The Effect of Fat Type on Pie Crust Texture and Palatability

Group Research Project NUTR 435

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Abstract
The rising statistics of American with excess visceral fat are a cause of concern, with relation to the increased risk of a multitude of chronic diseases. Increased antioxidant intake and unsaturated fats can help combat some of these diseases and risk factors. A standard pie crust uses hydrogenated vegetable oil or saturated animal fat in the recipe. Replacing this fat with a fat that provides more nutritional benefits, while maintaining the desired texture, color, and flavor can offer an improved option for consumers. To test the effectiveness of a fat substitution two alternate variations, coconut oil and smart balance, of a standard pie crust recipe were created and analyzed. The texture, color, and water activity were tested and compared. Subjective testing was conducted to assess consumer acceptance. Overall, based on consumer acceptance, it was found that with further experimentation on each variation, an acceptable replacement for hydrogenated oil or lard can be used to make a pie crust with improved nutritional content.
Title: The Effect of Fat Type on Pie Crust Texture and Palatability

Introduction:

Some of the problems now occurring in the United States include the existence and increasing mass of visceral fat in the population. Acute and chronic inflammatory response is a problem. All of the following are affected by acute and chronic inflammatory response: immune system, cancer, atherosclerosis, ischemic heart disease, and some neurodegenerative diseases, such as Alzheimer's. If people had a higher antioxidant intake, it would help decrease cancer and heart disease rates. These previous conditions can be improved by swapping out current oils or fats with coconut oil (Intahphuak and others 2010). Smart Balance's main oils include soybean, palm fruit, canola and olive oil. A diet high in soybean oil (vs. vegetable oil) has been shown to decrease total cholesterol and low-density lipoprotein factors (Iver and others 2012).

The purpose of this experiment was to evaluate fat substitutions in a standard pie crust recipe. The typical pie crust recipe used in in the United States is made of shortening or occasionally lard. For the purposes of this experiment Crisco brand shortening will be utilized as the control. To evaluate potential fat substitutes, smart balance and coconut oil are used to create pie crusts comparable to the control. Because of their structure, the fatty acids the fats used in standard pie crust have the ability to stack and form sheets when cut into flour, which facilitates the formation of the desirable flakiness in a standard pie crust. The goal of these experiments was to administer changes in fat content resulting in little or no deviations from the desired characteristics of a standard pie crust. Creating a pie crust using a healthier fat type, while maintaining consumer acceptance, would result in a healthier crust and contribute to pastry choices with higher nutritive value in the United States.

Methods:

To conduct the experiment, three variations of pie crust were prepared using the control fat and two fat substitutions, variables 1 and 2. All three variations and trials for each were prepared using the same recipe and procedures. After the crusts were baked, they underwent objective and subjective testing to gather data for comparison against the control.

The overall procedure to conduct this experiment was simple. A standard pie crust recipe, found on the Crisco website, was used for each experiment. The recipe and dough preparation procedure is as follows:

Ingredients:

- 166.25 g Pillsbury Best All-Purpose Flour
- 3.0 g Salt
- 102.5 g Crisco All-Vegetable Shortening
- 44.4-88.9g Ice Cold Water

Preparation:
1. Blend flour and salt in medium mixing bowl.
2. Cut chilled shortening into 1/2-inch cubes. Cut in chilled shortening cubes into flour mixture, using a pastry blender, in an up and down chopping motion, until mixture resembles coarse crumbs with some small pea-sized pieces remaining.
3. Sprinkle half of ice cold water over the flour mixture. Using a fork, stir and draw flour from bottom of bowl to the top, distributing moisture evenly into flour. Press chunks down to bottom of bowl with fork. Add more water by the tablespoon.
4. Shape dough into a ball.
5. Refrigerate for 30 minutes.
6. Roll dough from center outward with steady pressure on a lightly floured work surface (or between two sheets of wax or parchment paper) into a circle 2-inches wider than pie plate for the bottom crust. Transfer dough to pie plate by loosely rolling around rolling pin. Center the rolling pin over the pie plate, and then unroll, easing dough into pie plate.
7. Trim edges of dough leaving a 3/4-inch overhang. Fold edge under. Flute edge as desired.
8. Prick bottom and sides of unbaked pie dough with fork 50 times to prevent it from blistering or rising. Bake crust in lower third of oven, at 425°F; 10-12 minutes or until edges and bottom are golden brown.

Throughout the preparation and cooking of the pie crust variations, the only deviation from this recipe and procedure was in the type of fat used and water content. Under normal dough preparation conditions, one would add water until the desired consistency is reached. In order to maintain consistency for each trial and crust, an average of lowest and highest recommended amounts of water in the recipe was calculated, coming to 66.6 g, and was used for each variation. The second deviation occurs in the fat selections, which are the second and third variables. In place of the control, 102.5 g of Crisco, 112 g of chilled smart balance and 109 g of room temperature coconut oil were used in its place. The remaining ingredients and procedures stayed the same. The metric weights are varied, but the English measurements requested in the recipe are all equal to ½ cup. Using the English measurement maintains the ratio of fat to the rest of the ingredients consistent for each variation.

Ingredient preparation involved chilling the Crisco and Smart balance for at least 4 hours to aid in dough formation and handling. The coconut oil was too hard and brittle when chilled, and was easier to work with at room temperature. After the fat was chilled, the dough was prepared following steps 1-4 in the recipe provided above. The recipe suggested refrigerating the dough for at least 30 minutes to aid in rolling it out before placing in the pan. After the control dough was prepared, it was placed in the refrigerator. Next, the smart balance variation was prepared. This process continued until all three dough types were mixed and being chilled. Additionally, any observations during preparation were noted for future comparison. Starting with the control, the dough was removed from refrigeration, rolled out, placed in the pan, and baked according the directions in the recipe. Because each fat type has its own physical properties and behaviors, the bake time varied for each variable and was recorded for later analysis.

After the crusts were baked, objective tests to assess the texture, color, and water activity of each crust were performed. We used a texture analyzer with a knife probe, which is appropriate for measuring breaking strength and cutability (Connie M. Weaver, 2003). To assess the texture of each
crust, the texture analyzer was set to 2 mm/sec pretest, 5 mm/sec for testing, 5 mm/sec post test, 15 mm distance, and 4 g of trigger force. To determine the color difference between each variation of crust, the Hunter colorimeter was used. It was calibrated using black and white standard ceramic tiles. The device used Lab Scan XE software to perform the color analysis. Testing was conducted on the bottom center of the crusts. Lastly, the water activity of each crust was analyzed using an Aqua Lab water activity system to measure water composition within each variation. Once objective testing was completed, the subjective testing began.

The subjective test included sensory examination and description of the pie crusts’ texture (flaky, soft, etc.), appearance (color, consistency), and flavor (taste, aroma, etc.). The panel consisted of 6 random participants from the lab and home, plus 1 of the researchers for each trial. The panelists were varied in level of training and unaware of the contents of the food. An allergy screening was conducted to ensure the safety of the participants. The samples were cut into bite sized pieces, placed on identical white plates, and labeled using a three digit random code to prevent bias. The samples were presented in random order for each participant. The following sensory score card was provided.

<table>
<thead>
<tr>
<th>Sample#</th>
</tr>
</thead>
<tbody>
<tr>
<td>__________</td>
</tr>
</tbody>
</table>

**Sensory Evaluation** | **Description**
--- | ---
**Texture** | *Flakiness:*
 | *Stability:*
 | *Other:*
**Appearance** | *Color:*
 | *Consistency:*
 | *Other:*
**Flavor** | *Taste/Mouth Feel:*
 | *Aroma:*
 | *Other:*
Results:

Table 1. **Texture Analyzer (g)**

<table>
<thead>
<tr>
<th>Trial</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>Mean</th>
<th>S.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crisco</td>
<td>142.379</td>
<td>157.489</td>
<td>918.940</td>
<td>406.269</td>
<td>444.050</td>
</tr>
<tr>
<td>Coconut Oil</td>
<td>98.537</td>
<td>352.010</td>
<td>224.103</td>
<td>224.883</td>
<td>126.738</td>
</tr>
<tr>
<td>Smart Balance</td>
<td>208.851</td>
<td>214.384</td>
<td>353.429</td>
<td>258.888</td>
<td>81.922</td>
</tr>
</tbody>
</table>

**Figure 1** Grams of force required to break Crisco, Smart Balance, and Coconut Oil pie crust variations using Texture Analyzer.

Table 2a. **Hunter Colorimeter Readings**

<table>
<thead>
<tr>
<th>Trial</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crisco</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>58.940</td>
<td>61.150</td>
<td>63.250</td>
<td>61.113</td>
</tr>
<tr>
<td>A</td>
<td>2.540</td>
<td>2.010</td>
<td>2.220</td>
<td>2.257</td>
</tr>
<tr>
<td>B</td>
<td>17.200</td>
<td>18.120</td>
<td>18.040</td>
<td>17.787</td>
</tr>
<tr>
<td>Coconut Oil</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>61.910</td>
<td>59.880</td>
<td>57.540</td>
<td>59.777</td>
</tr>
<tr>
<td>A</td>
<td>1.860</td>
<td>1.720</td>
<td>1.700</td>
<td>1.760</td>
</tr>
<tr>
<td>B</td>
<td>17.500</td>
<td>17.060</td>
<td>16.520</td>
<td>17.027</td>
</tr>
<tr>
<td>Smart Balance</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>60.230</td>
<td>60.710</td>
<td>61.940</td>
<td>60.960</td>
</tr>
<tr>
<td>A</td>
<td>2.850</td>
<td>2.100</td>
<td>2.990</td>
<td>2.647</td>
</tr>
</tbody>
</table>
Table 2b.  
**Hunter Colorimeter Mean Values**

<table>
<thead>
<tr>
<th>Fat Type</th>
<th>L</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crisco</td>
<td>61.113</td>
<td>2.257</td>
<td>17.787</td>
</tr>
<tr>
<td>Coconut Oil</td>
<td>59.777</td>
<td>1.760</td>
<td>17.027</td>
</tr>
<tr>
<td>Smart Balance</td>
<td>60.960</td>
<td>2.647</td>
<td>19.987</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>N</th>
<th>3</th>
<th>3</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>60.617</td>
<td>2.221</td>
<td>18.267</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.731</td>
<td>0.444</td>
<td>1.537</td>
</tr>
</tbody>
</table>

![Graph showing Hunter Colorimeter readings for Crisco, Coconut Oil, and Smart Balance.](image)

**Figure 2** Average L, A, and B readings for Crisco, Smart Balance, and Coconut Oil pie crust variations using the Hunter Colorimeter.

Table 3.  
**Water Activity Readings for Pie Crust Variations**

<table>
<thead>
<tr>
<th>Trial</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>Mean</th>
<th>S.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crisco</td>
<td>0.679</td>
<td>0.773</td>
<td>0.577</td>
<td>0.676</td>
<td>0.098</td>
</tr>
<tr>
<td>Coconut Oil</td>
<td>0.831</td>
<td>0.672</td>
<td>0.727</td>
<td>0.743</td>
<td>0.081</td>
</tr>
<tr>
<td>Smart Balance</td>
<td>0.708</td>
<td>0.803</td>
<td>0.666</td>
<td>0.726</td>
<td>0.070</td>
</tr>
</tbody>
</table>
The purpose of this experiment was to replace the standard fat in a pie crust recipe to offer an option with improved nutritional value, while maintaining the desired characteristics as a typical pie crust. Using objective and subjective tests, it was determined that a fat type can be changed in a standard pie crust recipe to make an acceptable pie crust.

Objective Testing:

*Texture Analyzer:* Using the Texture Analyzer to explore the breaking strength of the pie crusts was a very important part of this process. Testing the crust with the Texture Analyzer gives the information needed to compare the three crusts in terms of breaking strength, stability, and cutability. In a standard pie crust, it is desired that the crust be strong enough to support fillings, be tender enough to cut with a fork, and flaky enough to please the palate. Because of their structure, the fatty acids in Crisco, have the ability to stack and form sheets when cut into flour, which facilitates the formation of the desirable flakiness in a standard pie crust. The goal was for the coconut oil and Smart Balance crusts to demonstrate the same characteristics or be similar to the control (Crisco) crust. Three trials were performed and the averages calculated (Refer to Table 1). The Crisco crust took the most force to break. This can be attributed to the structure of the fatty acids in this fat type. It is comprised of fatty acids that range from 12-18 carbons in chain length and contains saturated fat and fully hydrogenated oils. The chain length and structure of these fats increase the force needed to break the crust. The coconut oil had the lowest forced required to break the crust. This can be attributed to the structure of the fatty acids. Coconut oil is comprised of saturated, monounsaturated, and polyunsaturated fatty acids. The majority of the fat in coconut is saturated fat, and of the seven kinds of fatty acids present, the predominant ones have a medium chain length

![Figure 3 Water activity readings for Crisco, Coconut Oil, and Smart Balance pie crust variations.](image)
While the structure of saturated fat allows for more stacking and strength between chains, the shorter chain length contributes to a decrease in strength compared to the longer chain fatty acids in the control. This resulted in a similar crust, but with decreased strength. The Smart balance contains a multitude of ingredients other than fat and oil. Of the fats and oils present, they are long chain mono- and polyunsaturated fatty acids such as soy bean, palm fruit, canola, and olive oil (Smart Balance 2012). The other ingredients provide stability to the structure of the mixture, prevent the water from separation out of the emulsion, and prevent oxidation of the fatty acids. The mixture of ingredients resulted in a slightly flexible crust that took more force to break than the control on two of the three trials (Refer to Table 1). Based on the data from the texture analyzer it is apparent that natural variances occur in different parts of the crust, and between each trial. When the outliers are eliminated, then the three crusts’ average readings appear closer in values and indicate that the fat can be substituted with minimal change in breaking strength. Upon evaluation using ANOVA (p-value < 0.05), it was determined that the P value is 0.6990, and is considered not significant. According to this, variation among column means is not significantly greater than expected by chance.

**Hunter colorimeter:**
Appearance is a significant contributor to food appeal. Therefore, color changes that are clearly different from the control are important to consider when predicting consumer acceptance. The data was used to look for significant differences in color between different fat types. Tables 2a and 2b represent the values gathered from the Hunter Colorimeter. Color measurements are useful in determining the intensity of browning reactions in baked goods. In this experiment, color measurements help to determine if coconut oil and/or smart balance would be a suitable substitute for Crisco based on color variation. It gives the researchers objective data to compare with subjective observations. The L value represents the scale from light to dark. An One-way Analysis of Variance (ANOVA) calculation was completed, and found that the P value is 0.6215, which is considered not significant. Variation among column means is not significantly greater than expected by chance, which indicates little difference with respect to light and darkness of the crusts. The A value represents the scale from red to green and the B value represents the scale from yellow to blue. After performing ANOVA calculations comparing the mean A values (p-value <0.05), it was determined that P value is 0.0400, and is considered significant. Variation among column means is significantly greater than expected by chance. This means that in the case of colors red to green, there was significant difference between each variation of crust. With regard to the mean B values, upon calculation using an ANOVA (p-value <0.05), it was determined that P value is 0.0019, and thus is considered very statistically significant. Variation among column means is significantly greater than expected by chance, meaning that the colors from yellow to blue are quite different between each variation.

**Water activity:**
Fat type influences the ability of the mixture to trap varied amounts of water and air. Testing the water activity is a good way to observe any changes that may occur when substituting a fat with a different composition than the control, Crisco. If significant changes are observed, this could influence the shelf life and texture of the product. Water activity is commonly used as a predictor of
microorganism growth in food systems (Bruhn, 2006). The control had an average water activity of \(0.676\) (Refer to Table 3) between the three trials, and because most chemical reactions, bacterial and mold growth, and enzyme activities occur at \(a_w < 0.080\) (Connie M. Weaver, 2003) this figure is desirable provided the water activity is controlled after the crust is baked and packaged. Variable 2, the Smart Balance, had an average \(a_w = 0.726\) and variable 3, the coconut oil, had an average \(a_w = .743\). Because the water activity remains below 0.80, and deviates little from the control, this indicates the fat type has little effect on the water activity of the crust. Calculations using a One-way Analysis of Variance (p-value <0.05), found that the P value is 0.6215, and is considered not significant, which supports the initial comparison of water activity means between each variation.

**Subjective Testing**

*Preparation Observations:*

Observations during preparation were noted for each variable. As expected, the control was soft and smooth, and strong when being rolled out and placed in the pan. It took 20 minutes to cook. The Coconut oil was chilled, but became so rigid that room temperature oil was required for cutting the fat into the flour. It also seemed to need more water, although water wasn’t added to maintain consistency across recipes. The dough crumbled easier than the control and hardened up quickly when placed in refrigeration. It required 15 minutes to bake. The Smart Balance was easy to mix, created smooth dough that was almost silky, but was temperature sensitive and fragile while being rolled out and transferred to the pan. It didn’t need as much water as the control, but the full amount was added. It baked for 15 minutes.

*Texture Observations:*

The participants were provided a section on the scorecard to record observations with regard to the texture of the pie crust samples. The panelists all observed similar characteristics between each sample. For the control, it was commonly described as flaky and sturdy. These characteristics are expected and desired for a tender pie crust that can hold its shape when holding fillings. The Coconut Oil crust was reported to be less flaky than the control, and had a compact texture. The crust was stable and could likely maintain its shape, but was not as stable when compared to the control. The Smart Balance pie crust was reported as not flaky, but was crisp after extended cooling time. Before cooling, it was reported as chewy. The stability of the crust was unique to the three variations. It was flexible, which increased its breaking strength in the Texture Analyzer, but didn’t hold its shape as well as the control. The crust was thinner than the control and likely would not have held filling.

*Appearance:*

The section of the score card for appearance gave the participant the opportunity to make visual comparison between the control and variables. The control was observed as golden brown around the edges and light yellow to cream in the center, which are considered expected and desired. The consistency and visual texture was uniform with no bubbling or cracking. The Coconut Oil was
visually different from the control in color and consistency. It was reported to be too light in color and had an irregular and bubbled surface. The Smart Balance crust was reported to be more yellow in color with little browning. It had a uniform appearance with regard to texture.

**Flavor:**

The panelists were asked to smell and taste the samples, then record observations with regard to flavor, mouth feel, and aroma. The control was reported have a hint of saltiness, slightly oily mouth feel, and tasted like a standard pie crust, which was expected. It smelled of baked flour, but not an identifiable aroma. The coconut oil crust was reported to have a hint of flavor; that no panelist could identify. The aroma was also clearly different from the control, although not undesirable, and was familiar to most testers. None were able to ascertain the origin of the smell. The Smart Balance was reported to have a buttery and salty taste. It had a moist mouth feel, but not oily as was found in the control.

**Conclusions and Suggested Future Research:**

In this case, when consumer acceptance is the most important factor to consider, it is clear that the substitution of Crisco for an alternate fat type is possible. However, each variable had its own restrictions and characteristics to be dealt with when making this substitution. The coconut oil provided a pleasant change in flavor and aroma, but requires additional experimentation to improve appearance and stability. The Smart balance additionally offered a slight variation in flavor but is not stable enough to hold filling when prepared according to standard pie crust recipe and procedures. Perhaps cooling longer and rolling into a thicker crust would improve its stability after baking and allow the addition of filling.

**Works Cited:**

<http://drinc.ucdavis.edu/dairychem4_new.htm>


Other References:


