Does the duration of how long cookie dough sits for affect how much the cookie spreads?

I. Introduction

The art of baking cookies is both a science and a craft, where minor adjustments to ingredients or preparation methods can result in significant differences in the final product. One such aspect that has been widely discussed among bakers and culinary enthusiasts is the amount of time cookie dough is allowed to rest before baking. Traditional recipes often instruct to immediately bake the cookie dough after preparation, while some other recipes suggest allowing the dough to rest in the refrigerator for a period of time before baking. The idea behind this is that resting the dough might allow the ingredients to meld, the flavors to develop, allow for the flower within the cookie dough to rehydrate, and potentially influence the spread of the cookie during baking. The spread of a cookie, referring to its expansion and flattening during the baking process, greatly impacts its texture, thickness, and overall appearance.

The objective of this experiment is to investigate whether the resting time of cookie dough, specifically the duration of time it spends sitting out at room temperature before being baked, has a measurable effect on the spread of the cookie once baked. We aim to test different resting times at room temperature, as in some recipes, letting the cookie dough rest in the refrigerator, but not giving the dough adequate time to reheat can cause cookies to not be able to spread to its maximum. By conducting this experiment, we aim to provide insight into the optimal preparation methods for achieving the desired cookie texture and appearance. Understanding the relationship between resting time and cookie spread could offer valuable guidance to home bakers and professionals alike, ultimately enhancing the quality and consistency of baked goods.

II. Statistical Question

Is there a significant difference in the spread of cookies baked from dough that has been rested out in room temperature for various amounts of specified duration times compared to cookies baked from dough that has been immediately placed in the oven after being constructed?

III. Data Collection

In this experiment, we tried to employ a controlled trial design to investigate the impact of resting time on cookie dough on the spread of cookies once baked. All groups used the same cookie dough recipe to ensure consistency in ingredients and preparation. The ingredients consisted of all-purpose flour, granulated sugar, brown sugar, unsalted butter, baking soda, salt, vanilla extract, and chocolate chips. After the cookie dough was made, the dough was split evenly into equally weighted spheres that were then allowed to rest for their specified amount of time, depending on the group the cookies were split into. We will be using four groups of 15 cookies at resting times of 15 minutes, 30 minutes, 45 minutes, and 60 minutes. In order to compare these 4 groups, we ran an ANOVA test comparing these groups in order to determine if the mean spread for each of these groups are different.

For Group A, the cookie dough was prepared and then allowed to rest on a countertop at room temperature (generally defined as 70°F) for a specified duration of 15 minutes. This resting period theoretically aimed to allow the ingredients to barely meld and the flavors to develop to an extent. In contrast, Group B cookies were baked after resting for 30 minutes, Group C cookies were baked after resting for 45 minutes, and

Group D cookies were baked after resting for 1 hour. To maintain uniformity in the baking process, each batch of cookies were baked in a preheated oven set at 350°F (175°C) for a duration of 10 minutes. The cookies were then placed on identical baking sheets lined with parchment paper to ensure consistent cooling conditions after baking, and to make sure that the baking process was the most identical it could have been.

After the baking process, the spread of each cookie was then measured to determine the impact of resting time on the final product. The diameter of each cookie was measured using a ruler to the nearest millimeter, with measurements taken from the widest points of the cookie to determine the spread.

In conclusion, the rigorous methodology adopted in this experiment was used in an attempt to ensure a systematic and unbiased approach to data collection and analysis. This approach aimed to provide valuable insights into the effect of resting time on cookie dough on the spread of cookies once baked. Any observed differences in cookie spread between the four groups could be confidently attributed to the resting time of the dough, thereby eliminating potential confounding variables.

IV. Data

Cookie diameter (cm) for each group of various rest times

15 minutes	30 minutes	45 minutes	60 minutes (1 hour)
6.0	6.4	6.6	7.1
5.9	6.7	6.8	7.8
6.35	6.0	7.3	7.4
6.2	6.9	6.9	7.3
6.5	5.6	5.9	7.5
6.2	5.9	6.5	7.9

5.9	6.6	7.1	8.0
6.4	6.4	7.4	8.1
6.0	6.0	7.2	7.6
5.9	5.8	7.0	7.7
6.0	6.0	6.9	8.2
6.5	6.0	6.8	8.0
5.9	6.1	6.9	8.4
6.6	6.3	7.3	8.5
5.8	6.4	7.5	8.7
X bar 15 = 6.143	X bar 30 = 6.207	X bar 45 = 6.94	X bar 60 = 7.88
Sd 15 = 0.267	Sd 30 = 0.359	Sd 45 = 0.407	Sd 60 =0.459

V. Statistical test ran

In this experiment, we ran an ANOVA test comparing the 4 groups and their resting time to determine the impact that time has on cookie baked spread mean diameter, as well as 2 sample t-intervals comparing the means of each pair, meaning to try and compare the effects of almost no time to rest after construction of dough to letting the dough have time to rest and meld its flavor and ingredients and allow for the flower to rehydrate.

Here are the conditions and values found for the ANOVA test:

ANOVA TEST:

POPULATION

Let μ_1 = the true mean diameter (in cm) for the cookie group 1 which is defined as the group that was only given 15 minutes to rest. Let μ_2 = the true mean value for the cookie group 2 which is defined as the group that was only given 30 minutes to rest. Let μ_3 = the true mean value for the cookie group 3 which is defined as the group that was only given 45 minutes to rest. Finally, let μ_4 = the true mean value for the cookie group 4 which is defined as the group that was only given 60 minutes to rest.

HYPOTHESIS

Hypothesis null = H_0: $\mu_1 = \mu_2 = \mu_3 = \mu_4$

All the mean values of cookie width for the groups are equal

Hypothesis alternative = H_a:

At least one value of the means for the groups vary from each other.

α = 0.05 significance level

ASSUMPTIONS

Normality: The data within each group of 15 cookies are normally distributed.

Homogeneity of Variance: The variance of the data for each group should be equal or within the same range of values as to where the ratio of the smallest and largest values of standard deviation are between 0.5 and 2. (See table on page 4)

Independence: Each group was baked independently of each other, and so by design, each group is independent of each other.

NAME OF TEST - ANOVA

TEST STATISTIC

After running an ANOVA test, we were given the following values in the table:

Source of Variation	Sum of Squares (SS)	Degrees of Freedom (df)	Mean Squares (MS)	F
Factor	29.15046	3	9.71682	66.50746
Error	8.18167	56	8.18167	
Total	37.33213	59		

CONCLUSION

With a significance level of 0.05 and a corresponding P - value of 0.00000 (rounded to 5 decimal places), we can see that the P - value is less than the significance level. Therefore, we reject the null hypotheses. We have sufficient evidence that at least one of the mean values of widths for one of the groups of cookie resting time varies from each other. From the data, we can see how there is evidence of a difference in the cookie spread length due to resting time.

POST HOC ANALYSIS

CONFIDENCE INTERVALS(95%) 2 sample t-interval

- **M1-M2: (-0.3,0.17) 0 is within interval, not significant**
- **M1-M3: (-1.056, -0.5376) 0 not in interval, significant**
- **M1-M4: (-2.02, -1.453) 0 not in interval, significant**
- **M2-M3: (-1.021, -0.446) 0 not in interval, significant**

- **M2-M4: (-1.982, -1.364) 0 not in interval, significant**
- **M3-M4: (-1.264, -0.6156) 0 not in interval, significant**

What do these confidence intervals mean? With these intervals we were able to say that depending on the 2 groups that were compared (ie: The 15 minute resting group and the 30 minute resting group), we are 95% confident that the difference in mean resting length between group X and group Y are in between (LowerBound) and (UpperBound). With the first interval we ran, the interval that is also highlighted in red, since the interval included the value of 0, there is evidence to believe that there is not a difference in cookie spread between the group that rested 15 minutes, and the group that was rested for 30 minutes, therefore there is not a significant difference between resting for 15 minutes and 30 minutes. However, for the rest of the tests we ran, since the tests do not include the value 0, there is evidence that there is a difference in resting time between groups B (30 minutes), C (45 minutes), and D(60 minutes). The intervalues are negative since the mean values for the initial group is significantly smaller than the group it was getting compared to, such as Mean 1 (6.143) is less than Mean 2 (6.207).

TUKEY HSD TEST

INTRODUCTION

Since the F-value is significant, we also utilized the Tukey Honestly Significant Difference (HSD) test as a post hoc analysis to identify specific pairwise differences in cookie diameter between different dough sitting time groups. The Tukey HSD test allows us to pinpoint which combinations of dough sitting times exhibit statistically significant differences in cookie

diameter, providing valuable insights into the impact of dough resting time on final product characteristics.

ASSUMPTIONS

Normality: The data within each group of 15 cookies are normally distributed.

Homogeneity of Variance: The variance of the data for each group should be equal or within the same range of values as to where the ratio of the smallest and largest values of standard deviation are between 0.5 and 2.

Independence: Each group was baked independently of each other, and so by design, each group is independent of each other.

TEST STATISTIC

Q-statistic: $$Q_{i,j} = \frac{|\bar{x}_i - \bar{x}_j|}{s_{i,j}}$$

α=0.05, k=4, df=56

Q-critical=3.7448

Treatment pairs	Tukey HSD Test Statistic	Tukey HSD p-value	Tukey HSD inference
M1-M2	0.6464	0.9	p>0.05, insignificant
M1-M3	8.1311	0.001	p<0.05
M1-M4	17.7251	0.001	p<0.05

M2-M3	7.4847	0.001	p<0.05
M2-M4	17.0787	0.001	p<0.05
M3-M4	9.5940	0.001	p<0.05

CONCLUSION

The Tukey HSD test revealed significant differences in cookie diameter among dough sitting times. Cookies baked from dough that sat for longer periods tend to have larger diameters compared to those baked immediately. Since the p-values are less than the significance level of 0.05 for all pairs except m1-m2, there is convincing evidence that there is a difference in cookie diameter between the different bake times between all pairs of groups except between the 15-minute and 30-minute dough sitting times. These findings suggest that the duration of dough sitting time significantly affects cookie diameter and should be considered in baking practices.

VI. FINAL CONCLUSION

From this experiment, we were able to gather enough data that gave us enough evidence for the conclusion that allowing cookie dough resting time at room temperature does have an effect on how far the cookie spreads while being baked. However, there are some potential sources of error, such as variance in ingredients or the variation in the baking oven that was used in this experiment. However, we did our best in trying to eliminate these sources of error, and we are confident in saying that there is a difference between the time that cookie dough is allowed to rest and the mean width that a cookie is able to spread while being baked. If this experiment was to be run again, we think that running the experiment utilizing store bought cookie dough marketed as “ready to bake,”

but having it follow the procedure we followed would be effective in determining whether or not resting time has an effect.

Works Cited

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