of muffins was unaffected by
the addition of flaxseed meal( Shearer & Davies 2005). One researcher observed a softening effect
on bread with the incorporation of flaxseed gum (Shearer & Davies 2005) but a recent study on
muffins did not support this observation (Shearer & Davies 2005). Many studies suggest that
flaxseed incorporations create acceptable baked products but the author's own attempt on
incorporating flaxseed in muffins did not yield results consistent with these findings.
Researchers have not yet reach consent on the optimal ratio of flaxseed in a formula. One study
made acceptable muffins with up to 50% flaxseed (Alpers & Sawyer-Morse 1996) but most studies
suggest an optimal usage level of 15% of the flour or less.
The project was to explore the changes in physicochemical properties (texture and water activity) of
corn muffins with the addition of different amounts of flaxseed meal.

Methods
This project attempted to explore the changes in texture and moisture content when flaxseed is
incorporated into corn muffins. Boxed corned muffin mixes were used and the simplicity of the
recipe printed on the box was utilized. There were only three ingredients in the recipe: 1 box of
muffin mix, 1 egg and 1/3 cup of milk. The control batter contained no flaxseed, while variable 1
contained 5 gram of flaxseed per 100 gram of batter and variable 2 contained 10 gram of flaxseed
per 100 gram of batter. There was no increase in the liquid amount of the formula when flaxseed
meal was added. The amount of oil was not reduced with the addition of flaxseed meal either.
These are to reduce the variations in the experiment. But with the concern of high oil content in the
muffins, skim milk was used and egg beater was used to substitute eggs.

Table 1: Muffin Formulas (Jiffy Corn Muffin Recipe)

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Original Formula</th>
<th>Control</th>
<th>Variable 1(5g flaxseed per 100 g batter)</th>
<th>Variable 2(10g flaxseed per 100 g batter)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn Muffin Mix</td>
<td>1 box (240g)</td>
<td>80g</td>
<td>80g</td>
<td>80g</td>
</tr>
<tr>
<td>Milk</td>
<td>1/3 cup</td>
<td>26g</td>
<td>26g</td>
<td>26g</td>
</tr>
<tr>
<td>Egg</td>
<td>1 egg</td>
<td>19g egg beater®*</td>
<td>19g egg beater®*</td>
<td>19g egg beater®*</td>
</tr>
<tr>
<td>Flaxseed Meal</td>
<td>0</td>
<td>0</td>
<td>6.25g</td>
<td>12.5g</td>
</tr>
</tbody>
</table>

*Egg Beater® Ingredients: Egg white, less than 1 g per 100 g: natural flavor, color (includes beta-carotene), spices, salt, onion powder, vegetable gum (xanthan gum, guar gum)

To prepare the muffin batters, a box of muffin mix was divided into three portions. Since about 1/4 cup of egg beater (57 gram by weight) is equivalent to 1 egg, 19 gram of the egg beater was used in each variable. 1/3 cup of skim milk is about 78 gram by weight, therefore 26 gram of milk was used in each variable. Put the muffin mix with egg beater and milk for each variable together in separate mixing bowls. Mass of each mixture at this point was 125 gram. Then 6.2 gram and 12.5 gram of flaxseed meal were added to variable 1 and variable 2, respectively. Stir each mixture 9 strokes. 60 gram of each batter was taken out and put into one muffin pan lined with foil baking cup, making one muffin for each variable. Bake the muffins in an oven preheated to 400°F on center shelf for 12 minutes. Take muffin pan out of the oven and let muffins rest in pan for 3 minutes. Remove muffins from the pan.

Viscosity of the rest of each muffin batters was measured by consistometer. Consistometer measures the distance a batter flows in two minutes.

Water activity of baked muffins was measured by water activity machine. A small disk was filled
with muffin crumbles and placed in the water activity machine. Generally readings would be displayed in 5 to 10 minutes.

Texture of baked muffins was measured by texture analyzer. The texture analyzer was set to muffin mode. Each muffin was penetrated by probe at three random spots. The pre-speed of probe was set to 2.0mm/second and the speed was 3.0mm/second. The penetration force is an indication of the texture of muffin.

**Results**

Measured by consist meter in trial 1, the control batter flowed 0.8cm in two minutes, variable 1 flowed 0.2cm in two minutes, and variable 2 was too viscous to flow in two minutes. The data from trial 2 was missing.

The readings of water activity machine are shown in Table 2.

<table>
<thead>
<tr>
<th></th>
<th>$a_w$ (Trial 1)</th>
<th>$a_w$ (Trial 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>0.773</td>
<td>0.895</td>
</tr>
<tr>
<td>Variable 1</td>
<td>0.844</td>
<td>0.852</td>
</tr>
<tr>
<td>Variable 2</td>
<td>0.819</td>
<td>0.880</td>
</tr>
</tbody>
</table>

The results measured by texture analyzer are shown in Table 3.

<table>
<thead>
<tr>
<th></th>
<th>Penetration Force (Trial 1)</th>
<th>Penetration Force (Trial 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>87.1g/62.9g/81.0g</td>
<td>152.5g/109.0g/236.9g</td>
</tr>
<tr>
<td>Variable 1</td>
<td>166.1g/166.7g/166.7g</td>
<td>211.2g/199.0g/162.7g</td>
</tr>
<tr>
<td>Variable 2</td>
<td>145g/175.1g/157.6g</td>
<td>272.6g/224g/165.5g</td>
</tr>
</tbody>
</table>

The hypothesis proposed that the physicochemical properties of muffins with and without flaxseed
meal, including batter viscosity, water activity and texture will differ significantly. The results support the hypothesis.

**Discussions**

Due to water binding capacity of flaxseed meal, batters with flaxseed meal added is expected to be more viscous than batters without flaxseed meal. This was confirmed by the results measured by consist meter.

Water activity indicates the amount of free water (sometimes referred to as “unbound” or “active” water) present in a system. The addition of solutes always lowers the water activity because water will bind to solutes. Therefore muffins with flaxseed meal added are expected to have lower water activity than muffins without flaxseed meal, and muffins with more flaxseed meal added are expected to have lower water activity than muffins with less flaxseed meal added. However the results of this project were not consistent. Water activity of the control muffin measured in trial 1 and trial 2 was the lowest and highest among all samples, respectively, which was conflicting. While variable 2 (muffin with higher flaxseed ratio) in trial 1 had lower water activity than variable 1 (muffin with lower flaxseed ratio) in both trials as expected, variable 2 in trial 2 had higher water activity than variable 1 in both trials, contradictory to the prediction. The reasons behind the inconsistent readings could be errors in using the water activity machine. Even though the simplicity of the formula reduced the variations between trials, variations could arise from the different lengths of time the baked muffins cooled before being measured. It was a mistake that the temperatures at which water activity was measured were not recorded.

Water activity is not the same as water content, even an increase in $a_w$ is almost always accompanied by an increase in the water content, just not in a linear fashion. Water content determines the moistness of a food item. As suggested by previous studies, muffins with flaxseed added would be less moist than muffins without flaxseed and that is why an increase in the amount
of liquid is recommended when flaxseed is added to the original formula. Shelf life of flaxseed and flaxseed containing products was extensively studied with focus on the oxidative rancidity related to flaxseed’s high lipid content. Water activity is a critical factor that determines the shelf life of food products because it determines whether a microorganism will grow in a food and the rate at which it will grow. Most bacteria do not grow at water activities below 0.91, and most molds cease to grow at water activities below 0.80. Considering fluctuations in machine readings, it is safe to say that muffins with or without flaxseed added are still susceptible to microbial growth.

Since oil serves as a tenderizer for dough, it is expected that muffins with flaxseed meal added would be tenderer than muffins without flaxseed meal, and thus penetration force of muffins with flaxseed meal added would be smaller than that of muffins without flaxseed meal. The average penetration force of the control muffin in trial 1 was 75g and 166g in trial 2. The average penetration force of variable 1 was 166.5g in trial 1 and 191g in trial 2. The average penetration force of variable 2 was 159.2g in trial 1 and 220.7g in trial 2. These results were very inconsistent and made it difficult to interpretate. It seems that in general the penetration force of the control is smaller than that of the two variables. It is noted that the muffin with the lowest water activity (the control in trial 1) bears the smallest penetration force, the muffin with second highest water activity (the variable 2 in trial 2) bears the largest penetration force, and within each variable, the one with higher water activity requires larger penetration force.

The physicochemical properties of muffins with and without flaxseed meal, including batter viscosity, water activity and texture differs significantly, but the differences between muffins with 5% flaxseed and 10% flaxseed were not as significant.

Modifications in the original formula have to be made to yield comparable products. These modifications may include an increase in the amount of liquid and a reduction in oil.
Future studies can be done in finding optimal ratio of flaxseed in a formula, the appropriate amount of increase in the liquid content, the appropriate amount of reduction in the oil content.

References


Manthey, F.A., Lee, R.E. & Hall, I.C.A. 2002. Processing and cooking effects on lipid content and stability of linolenic acid in spaghetti containing ground flaxseed. *Journal of Agricultural and Food Chemistry. 50(6), 1668-1671*
