The Effects of Using Different Fats on the Diameters of Cookies

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Abstract

In this study, we investigated the effect of different fat sources on cookie diameters in baking. We conducted five controlled experiments that adopted cookie recipes with vegetable shortening, coconut oil, butter, sunflower oil, and margarine to collect diameter measurements for cookies baked using different fats. We calculated the mean and median values for each dataset, and visualized the experiment's results using side-by-side box plots. A statistical analysis using a one-way ANOVA test and a Tukey's HSD test were performed for all of the cookie diameter data to compare and determine any significant differences between the groups. We found all of the resulting groups to be significantly different from each other with vegetable shortening versus margarine being the only exception, which supports our hypothesis that using different fats when baking cookies will affect the diameters of the resulting cookies. Lastly, we discussed the limitations and any possible source of error that may have influenced the experiment.

Introduction

The basic ingredients in a soft dough biscuit are flour, sugar, fat, water, and salt, and the role of fats in biscuit manufacturing is varied. Fat is the main element that gives cookies their suppleness, keeps their quality, adds grain and texture, and gives them a rich flavor (Antonela Verkovic, 2022). Biscuit mechanical qualities are mostly determined by the fat content of the recipe. Fat interacts with other substances to shape the product's texture, mouthfeel, and overall lubricity experience. The chemical and physical characteristics of fats can be affected by thermal treatments such as baking, toasting, or pasteurizing, depending on the lipid content and treatment circumstances (Alexander JC, 1981). They add their own features to various properties of numerous cookies as a result of the aforementioned changes. The rheological qualities of cookie dough are also influenced by fat (Pareyt et al., 2009). Our research looks at the effect of fat levels on cookie structure, and we hypothesize that if we use different baking fats in cookies, then the resulting cookies will have different diameters and spreadability. This hypothesis is based on the basics of baking science. Fats are made up of a variety of molecules with varying structures. Shortenings with a greater solid fat content (SFC) tend to be more finely dispersed among the wheat and sugar particles in a cookie, while the SFC in oil can hinder the development of the gluten network in the dough (Sciarini et al., 2013). Some macroscopic qualities of the dough, such as viscosity, hardness, and spread after baking may be affected by the degree of gluten polymerization. As a result, we anticipate that using various fats will result in varying cookie sizes. As people become more aware of health concerns, they will seek foods that better fit their needs. Healthy fats are required by the human body for energy and other activities, however, eating too much fat can lead to cholesterol buildup in your arteries (blood vessels). LDL ("bad") cholesterol is raised by fat. High LDL cholesterol raises your chances of developing heart disease and stroke (Meagan Bridges, 2021). Fat is one of the most essential substances used in cookie production, coming in third after flour and sugar and accounting for the majority of the caloric content of cookies. It is therefore becoming increasingly important to study the effects of fat on cookies.

Methods

To prepare for baking our cookies, we first calibrated our individual ovens. We placed spoonfuls of sugar on top of tin foil boats in our ovens to test at what temperature the sugar would melt. We used the known melting point of sugar (367°C) to find out the temperature settings that our ovens would need to be at to get a given desired actual temperature. We started by putting the sugar in our ovens at the 350°C setting. If the sugar melted, we decreased the temperature by 5°C intervals and tested new spoonfuls of sugar until we found a setting where it didn't melt. If the sugar did not melt at the 350°C setting, then we increased the temperature by 5°C intervals and tested new spoonfuls of sugar until we found a setting where it did melt. Doing this, we found out which temperature setting on our ovens corresponded to 367°C, and using this, we extrapolated to find out which settings our ovens had to be on to reach a desired actual temperature.

We had five different experimental groups in this experiment. We baked 5 batches of 48 cookies, each batch using a different fat source (vegetable shortening, butter, sunflower oil, coconut oil, and margarine). For each batch, we started out by stirring 2 ¾ cups of all-purpose flour, 1 teaspoon of baking soda and ½ teaspoon of baking powder into a small bowl. We then added 1 cup of the selected fat source with 1 1⁄2 cups of sugar into a larger bowl and mixed until it became smooth. 1 egg and 1 teaspoon of vanilla extract were beaten into the fat and sugar mixture. The contents from the small bowl were then gradually blended into the large bowl to complete the cookie dough.

We measured out 1 tablespoon sized lumps of dough and rolled them into balls by hand (Figure 1a). They were then evenly placed onto cookie sheets, making sure there was plenty of space in between each cookie so they wouldn't interfere with each other when expanding in the oven (approximately 10 cm between each dough ball). The cookie sheets were then placed into a preheated, calibrated oven at 375°C and left to bake for 8 minutes. After the cookies were done baking, they were taken out of the oven and left to sit at room temperature for 15 minutes before being measured (Figure 1b).

Figure 1. (Left) Dough balls before being put in the oven. (Right) Cookies after being taken out of the oven.

To measure the cookies, we used simple rulers. We measured the diameter of each cookie two times to the nearest millimeter in the shape of a plus (Figure 2). This was done to account for oval shaped cookies, as their diameters are not uniform all around. After getting these two measurements, we found the average diameter for each cookie and recorded the results. For example, if a cookie had a diameter 1 of 48 mm, and a diameter 2 of 50 mm, then the average diameter of the cookie would be (48 + 50) / 2 = 49 mm.

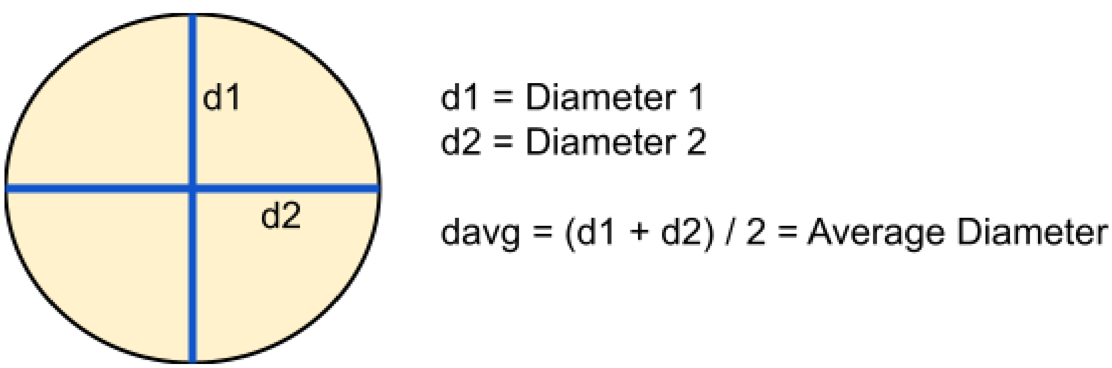

Figure 2. Method of measuring average cookie diameter (davg).

A one-way ANOVA test was then performed on all of the average cookie diameters to test for a difference between any of the groups, and then a Tukey HSD test was performed to find out which groups were significantly different from each other.

Results

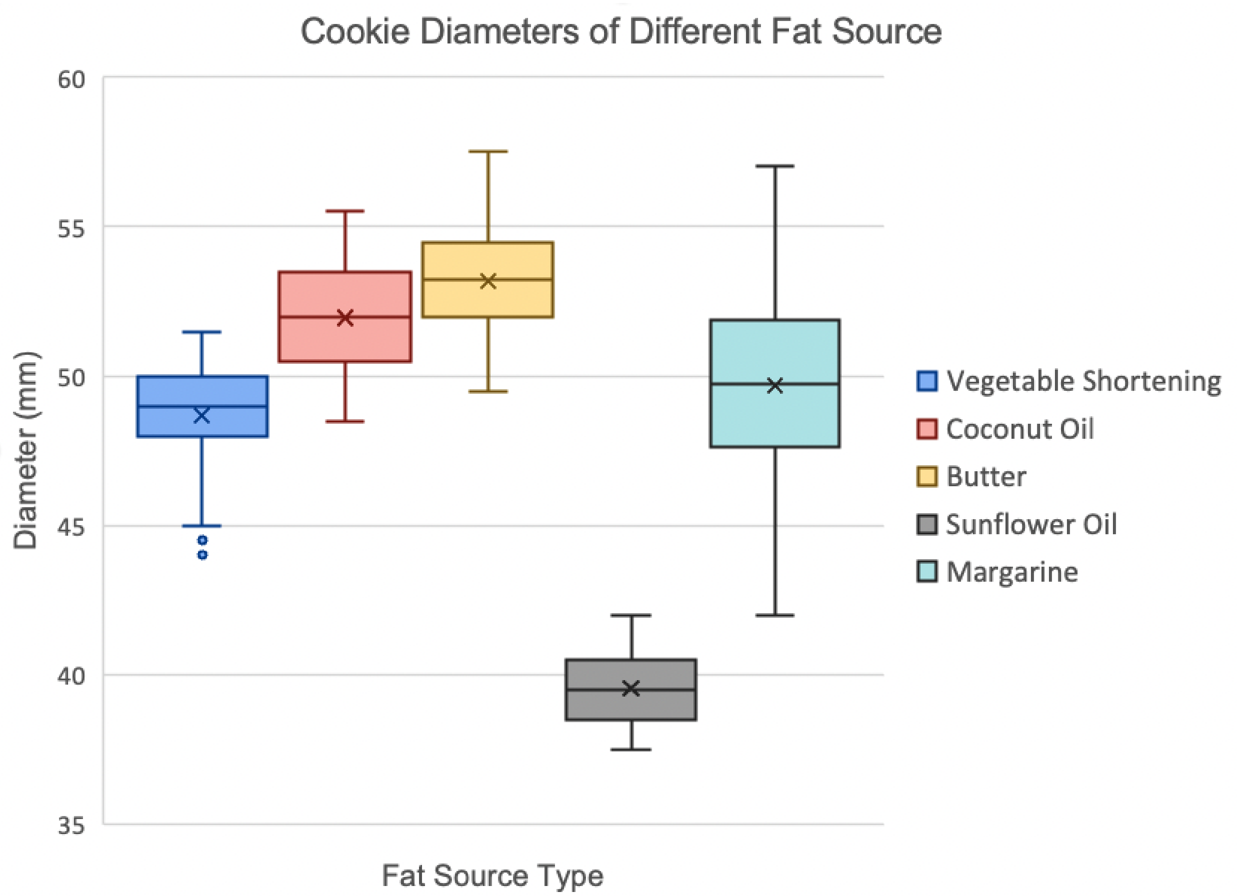

Figure 3. Summary of diameter measurements from each fat source. Each box plot represents 25% and 75% percentiles for different fat source; middle line marks median diameter m (mm); × marks represent average diameter μ (mm); the upper and lower whiskers extend to the maximum and minimum diameters; two outliers for vegetable shortening are marked by the blue dots. Sample size for each group was: vegetable shortening (n = 51), coconut oil (n = 47), butter (n = 48), sunflower oil (n = 47), margarine (n = 48).

Figure 3 shows the distribution of average cookie diameters for each of the five fat sources. We found a similar range in mean average cookie diameter involving vegetable shortening ($\mu = 48.67$ mm), margarine ($\mu = 49.69$ mm), coconut oil ($\mu = 51.96$ mm), and butter ($\mu = 53.18$ mm). Far outside this range is the mean average cookie diameter for sunflower oil ($\mu = 39.57$ mm). We also found a similar standard deviation between vegetable shortening ($s = 1.78$ mm), coconut oil ($s = 1.90$ mm), and butter ($s = 1.99$ mm). Sunflower oil was found to have a lower standard deviation of 1.12 mm and margarine was found to have a higher standard deviation of 3.13 mm.

A one-way ANOVA test was conducted on GraphPad Prism (version 9.3.1.471) to determine whether the means of the different fat source groups were statistically different. With our chosen significance level of $\alpha = 0.05$, we found that the one-way ANOVA test showed statistical significance in our data with a p-value of <0.0001.

A Tukey HSD test was also conducted on GraphPad Prism to determine which of the different fat source groups were statistically different from each other. Out of the total ten group comparisons, nine were found to be statistically significant with an adjusted p-value lower than 0.05. Eight of those nine comparisons were found to have an adjusted p-value of <0.0001. The coconut oil versus butter comparison was found to have an adjusted p-value of 0.0382. The only comparison that was not statistically significant was vegetable shortening versus margarine, with a p-value of 0.1105.

Discussion

The data collected in these experiments suggest that the source of fat used when baking cookies does affect the diameter of the cookie in a statistically significant way. When comparing the diameters of cookies baked using butter, margarine, vegetable shortening, coconut oil, and sunflower oil, analysis using a one-way ANOVA concluded that mean diameters of the cookies were different, with a p-value <0.0001. Furthermore, analysis using a Tukey HSD test found that of comparisons between fat types, all pairings were significantly different with the only exception being between margarine and vegetable shortening. Based on the results of these statistical tests we can reject the null hypothesis that the type of fat used in baking does not impact the diameters of cookies produced. We therefore conclude that the source of fat does impact the diameter of cookies when baking.

This finding that cookie diameter does vary with use of different fat sources in baking is supported by previous findings in the literature. Previous studies have reported that the differing fat contents found in commonly used sources of fat in baking do impact the spread and resulting diameter of the cookies that are produced (Pareyt et al., 2009). However, while we similarly found a significant difference in diameters between the different types of fats used in this study, the relationship between the fat content in the sources used and the diameter was not consistent with some previously reported findings. Research has suggested that it is the overall fat content of different fat sources that impacts the cookie diameter, and that there is a positive, linear correlation between the fat content of the source and the diameter of the resulting cookies (Pareyt et al., 2009; Sudha et al., 2007). The fat sources used in this experiment do contain different levels of fat. It has been reported that of the sources used in this experiment, the vegetable shortening contains the highest fat content with a reported 99.97g of fat per 100g portion, followed by coconut oil with 99.1g of fat per 100g portion, sunflower oil with 93.2g fat per 100g portion, butter with 82.2g of fat per 100g portion, and finally margarine with 80.32g of fat per 100g portion (US Department of Agriculture) (Huang et al., 2019). However, the data from this experiment did not follow a linear relationship with increasing fat content (Figure 2), thus showing an inconsistency with previously reported data. Furthermore, it has additionally been reported that liquid fat sources, such as oils, also result in greater cookie spread and therefore diameter than solid fat sources (Devi & Khatkar, 2016). Our data are again not consistent with these reports, with neither of the oils used in this experiment showing the largest diameters. Surprisingly, the cookies baked using sunflower oil showed the smallest diameters of all sources of fat. Thus, while the significant differences in diameter reported here are in agreement with previously reported literature, the pattern of difference in diameter based on the type and content of the fats did show some inconsistencies with prior research.

When interpreting the results of this study there are a few key limitations to be noted. The greatest limitation affecting this study was that each batch of cookies was baked separately by a different experimenter. In order to mitigate the impacts of having different bakers, we introduced control measures such as ensuring ingredients (other than the fat source) were consistent across all batches, that the amount of dough used for each cookie was the same, and that all ovens were calibrated prior to baking to ensure that all cookies were baked at the same temperature. However, despite these measures, sources for error remained. One source of possible error was that the storage conditions of ingredients prior to baking was not specified. This is notable as differing humidity levels in storage conditions could result in increased water content in the cookie dough. It has been reported that one factor contributing to cookie spread is the level of dissolved sugar in the dough, with drier doughs containing a greater amount of undissolved sugar that dissolves and increases spread during baking (Pareyt & Delcour, 2008). Thus, if there was differing water content in the dough between batches of cookies in this experiment due to differences in humidity during storage of ingredients, this would introduce a confounding variable to our results. Additionally, the mixing speed and mixing duration of the dough was not specified. This could again impact the amount of sugar that had the opportunity to dissolve during mixing, and also the level of aeration of the dough, both of which have been found to impact cookie spread during baking (Pareyt & Delcour, 2008). These limitations introduce two key sources of human error into this experiment that may have impacted the results reported here. In the future, this experiment could be run again while controlling for these variables, which would increase the level of confidence that any differences in diameter were due to the fat sources used during baking.

Conclusion

We found that all but one (vegetable shortening versus margarine) cookie groups were statistically different from each other, supporting our hypothesis that the source of fat has an impact on cookie diameter, which is also consistent with the literature. Our results were not consistent with the literature in regards to the fact that we did not find a positive relationship between fat content and cookie diameter, or with liquid fat sources producing cookies with larger diameters than solid fat sources. This inconsistency may have resulted from each cookie group being baked by a different experimenter, which may have introduced sources of human error.

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