Kelsie Hayes  
Monica Duffy  
Kiersten Witkamp  
November 19, 2013

**Nutr 453 Written Report**

**TITLE:** The Effects on Fudge from Avocado as a fat replacer.

**ABSTRACT:** This experiment explores the effects on fudge from avocado as a fat replacer instead of butter in order to replace the saturated fats of butter with the monounsaturated fats of avocado. Replacing the saturated fats of butter with the monounsaturated fats of avocado may increase one’s health and decrease one’s risk for disease (Centers for Disease Control and Prevention, 2012). It is hypothesized that there will be no effect on color, texture, mouthfeel, and consumer preference due to the replacement of butter with avocado. The experiment was carried out in the style of a triplicate procedure. Each trial had a control; this had no change to the recipe meaning the full amount of the required butter was used. The first variable of each trial consisted of using half the amount of butter and the other half avocado. And the second variable of each trial consisted of using all avocado instead of butter. The experiment found that there was very little difference in mouthfeel between the control and variable 1, although the control was slightly higher in rating. Consumer preference ranking resulted in the following percentages of most preferred: control (46%), variable 1 (37%), and variable 2 (17%). The effect on color from avocado was extremely minimal. The differences were so small (no difference greater than 1.99) that it’s considered no change in color. Also, avocado as a fat replacer did not significantly affect the texture of the fudge. This experiment determined that replacing butter with avocado will have effects on the properties and preferences of avocado fudge. This is a significant difference in consumer preference when 100% of the butter is replaced with avocado. In order to maintain consumer preference as much as possible, replace only half of the butter with avocado.

**INTRODUCTION:** Avocado is generally seen as a healthy fat for consumption. Avocados are high in monounsaturated fats which are believed to help decrease the risk of heart disease with many other benefits (Davenport and others 2013). Butter is a source of high saturated fatty acid levels (Centers for Disease Control and Prevention, 2012). Consuming a regular amount of butter with its saturated fats has shown negative health effects such sensitivity and resistance to insulin, as well as a negative change in the gut flora which has shown to relate to obesity and hepatic steatosis (Dâmaso and others 2013). Therefore, replacing the saturated fats of butter with the monounsaturated fats of avocado into foods may increase one’s health and decrease one’s risk for disease and/or obesity. A triplicate procedure was followed for this experiment with the purpose of determining whether or not replacing butter with avocado will have an effect on the color, texture, mouthfeel, and consumer preference of fudge. The independent variables of this experiment were the differing amounts of butter and fudge used, and the dependent variables were the outcomes of color, texture, mouthfeel, and consumer preference.

**METHODS:** To test the hypothesis, three batches of fudge were made with 3 different amounts of avocado it them. One batch, the control variable, had the called for ¼ cup (57g) of butter and no
avocado. The second batch, variable 1, had 1/8 cup (29g) of butter and 1/8(29g) cup of avocado. The third batch, variable 2, had ¼ cup (57g) of avocado and no butter. Each of these three variables was then tested with a sensory panel as well as a hunter colorimeter and texture analyzer. This was done 3 different times on 3 different days to produce triplicate results.

Recipe

- 1 7oz jar (198g) of Marshmallow Crème -1/4 teaspoon (1.5g) salt
- 1 ½ cup(300g) sugar - 2 cups (627g) milk chocolate chips
- 2/3 cup (158mL) evaporated milk - 1 cup (313.5g) semisweet chocolate chips
- ¼ cup (57g) butter or avocado - 1 teaspoon (5g) vanilla extract

In a large saucepan over medium heat, combine marshmallow cream, sugar, evaporated milk, butter and salt. Bring to a full boil, and cook for 5 minutes, stirring constantly.

Remove from heat and pour in semisweet chocolate chips and milk chocolate chips. Stir until chocolate is melted and mixture is smooth. Stir in vanilla. Pour into prepared pan. Chill in refrigerator until firm.

Following the recipe, marshmallow crème, sugar, butter, and salt were boiled on the stove for 5 minutes. Avocado, if the variable called for it, was mashed with a fork and added after boiling. The chocolate chips and vanilla were then added and the mixture was stirred until the chocolate was melted completely and it had reached a smooth texture. All three fudge mixtures were poured into pans and put in the refrigerator. During the first trial, all three mixtures were poured into disposable 8x8 aluminum pans for refrigeration. In the second trial, all three mixtures were poured into stainless steel baking pans. However, the pans for variables 1 and 2 were lined with aluminum foil while the control pan was not. In trial 3, all three mixtures were poured into stainless steel baking pans all lined with aluminum foil. The three mixtures in all three trials were refrigerated for 1 hour and then moved to the freezer for 15 minutes. They were then refrigerated for another 15 minutes before being analyzed.

To objectively analyze the samples, the texture analyzer and hunter colorimeter were utilized. The texture analyzer was used with the cone probe and was set to the fudge setting. Subjective evaluations were performed by a taste panel of students. Trial 1 was taken home by one group member to collect evaluations. Trial 2 was taken home by another; the third group member took home trial 3. Panelists were asked to analyze mouth-feel and their preference for each variable. Mouth feel was evaluated using a 9-point hedonic scale with 1 correlating to a mouth-feel that is sticky, hard, and unpleasant; a score of 9 correlated to a mouth-feel that was smooth, creamy, and pleasant. Panelists were asked to indicate which of the three samples they preferred the most, which they preferred the least, and which was in the middle. A sample of the scorecard used is shown in below.

Here is an example of the scorecards:

*Please rate the mouth-feel of each fudge based on a 9 point hedonic scale. Circle the appropriate rating.*
*1=sticky, hard, unappealing  9=smooth, creamy, soft, appealing*
Please rank your preference of the fudge.

<table>
<thead>
<tr>
<th></th>
<th>630</th>
<th>217</th>
<th>312</th>
</tr>
</thead>
<tbody>
<tr>
<td>Most Preferred</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Middle Preference</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Least Preferred</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**DISCUSSION:**

The results of this experiment determined that the use of avocado as a fat replacer in fudge did have effect on the texture of the fudge. Table 1 summarizes the collected data. The control, with ¼ cup butter had the highest measurement for texture analysis with an average of 45.9g. This indicates that this fudge was the hardest out of the three variations. Variable 1 was the softest with an average texture measurement of 19.33g. The final variation was in the middle measuring 36.37g. These results could indicate that the use of only avocado produces fudge that is softer than one produced with only butter, but that fudge produced with both avocado and butter produce fudge that is softer than either fat alone. A study published in the Journal of Food Science evaluated the effects of fat replacement as well. Avocado oil was used as a fat-replacement in burger patties and the hardness was analyzed using a texture analyzer to measure compression of the patty after being cooked. When compared to the control, the burger made with avocado oil was softer than the burger made with pork-back fat. This is conclusive with our results and researchers speculate that these results could be due to a correlation between protein carbonyls and hardness (Rodriguez, Morcuende & Estevez, 2011.)

Lipid oxidation has been shows to negatively affect the texture of meats and other foods. When unsaturated lipids undergo oxidation, they produce lipid radicals that contain carbonyls.
These carbonyls form a cross-linked structure that contributes to a harder texture in foods (Utera, Armenterosa, Ventanas, Solano & Esteves, 2012.) The use of fat replacement and fruit and vegetable oils acts as an antioxidant and prevents this production of carbonyls and therefore creates a softer texture in foods (Morcuende, Ganhao & Estevez, 2012.) This explains why the fudge made with only avocado had a lower texture reading than the fudge made with only butter.

Both the control and variable 2 had large standard deviations, over 31, in their average texture readings between the three trials. The large deviations in the measurements of each trial correlated to results that were not statistically significant. The p-value for the texture analyzer measurements was found to be 0.4981. This insignificance is most likely due to experimental errors. For instance, when making the fudge, certain variations experienced carmelization during cooking while others did not. This could have had an effect on the texture of the fudge. In trial 2, the use of foil in only two, instead of all three, pans could have affected the cooling and setting process and would have attributed to the deviation between the three trials. Another major variation between variables that could contribute to a large standard deviation is the cooling and setting of the fudge. Despite being refrigerated and frozen for the same amount of time, certain variables of the fudge set more firmly than others for unknown reasons and produced a higher texture measurement.

All data from this experiment leads to the conclusion that the replacement of butter with avocado in fudge does not significantly change the texture. While combining both butter and avocado in fudge could lead to an undesirable, soft product, the use of just avocado can lead to fudge that is no different than fudge made with butter. This substitution leads to healthier fudge with a much more favorable unsaturated: saturated fat ratio that promotes a decreased cardiovascular disease risk.

Through the experiment it was found that replacing butter with avocado had very little effect on the color of the fudge. As seen in Table 2 and Figure 2, the L (lightness) values were as follows: Control (21.98), Variable 1 (19.99), and Variable 2 (20.75). This shows that the shade of the color of the fudge was very uniform across the variations. This may occur because the amount of chocolate in comparison to avocado was much greater; therefore the darkness of the chocolate most likely overpowered the avocado lightness. The A (green to red) values were as follows: Control (9.04), Variable 1 (9.16), and Variable 2 (8.3). And the B (blue to yellow) values were as follows: Control (8.34), Variable 1 (8.1), and Variable 2 (7.61). As seen in Table 3, the highest standard deviation among all the variations was only 1.79. This signifies that our results were all very close and therefore provide more reassurance of their accuracy.

A study titled “Partial replacement of pork back-fat by vegetable oils in burger patties: Effect on oxidative stability and texture and color changes during cooking and chilled storage” dealt with the effects of avocado oil in place of fat in beef patties. One of the variables studied was color. This study found that there was very little change between the color of the patties whether it was replaced with avocado oil or not. In regards to the L (lightness) values, the following values resulted: Control: Raw (69), Cooked (74), Cooked+ Chilled (78) and in avocado Oil: Raw (72), Cooked (75), Cooked+ Chilled (80). Although the differences are small, they could still occur because of the small oil globules in avocado oil will reflect more light than the large beef fat globules. In regards to the A (green to red) values, the
following values resulted: Control: Raw (12), Cooked (3), Cooked+ Chilled (1), and in avocado: Raw (8), Cooked (2), Cooked+ Chilled (-1). And although these differences are small as well, they could still occur because of the large amount of pigments and chlorophylls that are present in avocado oil.

Through both the study and this experiment, it can be seen that adding avocado to fudge (and beef patties) has no significant effect on the fudge and therefore there in promotes the null hypothesis in the way that there is no effect on color by replacing butter in fudge with avocado.

For the subjective methods of replacing fat with avocado in fudge, panelists rated each variable of fudge for mouthfeel on a 9 point hedonic scale then ranked the three variables in from most preferred to least preferred. Consumers did not notice a significant difference in mouthfeel in the three samples of fudge, as seen in table 4. The mouthfeel rating declined as the amount of avocado increased in the fudge, but not by much. Avocado and butter both have a creamy and soft mouthfeel, which accounts for the similar ratings on a 9 point hedonic scale.

As seen in figure 4, on average the control variable that contained only butter was the most preferred. Variable one with half butter and half avocado was the middle preference, and variable two or the full avocado replacement was the least preferred. Although the half replacement of butter in variable 1 was not the most preferred overall, more than one third of the panelists preferred it the most. Variable 2 or full avocado, however, was by far the least preferred as more than half of the tasters marked it as their least preferred and only 17% of tasters preferred it the most. The consumer preference did not decrease by much when replacing with half avocado because the amount was not very noticeable and did not change the taste or mouthfeel significantly. In a study by the Journal of Food Quality, avocado and oatrim replaced the butter in oatmeal cookies. The cookies with half Avocado or Oatrim and half butter were acceptable to consumers (Wekwete 2008).

As seen in table 5, having 57% of panelists select variable two as their least favored fudge sample, the least preferred variable was variable 2, where the butter was fully replaced with avocado. Tasters can probably notice a difference when the buttery taste in fudge that they are accustomed to is no longer present. In a study from Emirates Journal of Food and Agriculture, researchers did a similar experiment replacing butter with applesauce in cookies. Consumer preference significantly decreased as well when the butter was fully replaced with applesauce. There was not a significant difference in consumer preference between the control variable and the cookies half replaced with applesauce (Hayek 2013). Although in the fudge experiment, the control was more preferred than the other variables, the half replacement of butter with avocado in variable 1 was most preferred by more than one third of panelists. If one is making a dessert or baked good and wants to improve the nutrient content of the food without significantly reducing preference, replacing have of the fat may be the leading choice.

Replacing the fat in desserts will likely alter the qualities of the food. However, when only half of the fat is replaced the consumer preference and qualities like mouthfeel may not be significantly lower than the control. If one is looking for a healthier option in dessert recipes, replacing half of the butter with another soft and creamy ingredient like avocado is a good option. Replacing all of the fat is an option, but will likely have a much lower consumer preference.
In the future, researchers should explore other options for improving the nutritional value of fudge. This can be done by adding various amounts of fiber in the form of ground flaxseed. They can also replace the butter in other dark, dense chocolatey desserts like flourless chocolate cake with avocado.

RESULTS:

Objective Methods

Table 1: The Effect of Replacing Butter with Avocado on Texture of Fudge

<table>
<thead>
<tr>
<th>Trial</th>
<th>Control (Only Butter) in grams</th>
<th>Variable 1: Half Avocado Half Butter in grams</th>
<th>Variable 2: Only Avocado in grams</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trial 1</td>
<td>11.7g</td>
<td>11.2g</td>
<td>18.5g</td>
</tr>
<tr>
<td>Trial 2</td>
<td>72.4g</td>
<td>16.3g</td>
<td>17.5g</td>
</tr>
<tr>
<td>Trial 3</td>
<td>53.6g</td>
<td>30.5g</td>
<td>73.1g</td>
</tr>
<tr>
<td>Average</td>
<td>45.9</td>
<td>19.33</td>
<td>36.37</td>
</tr>
</tbody>
</table>

Instat Results:

One-way Analysis of Variance (ANOVA)

The P value is 0.4981, considered not significant.

Variation among column means is not significantly greater than expected by chance.

Post tests

Post tests were not calculated because the P value was greater than 0.05.
Table 2: Effect of Replacing Butter with Fudge on Color

<table>
<thead>
<tr>
<th></th>
<th>L</th>
<th>a</th>
<th>b</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>21.98</td>
<td>9.04</td>
<td>8.34</td>
</tr>
<tr>
<td>Variable 1: ½ Butter and ½ Avocado</td>
<td>19.99</td>
<td>9.16</td>
<td>8.1</td>
</tr>
<tr>
<td>Variable 2: Full Avocado</td>
<td>20.75</td>
<td>8.3</td>
<td>7.61</td>
</tr>
</tbody>
</table>

Table 3: Effect of Replacing Butter with Avocado on Color: Standard Deviation

<table>
<thead>
<tr>
<th></th>
<th>L</th>
<th>a</th>
<th>b</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Standard Deviation</td>
<td>1.78742</td>
<td>1.207739</td>
<td>1.645063</td>
</tr>
<tr>
<td>Variable 1: ½ Butter and ½ Avocado Standard Deviation</td>
<td>0.885118</td>
<td>0.522047</td>
<td>0.43501</td>
</tr>
<tr>
<td>Variable 2: Full Avocado Standard Deviation</td>
<td>1.309975</td>
<td>0.6245</td>
<td>0.432782</td>
</tr>
</tbody>
</table>
Subjective Methods

Table 4: Effect of Replacing Butter with Avocado on Fudge Mouthfeel

<table>
<thead>
<tr>
<th>Variable</th>
<th>Average Mouthfeel Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>7.3</td>
</tr>
<tr>
<td>Variable 1: ½ Butter and ½ Avocado</td>
<td>7.1</td>
</tr>
<tr>
<td>Variable 2: Full Avocado</td>
<td>6.4</td>
</tr>
</tbody>
</table>
Table 5: Effect of Butter Replacement with Avocado on Consumer Preference of Fudge

<table>
<thead>
<tr>
<th>Ingredient Used for Fat</th>
<th>Control</th>
<th>Variable 1: ½ Butter and ½ Avocado</th>
<th>Variable 2: Full Avocado</th>
</tr>
</thead>
<tbody>
<tr>
<td>Most Preferred (% of people)</td>
<td>46</td>
<td>37</td>
<td>17</td>
</tr>
<tr>
<td>Middle Preference (% of people)</td>
<td>31</td>
<td>45</td>
<td>26</td>
</tr>
<tr>
<td>Least Preferred (% of people)</td>
<td>23</td>
<td>20</td>
<td>57</td>
</tr>
</tbody>
</table>
Effect of Replacing Butter with Avocado on Average Consumer Preference of Fudge

% of People who Tasted

Control
Variable 1: ½ Butter and ½ Avocado
Variable 2: Full Avocado

Ingredient Used for Fat

Most Preferred
Middle Preference
Least Preferred

FIGURE 4
REFERENCES:


