Title: The Effect of Soy Product Substitution on the Texture, Color, and Palatability of Chocolate Chip Muffins.

Abstract:

The effects of soy products are found to reduce risk of disease as well as promote a healthier lifestyle. The objective of this experiment was to develop a chocolate chip muffin containing soy products that would be acceptable in terms of texture, consistency and overall preference. Methods included using a Texture Analyzer, Hunter Colorimeter, and a subjective taste panel. It was found that the muffin containing soy milk was as much desired as the control muffin which contained no soy products.

Introduction:

Soy protein has been getting a lot of attention recently due to the potential health effects that it has to offer. According to the American Dietetic Association, Soy protein helps prevent disease. The Approved health claim states “Diets low in saturated fat and cholesterol that include 25 grams of soy protein a day may reduce the risk of heart disease” (Hasler et al., 2004, p. 817). Consumption of soy in the diet has increased from about 3 times a week to almost 10 times a week (Klein, Perry & Nancy, 1995). New products such as “Silk Soymilk” have become very well known on the market. The product’s website contains information for consumers about isoflavones from soy including information about how they can prevent cancer and disease (Living a Healthy Lifestyle, 2007). However, the general population may be skeptical about substituting soy products into foods that they are used to consuming. Kids for example are known to be very picky eaters. A study was done where soy protein was incorporated into school lunches to make them healthier. They adjusted the meat portion of entrees with a 30% soy protein concentrate (Thomas & Lutz 2001). The results showed that the meals were indeed healthier, but they still aren’t sure how acceptable the meals would be to kids across the country. More research needs to be done with this population.

One population that can give reasonably accurate results is college students. This is a good age group to test because they are adults yet they can still have picky appetites like children and will not eat something that isn’t appealing. This is an easy population to test because the experiment is conducted on a college campus. A study conducted by Klein, Perry, and Adair (1995) used college students to see how well soy nuts were liked by college students. They emphasized the fact that soy carries many health benefits including bone health, prevention of cancer, and maintaining healthy cholesterol levels. Conclusions were that college students pay more attention to taste, appearance and quality rather than nutrition; they would choose a tastier product rather than a more nutritious product (Klein, Perry & Adair 1995). This study was with just nuts but the experiment conducted in this project will be substituting only one ingredient in an
otherwise familiar food. The use of chocolate chips may also make the product more appealing.

Klein, Perry, and Adair reiterate the fact that the use of soy products would be used a lot more if foods containing them can be made that people would actually enjoy (1995). Until recently developers have not had much success making such products, but now they have new methods to better taste and quality. Soy effects on sensory quality in bake products include color and beany or nutty flavors (Klein, Perry & Adair 1995). Soy product function can be depended on time, temperature, moisture and pH conditions during the experiment; therefore more than one [soy] product should be tested (Klein, Perry & Adair 1995). In this project there are two different variables, milk and flour, which will tell us how different soy products affect products. These variables will have to be monitored and amounts adjusted if needed.

Another experiment evaluates more characteristics of soy. Brewer and Potter (1992) studied the effect of soy products on color, physical and sensory characteristics on baked products. They note that a small amount of soy product will not alter the product, but wanted to look at the effects of higher levels. They found that in muffins, the more soy that was put into the batter, the higher the viscosity was. They also found that the volume of the baked muffins decreased with any amount of soy flour. The muffins had more air cells, were darker, less sweet, and a beany flavor was more prevalent. Moistness and denseness increased, but flavor change was not as detectable (Brewer and Potter 1992). In the muffin experiment these characteristics will be looked at and the results compared with this research.

The functional, chemical, and physical properties of soy proteins are important because they alter the final product such as texture and palatability. Soy proteins do a number of things including stabilizing emulsions, absorbing fat and water (Wolf 1970). Since the products absorb water, they tend to have a more moist consistency. This property should be expected in this muffin experiment. Wolf examined these properties and stated that they are moving from a “role of merely providing functional properties to serving both as functional additives and as a source of nutritive protein” (Wolf 1970).

This experiment will test the acceptability of muffins made with this “nutritive” soy protein substituted into the ingredients. The independent variables will be the type of flour or milk used (all-purpose or soy flour, 2% milk or soy milk). The dependent variables measured will be texture, color, and overall preference of the muffins. The chocolate chips will most likely increase the acceptability, but since they are also used in the control they shouldn’t alter results. More than one soy product will be used which should provide better results. The type of milk and flour will affect texture, color, and palatability. The methods measuring these variables are standard procedures that have been used in many studies and should provide relatively accurate results if used correctly. The research has pointed out some expected results; an example is that the muffins should be more moist due to water retention.
Methods:

Overall Design:

The experiment will consist of three different types of muffins; the control will be a muffin made from a standard recipe containing 2% milk and all purpose flour. The samples are made from a variation of the control recipe in which either soy flour or milk is added to the muffins. The following table shows the variable samples along with their corresponding random three digit code which will be used for the taste panel. The recipe for the muffins follows the table.

<table>
<thead>
<tr>
<th>Random 3 Digit Code</th>
<th>Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>584</td>
<td>2% milk + All Purpose flour</td>
</tr>
<tr>
<td>382</td>
<td>Soy milk + All Purpose flour</td>
</tr>
<tr>
<td>945</td>
<td>2% milk + Soy Flour</td>
</tr>
</tbody>
</table>

Recipe:

The recipe used for the muffins as seen below came from a website entitled “All recipes: Chocolate Chip Muffins.” It is a basic muffin recipe, submitted by a member of the website named Lori Thompson (2007). The recipe and procedure is as follows:

The yield is 10 muffins each time:

- Flour (all-purpose or soy): 210g
- Sugar: 85g
- Baking Powder: 8g
- Salt: 3g
- Egg: 7/8
- Milk (2% or soy): 150ml
- Vegetable oil: 65ml
- Miniature semisweet chocolate chips: 125g

Procedure:

The wet ingredients will be mixed together in a room temperature bowl and added to the pre-mixed dry ingredients (except chocolate chips). Stirring time will be just enough to make the dry mix moist and the stroke number will be noted to be used for all of the future batches. The chocolate chips will then be folded in. The muffins will be portioned out using the same scoop for each muffin to ensure uniformity. Baking will be at 204°C for 18-20 minutes or until the toothpick comes out clean. After cooling, the muffins will be tested for differences in and texture. A subjective sensory panel will be
conducted testing the palatability including taste, texture, and consistency of the muffins. Random numbers are assigned to samples to ensure that they are unknown to the panelist. The sensory score card is seen below.

**Sensory Evaluation:**

Please taste each sample in front of you. On the scales below circle the number that best describes each sample.

<table>
<thead>
<tr>
<th>Texture</th>
<th>Dislike</th>
<th>Slightly Dislike</th>
<th>Neither Dislike nor Like</th>
<th>Slightly Like</th>
<th>Like</th>
</tr>
</thead>
<tbody>
<tr>
<td>584</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>392</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>945</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Consistency</th>
<th>Dislike</th>
<th>Slightly Dislike</th>
<th>Neither Dislike nor Like</th>
<th>Slightly Like</th>
<th>Like</th>
</tr>
</thead>
<tbody>
<tr>
<td>584</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>392</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Dislike  Slightly Dislike Neither Dislike or Like Slightly Like  Like

945

Rank the samples in order of preference. 1 being the one you like most and 3 being the one you like least

584

392

945

Comments:


1. Select the appropriate probe. (The cone will be used for this experiment)
2. Turn on the computer, monitor, and texture analyzer
3. Select the Texture Expert software from the Windows screen
4. Attach the probe. Probe height can be changed by using the arrow and fast buttons on the texture analyzer. There are “safety” stops on the arm of the texture analyzer. You may get an error if the probe goes beyond these settings.
5. You can adjust the “safety” stops by manually moving them up and down
6. Prepare all 3 muffin samples. Make sure enough sample is used for the probe to penetrate into the muffin.
7. Select FILE, NEW, GRAPH WINDOW
8. Select T.A., T.A. Settings, Load
9. Choose the muffin setting.
10. Choose UPDATE-this sends the T.A. settings to the texture analyzer.
11. Place the sample under the probe in order to adjust
12. Select T.A., Quick Test Run (test will run and a graph will appear on the screen)
13. Analyzing the graph: Select Process Data, Macro, and Run. This option will give the various results about the graph depending on what kind of macro that was constructed.
14. To view graph of interest, select VIEW, GRAPH, and VIEW SELECTED ONLY.
15. Record force required to penetrate the muffin.
16. After each series fun, close the graph window. Close the results window. In each case you will be asked to save the results, to which you should generally answer NO. Then run a different sample by following the instructions above starting from step 8.

17. To exit and close, select FILE, EXIT.

**Hunter Colorimeter** (CM Weaver, JR Daniel, 2003)

The purpose of this instrument is to measure the color of the muffins. It can “see” color as the human eye sees it and reports it in the Hunter parameters, which are L, a, and b.

1. Turn on the Lab Scan XE, computer and monitor
2. Double click the UNIVERSAL icon on the desktop
3. Standardize the instrument:
   a. Choose Sensor, then Standardize on the tool bar
   b. Click ok when the Standardize dialog box appears
   c. Place the Black Glass at the measuring port; click OK
   d. Place the White Tile at the measuring port; click OK
   e. Click ok once more when “Sensor Successfully Standardized” box appears
4. Place the muffin at the measuring port in a Petri dish.
5. Click the Read Sam (Sample) button on the toolbar.
6. The Average Hunter Lab box should appear; click “Average”
7. Name the muffin sample in the Enter Sample Information box; click OK
8. You will see the muffin data in the Master Color Data window
9. Record Data and close the Universal main window.
10. To exit and close select “exit” and save changes if desired.

**Replications:**

The experiment will be conducted with three different trials, each trial containing a soy product such as milk or flour substituted for regular milk and flour. The sample containing both regular milk and regular flour will be the control. Each trial will use the Stable Micro Systems Texture Analyzer, the Hunter Colorimeter, and a taste panel. Each sample will be tested in duplicate. The Stable Micro Systems Texture Analyzer will measure the texture of the chocolate chip muffins using the cone probe. The Hunter Colorimeter will measure the color of each sample placed in Petri dishes. 8-10 semi-trained panelists will taste all 3 samples in each trial. The samples will contain random 3 digit number codes and will be given to panelists in no particular order.

**Discussion:**

The data collected from the Stable Micro Systems Texture Analyzer was entered into a Microsoft Excel spreadsheet. The averages and standard deviations were found for Trials 1, 2, and 3. Table 2 contains the averages for each trial as well as the average of all 3 trials and the standard deviations of all 3 trials. Figure 2 also contains these values which clearly show that much more force was required to penetrate the muffin containing the soy flour, while the control muffin and the soy milk muffin required about the same amount of force. According to an experiment that looked at the functionality of soy milks, the use of soy milk for dairy milk did not produce differences in hardness, cohesiveness, gumminess or chewiness (Swanson et al., 2006) which is close to what was
found in this experiment. The standard deviations were high which could be due to error such as improper placement of the muffin on the Stable Micro Systems Texture Analyzer. The chocolate chips may have also contributed to error. The Texture Analyzer may have measured force of chocolate chips instead of the actual muffin crumb. However, the results obtained seem to correlate with previous findings. Klein, Perry & Adair (1995) stated that if there is too much soy present, the product would produce an undesirable dense and crumbly texture. This is shown by how much more force was required in the soy flour muffin as compared to the other two. The higher force is also congruent with the experiment of Brewer and Potter (1992). They studied effects of high levels of soy product and found that the more soy put into batter, the higher the viscosity was. This would then make sense as to why the finished product is denser.

Next the data collected from The Hunter Colorimeter was entered into Microsoft Excel. This Instrument measures color using three different values. The first is “a” which are for the colors red to green, “b” which measures yellow to blue, and “L” which measures the lightness. The average colorimeter values for all three trials can be seen in Table 1 as well as Figure 1. There is a clear decrease in the “L” value in Figure 1 which means that with the addition of soy product to the muffin, the brightness decreased. In Brewer and Potter’s (1992) experiment they also found that the more soy introduced into the product, the darker the color became. This is also seen in an experiment comparing soy milks with regular dairy milk. It was found that the soy milks were darker in color. (Swanson et al., 2006). The other values, “a” and “b” as seen in Figure 1, are not significant to this experiment because they show little variation.

Finally, data was collected from a taste panel using a hedonic scale which rated consistency, texture, and overall preference of the muffins. Consistency and texture was measured on a scale of 1-5 with 1 being “Dislike” ranging to 5 being “Like.” Preference of the muffins was measured by ranking on a 1-3 scale, with 1 being “Like the most” and 3 being “Like the least.” All of the data was put into excel and the averages were found for each of the trials. Table 3 and Figure 3 contain the results of consistency. These values indicate that both the control and the muffin containing the soy milk had a high ranking for consistency, while the muffin containing the soy flour had a low ranked consistency. This is probably due to the following: the batter had an increased viscosity as was discussed previously from Brewer and Potter’s (1992) experiment, and Klein, Perry & Adair’s (1995) findings that the more soy in the product, the less desirable and crumbly it would be. Table 4 and Figure 4 look at the average texture rankings. The results are similar to the consistency rankings. Texture was found desirable in both the control and the muffin with soy milk, but was greatly decreased in the muffin with the soy flour. Finally, preference rankings can be seen in Table 5 as well as Figure 5. It can be clearly seen that the control sample was ranked as most preferred overall and that the sample containing the soy flour was the least preferred. However, the muffin that contained the soy milk was almost equally preferred to the control. This is probably due to the fact that soy gives a beany flavor, according to Brewer and Potter (1992), however milk does not change the structural characteristics as much as flour does and therefore is not as detectable.
The experiment could have been performed better by making the objective testing more accurate. For example, when using the texture analyzer and the Hunter colorimeter, the muffins should have been tested without the chocolate chips. Although the chocolate chips were useful for masking the appearance of a change for the subjective testing, they could have easily altered the true color changes as well as the force measured. More repetitions should have also been done on each trial for the objective tests due to the large standard deviations.

Further work could be done on this experiment testing different types of soy products in the muffins other than flour and milk; an example is powder which would likely have less dramatic effects on texture, consistency, and color. Also, amount of each type of soy product could be studied. For example, if less soy flour was used the muffin may be more acceptable because less liquid would be absorbed which would reduce viscosity and give an overall more desirable product.

Take home message:

The substitution of soy products into baked products may provide healthier options would also provide benefits such as a reduced risk of disease. The substitution of milk and flour with soy products may affect a product’s texture, color, and overall preference. More research is needed to make products containing soy that is acceptable to consumers.

Results:

Table 1. Average Colorimeter Values For Trials 1,2,3.

<table>
<thead>
<tr>
<th>Variable</th>
<th>L</th>
<th>a</th>
<th>b</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>45.37</td>
<td>2.35</td>
<td>14.53</td>
</tr>
<tr>
<td>Soy Milk</td>
<td>41.08</td>
<td>2.67</td>
<td>4.11</td>
</tr>
<tr>
<td>Soy Flour</td>
<td>33.19</td>
<td>4.11</td>
<td>13.48</td>
</tr>
</tbody>
</table>
Figure 1: Average Parameter Values Among Varying Soy Product Substitutions in Chocolate Chip Muffins: Trials 1, 2 & 3.

Table 2. Texture Analyzer Values for All 3 Trials

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Soy Milk</th>
<th>Soy Flour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trial 1</td>
<td>25.1</td>
<td>39.5</td>
<td>72.3</td>
</tr>
<tr>
<td>Trial 2</td>
<td>42.7</td>
<td>33.6</td>
<td>46.3</td>
</tr>
<tr>
<td>Trial 3</td>
<td>26.9</td>
<td>21.3</td>
<td>36.1</td>
</tr>
<tr>
<td>Averages of Trials 1,2,3</td>
<td><strong>31.57</strong></td>
<td><strong>31.47</strong></td>
<td><strong>51.57</strong></td>
</tr>
<tr>
<td>STD Deviation</td>
<td><strong>9.683</strong></td>
<td><strong>9.286</strong></td>
<td><strong>18.66</strong></td>
</tr>
</tbody>
</table>
Figure 2: Texture Analyzer Force Among Varying Soy Product Substitutes in Chocolate Chip Muffins. Average of Trials 1, 2 & 3.

Table 3. Average Subjective Analysis Scores of the Consistency of Each Product Containing Varying Soy Product Replacements. The Scale was a 5 Point Scale with 1 Being Dislike and 5 Being Like. All 3 Trials.

<table>
<thead>
<tr>
<th></th>
<th>Averages of Trial 1</th>
<th>Averages of Trial 2</th>
<th>Averages of Trial 3</th>
<th>Averages of all 3 Trials</th>
<th>STD Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>4.31</td>
<td>4.30</td>
<td>3.50</td>
<td>4.04</td>
<td>.4648</td>
</tr>
<tr>
<td>Soy Milk</td>
<td>3.94</td>
<td>4.38</td>
<td>4.08</td>
<td>4.13</td>
<td>.2248</td>
</tr>
<tr>
<td>Soy Flour</td>
<td>1.91</td>
<td>2.52</td>
<td>2.78</td>
<td>2.40</td>
<td>.4466</td>
</tr>
</tbody>
</table>
Figure 3: Average Consistency Scores According to Subjective Tests Compared Among Varying Soy Product Substitutes in Chocolate Chip Muffins: All Three Trials

Table 4. Average Subjective Analysis Scores of the Texture of Each Product Containing Varying Soy Product Replacements. The Scale was a 5 Point Scale with 1 Being Dislike and 5 Being Like. All 3 Trials

<table>
<thead>
<tr>
<th>Product</th>
<th>Averages of Trial 1</th>
<th>Averages of Trial 2</th>
<th>Averages of Trial 3</th>
<th>Averages of all 3 Trials</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>4.28</td>
<td>3.76</td>
<td>3.59</td>
<td>3.89</td>
<td>.3594</td>
</tr>
<tr>
<td>Soy Milk</td>
<td>3.78</td>
<td>3.74</td>
<td>3.97</td>
<td>3.83</td>
<td>.1229</td>
</tr>
<tr>
<td>Soy Flour</td>
<td>2.10</td>
<td>2.58</td>
<td>2.14</td>
<td>2.27</td>
<td>.2663</td>
</tr>
</tbody>
</table>
Figure 4: Average Texture Scores According to Subjective Tests Compared Among Varying Soy Product Substitutes in Chocolate Chip Muffins: Trials 1, 2 & 3.

Table 5. Average Subjective Analysis Scores of the Flavor Preference of Each Product Containing Varying Soy Products. The Scale was a 3 Point Scale, 1 Being Like the Most and 3 Being Like the Least. All 3 Trials.

<table>
<thead>
<tr>
<th></th>
<th>Averages of Trial 1</th>
<th>Averages of Trial 2</th>
<th>Averages of Trial 3</th>
<th>Averages of all 3 Trials</th>
<th>STD Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>1.25</td>
<td>1.50</td>
<td>1.67</td>
<td>1.47</td>
<td>.2113</td>
</tr>
<tr>
<td>Soy Milk</td>
<td>1.88</td>
<td>1.70</td>
<td>1.33</td>
<td>1.64</td>
<td>.2804</td>
</tr>
<tr>
<td>Soy Flour</td>
<td>2.88</td>
<td>2.80</td>
<td>3.0</td>
<td>2.89</td>
<td>.1007</td>
</tr>
</tbody>
</table>
Figure 5: Average Flavor Preference Rankings According to Subjective Tests Compared Among Varying Soy Product Substitutes in Chocolate Chip Muffins: Trials 1, 2 & 3.
References:


