The Effect of Temperature and Fat Type on the Physical and Sensory Properties of Doughnut Holes

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Abstract

Fats contribute to the texture, color, mouth feel, and taste of foods. The purpose of this experiment was to determine the effect on general appearance, fat flavor, mouth feel, and percent fat absorption using different frying fats and different frying fat temperatures when frying doughnuts. Doughnut holes were fried in vegetable oils of 160˚C, 175˚C, 190˚C, and 205˚C; and in olive oil, peanut oil, lard, and Crisco. Results showed that there was no significant sensory preference in the temperature variations, while Crisco scored high and lard scored low on sensory preference. Differences were shown in both sets of variations for percent absorption.

Introduction

The commercial deep-fat frying economy in the United States is estimated to be $83 billion dollars (Choe, 2007). Deep fat frying is a popular food preparation method. Fats contribute to the texture, color, mouth feel, and taste of foods. When food is deep fried, it is quickly cooked in stages: moisture transfer, fat transfer, crust formation, and interior cooking (Brown, 2008). The frying process reduces cooking time (Casal, 2010). The food is submerged in fat and the water surrounding the food vaporizes into the oil, this brings the moisture in the food to its surface. A protective layer of steam forms around the food shielding it from the high oil temperature and preventing saturation from the oil. However, some oil will enter the food through the water escaping pores. The crust browns, partially due to Maillard reaction, and becomes more porous and larger due to escaping water. The inner part of the food is cooked
from heat penetration rather than from direct oil contact. Most of the absorbed oil is in the outer layer and the crust (Brown, 2007).

The purpose of this experiment was to determine the effect on general appearance, fat flavor, mouth feel, and percent fat absorption using different frying fats and different frying fat temperatures when frying doughnuts. In order to see how the fats compare, both sensory and instrumental evaluations must be performed.

When frying foods, it is important to not let the oil temperature get too high or too low. If the oil temperature is too high, then the crust can burn, while the inside remains uncooked. This can also lead excess fat absorption. If the oil temperature is too low, then it may cause excess fat absorption, causing the food to be soggy and greasy. This can happen if a large amount of frozen or cold food is added to hot oil. To prevent this, food should be added in small batches so that the oil temperature is not heavily affected. The optimal fried food should have a golden brown crust that is crisp, with a cooked inside. High moisture foods need lower oil temperatures so that the inside cooks, without the steam being trapped inside. Low moisture foods need higher oil temperatures, so that the inside cooks quickly without the oil entering the food. The optimal frying temperature is 191°C. Higher oil temperatures range from 191°C - 199°C and require pieces of food that are smaller, while lower oil temperatures range from 177°C - 185°C and require pieces of food that are larger (Brown, 2007). This experiment will fry doughnut holes in vegetable oil at 4 different temperatures: 160°C, 175°C, 190°C, and 205°C. The percent fat absorption will be calculated and the sensory qualities evaluated.

The type of oil used can also affect both the percent fat absorption and the sensory qualities. With an increased public awareness or obesity, high cholesterol, and cardiovascular disease, many consumers are looking for healthier frying options. Percent of saturated fat,
monounsaturated fat, and polyunsaturated fat in the oil can affect the health benefits from the oil. This experiment will fry doughnuts in olive oil, peanut oil, Crisco, and lard. The temperature will remain at 190°C for each oil. The olive oil and peanut oil are high in monounsaturated fat, while the lard is high in saturated fat. Crisco is an example of a hydrogenated fat, which has relative amounts of both monounsaturated fat and saturated fat. This can affect the overall qualities of the doughnut hole.

The vegetable oil with the low temperature of 160°C and the high temperature of 205°C should have the highest percent of fat absorption, followed by the temperature of 175°C and 190°C, due to the temperature being away from the optimal temperature of 190°C. The temperature of 190°C should result with the highest sensory qualities because it is the optimal temperature for frying. The lard should allow for a high fat flavor and absorption, which should be followed by Crisco, peanut oil, and olive oil.
Methods

Each group received commercially prepared biscuit dough. The biscuits were cut into 30 evenly sized pieces and rolled into “holes”. A 1 quart pot, with at least 1 inch of oil or about 500g of solid fat was heated to 190 degrees Celsius, or until the temperature variation. One biscuit hole was weighed before frying. Two biscuit holes, including the one that was weighed, were placed into the oil with a metal spatula. The hole was turned over and fried to a golden brown, while being timed. The biscuit holes were removed. The second hole was cut in half to check for doneness. The originally weighed hole was weighed again; both the weight and time were recorded. The rest of the holes were placed in the oil and cooked to a golden brown in batches of about 5 holes. The cooked holes with fat variation were placed in a zip-loc bag of ¼ cup sugar and 1 tablespoon cinnamon, while the temperature variation were placed in a zip-loc bag of powdered sugar. The bag was shaken to coat the holes (Matak, 2009).

The original hole and the rest of the batch were placed on a labeled plate and placed on the sensory evaluation table. Each person performed sensory evaluation, filling out a scorecard, which evaluated general impression, fat flavor, and mouth feel. Each category was rated on a scale of 1-5, where 1=dislike extremely, 2=dislike moderately, 3=neither like nor dislike, 4=moderately like, 5=like extremely. The % absorption was calculated using the following equation (Matak, 2009):

\[
\text{% Fat Absorption} = \frac{\text{Weight After Frying} - \text{Weight Before Frying}}{\text{Weight Before Frying}} \times 100
\]
Results and Discussion

Figure 1: Effect of Temperature and Fat Type Graph

![Graph showing the effect of temperature and fat type on sensory properties of doughnut holes]

*The Effect of Temperature and Fat Type on the Sensory Properties of Doughnut Holes*

Table 1: Percent Absorption and Frying Times of Variations

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Weight Before</th>
<th>Weight After</th>
<th>% Absorption</th>
<th>Frying time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetable Oil 160°C</td>
<td>13</td>
<td>14</td>
<td>7.69</td>
<td>1 min 42 sec</td>
</tr>
<tr>
<td>Vegetable Oil 175°C</td>
<td>5.83</td>
<td>5.85</td>
<td>0.343</td>
<td>1 min 5 sec</td>
</tr>
<tr>
<td>Vegetable Oil 190°C</td>
<td>12</td>
<td>14</td>
<td>16.6</td>
<td>2 min</td>
</tr>
<tr>
<td>Vegetable Oil 205°C</td>
<td>8</td>
<td>8</td>
<td>0</td>
<td>1 min 40 sec</td>
</tr>
<tr>
<td>Peanut Oil</td>
<td>8</td>
<td>10</td>
<td>25</td>
<td>2 min 10 sec</td>
</tr>
<tr>
<td>Olive Oil</td>
<td>4</td>
<td>6</td>
<td>50</td>
<td>1 min 15 sec</td>
</tr>
<tr>
<td>Lard</td>
<td>7</td>
<td>8</td>
<td>14.29</td>
<td>1 min 50 sec</td>
</tr>
<tr>
<td>Crisco</td>
<td>8</td>
<td>10</td>
<td>25</td>
<td>1 min 30 sec</td>
</tr>
</tbody>
</table>

*Type of Oil:
- Vegetable Oil
- Peanut Oil
- Olive Oil
- Crisco
- Lard

*Average Rating:
- General Impression
- Fat Flavor
- Mouthfeel

*Average Rating* is based on a scale of 1-5, where 1=dislike extremely, 2=moderately dislike, 3=neither like nor dislike, 4=like moderately, 5=like extremely

*n = 21. General impression, fat flavor, and mouthfeel were rated on a scale of 1-5, where 1=dislike extremely, 2=moderately dislike, 3=neither like nor dislike, 4=like moderately, 5=like extremely*
The purpose of this experiment was to determine the effect on general appearance, fat flavor, mouth feel, and percent fat absorption using different frying fats and different frying fat temperatures when frying doughnuts. Figure 1 shows the results of the sensory evaluation. The sensory evaluation was conducted by 21 people and the results were averaged. The vegetable oil at 160˚C had a general appearance of 4.048, fat flavor of 3.81, and mouth feel of 3.714. The vegetable oil at 175˚C had a general appearance of 3.762, fat flavor of 3.524, and mouth feel of 3.524. The vegetable oil at 190˚C had a general impression of 3.905, fat flavor of 3.667, and mouth feel of 3.857. The vegetable oil at 205˚C had a general impression of 3.952, fat flavor of 3.762, and mouth feel of 3.905. The peanut oil had a general appearance of 3.619, fat flavor of 3.667, and mouth feel of 3.286. The olive oil had a general appearance of 3.81, fat flavor of 3.476, and mouth feel of 3.286. The Crisco had a general impression of 4.095, fat flavor of 3.81, and mouth feel of 4.286. The Lard had a general impression of 2.524, fat flavor of 2.2857, and mouth feel 2.714. Overall, nothing scored higher than 4.3 or lower than 2.2.

The temperature variations had similar results without one variation being significantly above or below the others. The vegetable oil at 175˚C scored lowest for all 3 categories. The vegetable oil at 160˚C scored highest on general appearance and fat flavor. The vegetable oil at 205˚C scored highest on mouth feel. The vegetable oil at 190˚C, which is the typical frying temperature, was in between the highest and lowest on all three categories. These results show that there was no significant preference over one temperature variation. The expected results were that the control would be desired, however the control was shown no preference over the others.

The oil type variations from figure 1 did have sensory preference. The lard scored the lowest in all three categories, and was at least 1 below the values of the other variations. The
Crisco scored the highest in all three categories, with the score in mouth feel being significantly higher with 1 point higher than both peanut and olive oil and 2 points higher than lard. This was unexpected because lard has a high saturated fat content, which should carry fat flavor. However, this may have resulted in too much of an undesirable fat flavor. The Crisco preference can be due to the balance of both saturated and unsaturated fatty acids, which would give a smooth texture to the doughnut.

Most of the results except the lard showed a sensory evaluation rating between 3 and 4, meaning between “neither like nor dislike” and “like moderately”. The lard had ratings between 2 and 3, meaning between “moderately dislike” and “neither like nor dislike”.

Table 1 shows the before and after weights, percent absorption, and the frying times of the variations. For the temperature variations, the 190°C had the highest absorption with 16.6%, followed by 160°C at 7.69%, 175°C at .343%, and 205°C at 0%. The longest frying time was 190°C at 2 minutes, followed by 160°C at 1 minute 42 seconds, 205°C at 1 minute 40 seconds, and 175°C at 1 minute 5 seconds. These were unexpected because the expected result was that the 160°C would have the highest fat absorption and the longest frying time. However, it may have lost some of its weight from water loss, meaning it may have absorbed more oil. It was also expected that the 205°C would have a higher fat absorption.

The oil type variations also had significant differences in the fat absorption. The olive oil had the highest fat absorption with 50%, followed by both peanut oil and Crisco at 25%, and lard at 14.29%. The peanut oil had the longest frying time at 2 minutes 10 seconds, followed by lard at 1 minute 50 seconds, Crisco at 1 minute 30 seconds, and olive oil at 1 minute 15 seconds. The fat absorption results were unexpected. However, although the lard had the lowest absorption, it
has the most saturated fat. The olive oil had the highest absorption, but olive oil has the least amount of saturated fat and the most amount of monounsaturated fat.

Some of the unexpected results from this experiment can be due to wrong oil temperatures, which can be due to thermometer. It could also be due to the difference in size of the doughnuts in the variations, which could affect the frying times.

**Conclusion**

The evaluation of general impression, fat flavor, mouth feel, and percent absorption showed that there is not a significant difference in temperature differences, but there is in oil type. None of the temperature variations were preferred over the others. The Crisco oil type was preferred over the olive oil and peanut oil, which were all significantly preferred over the lard variation. These preferences were conducted by sensory evaluation. The percent absorption showed a difference between the temperature variations, where the 190˚C variation absorbed the most, while the 205˚C absorbed the least. The percent absorption for the oil type showed that the lard absorbed the least, while the olive oil absorbed the most. This was conducted by using an equation to measure weight before and after frying.

