

The Mystery of Unpopped Popcorn Kernels

I. Introduction

Popcorn is a delectable treat, often enjoyed while watching a movie at home or in the theater. After the COVID-19 pandemic caused many avid movie-goers to stay at home, the use of streaming services and microwaveable popcorn increased significantly. However, one constant problem with popcorn remained: the number of unpopped kernels left at the bottom of the bag that had to be thrown away.

As someone who enjoys watching movies with a bag of popcorn in hand, I usually opted to buy the store-brand popcorn since that was cheaper than the name-brand one and tasted about the same. However, I started to question my choice and wonder if using store-brand popcorn was the reason behind so many unpopped kernels. I decided to conduct a controlled study to observe the differences in the number of unpopped kernels in different brands of popcorn. My goal was to see if using store-brand popcorn would result in more unpopped kernels than name-brand popcorn.

II. Statistical Question

Will using store-brand microwave popcorn result in a greater mean number of unpopped kernels than name-brand microwave popcorn?

$$H_0: \mu_S = \mu_N$$

$$H_a: \mu_S > \mu_N$$

Where μ_S is the true mean number of unpopped kernels in store-brand popcorn bags and μ_N is the true mean number of unpopped kernels in name-brand popcorn bags

III. Data Collection

The first step in conducting this study was to decide what store-brand and name-brand microwavable popcorn I should buy and how many bags of each. After doing some research, I decided to use 10 bags of Orville Redenbacher's Movie Theater Butter for my name-brand popcorn sample and 10 bags of Kirkland Signature Movie Theater Butter for my store-brand popcorn sample. I chose these brands because they were similar enough to remove some confounding variables. Both were “movie theater butter flavored” which prevented any confounding variable caused by the flavor of popcorn. The Kirkland Signature bags weighed 3.30 ounces each, while the Orville Redenbacher’s bags weighed 3.29 ounces each. This small difference in weights shouldn’t have posed any significant impact on the results of this study.

One of the possible confounding variables could have been the amount of time each bag was microwaved. The Orville Redenbacher's bag suggested putting it in the microwave for 1 to 2 minutes, while the Kirkland Signature bag suggested putting it in the microwave for 1 minute and 45 seconds. I decided to microwave all the bags for 1 minute and 45 seconds since it fit the suggested times for both brands’ bags. By keeping the amount of time each bag was microwaved constant, I could ensure that the number of unpopped kernels that resulted was only because of the difference in brands.

Another confounding variable would have been the varying power of the microwave. My microwave is automatically set to 1000 watts, but if I were to consecutively microwave all 20 bags, my microwave would most likely overheat and shut itself down in the middle of cooking the popcorn. This would cause the first few bags to be microwaved normally, but cause the next few bags to be cooked unevenly since the microwave would take cooling breaks in between. To avoid this possibility, I assigned each bag a random number 1 through 20 which would represent

when the bag would be microwaved (bag number 1 would be microwaved first, bag number 2 would be microwaved second, etc). More notably, I was going to give the microwave a 5-minute break after microwaving each bag of popcorn. These 2 precautions would make sure that the order that the bags were microwaved in wouldn't make a difference in the results of the study.

To conduct this study, I randomly chose 10 bags from the name-brand box of popcorn and 10 bags from the store-brand box of popcorn. Next, I microwaved each bag in the order described above, making sure to give the microwave a 5-minute break between each bag. Then after each bag cooled down, I emptied each bag's popcorn into different plates and then separated the unpopped and popped kernels. The half-popped kernels were sorted based on whether or not they could be partially eaten. If any part of the kernel was edible, it would be sorted into the "popped" category but if it was completely inedible, it would be sorted into the "unpopped" group. Then, the number of unpopped kernels in each bag was recorded. For the sake of consistency, I decided to use "store-brand" and "name-brand" for the names of my samples in my graphs and tables.



Figure 1. Image showing the Orville Redenbacher's popcorn box with a bag laid out on the left side and the Kirkland Signature popcorn box with a bag laid out on the right side

IV. Data Display

Store-brand	5	7	14	13	18	14	12	10	10	6
Name-brand	2	8	12	2	15	6	4	3	5	10

Figure 2. A table showing the number of unpopped kernels for each bag separated by the brand

Group Name	n	Mean	SD	Min	Q ₁	Med	Q ₃	Max
Store-Brand	10	10.9	4.095	5	7	11	14	18
Name-Brand	10	6.7	4.448	2	3	5.5	10	15

Figure 3. A table showing the summary statistics of the data collected above

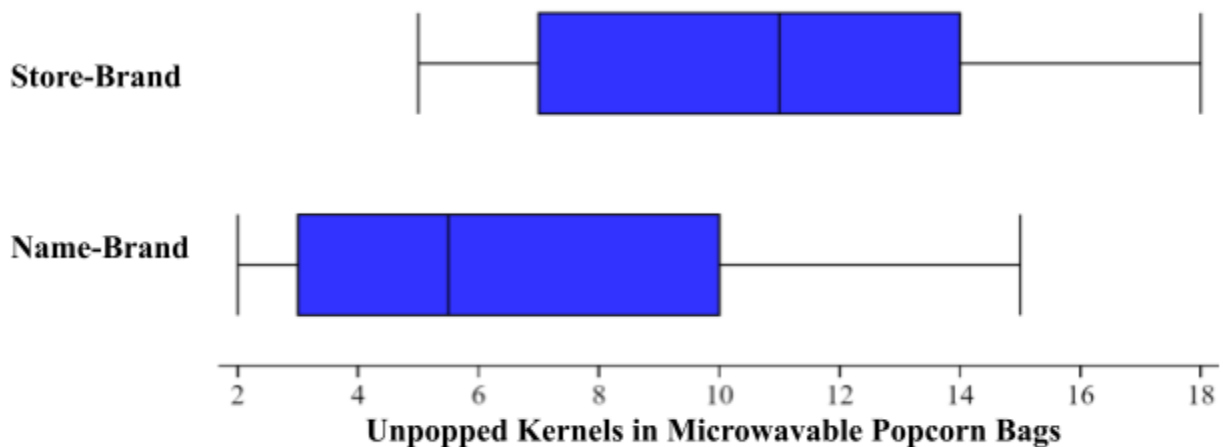


Figure 4. A comparative box plot showing the distribution of unpopped kernels for each brand

V. Data Analysis

I conducted a 2-sample t-test with 17.88 degrees of freedom using a significance level of $\alpha = 0.05$. My conditions for inference were all met as shown below:

- a) Random: As stated above, I randomly chose 10 bags of store-brand popcorn and 10 bags of name-brand popcorn from their respective boxes. I also randomly arranged the order that the bags would be microwaved in to further ensure that this condition would be met.

- b) Independence: Since a bag of popcorn cannot be both store-brand and name-brand, there was no overlap between the results of the study. In addition, by giving the microwave a 5-minute break between each bag, the results of one bag did not affect the results of another bag, which means that the independence condition was met.
- c) 10% Condition: 10 Orville Redenbacher's Movie Theater Butter popcorn bags are less than 10% of the population of these bags and 10 Kirkland Signature Movie Theater Butter popcorn bags are less than 10% of the population of these bags, so the 10% Condition was met.
- d) Normal/Large Sample Condition: Since my sample sizes were not equal to or greater than 30, I can't use the Central Limit Theorem to prove that the sampling distribution is approximately normal. In addition, the boxplots of both of the samples, as shown in Figure 4, could be interpreted to be skewed right. Therefore, I decided to create normal probability plots for both samples:

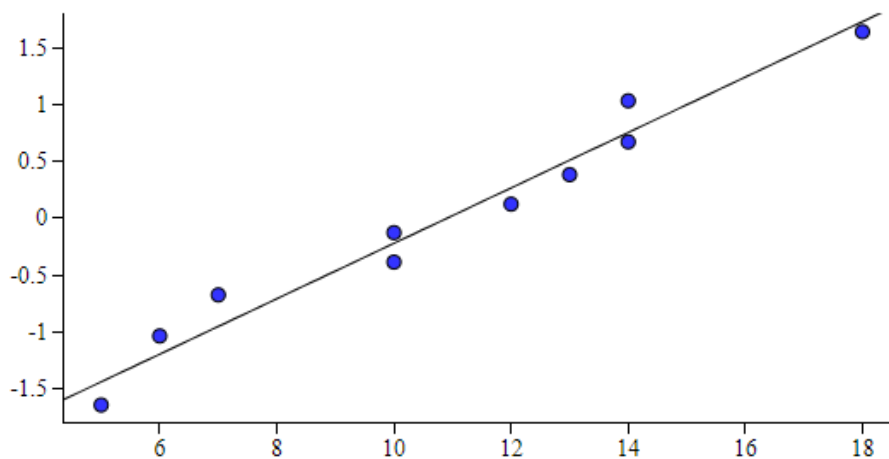


Figure 5. Normal probability plot for the store-brand popcorn sample

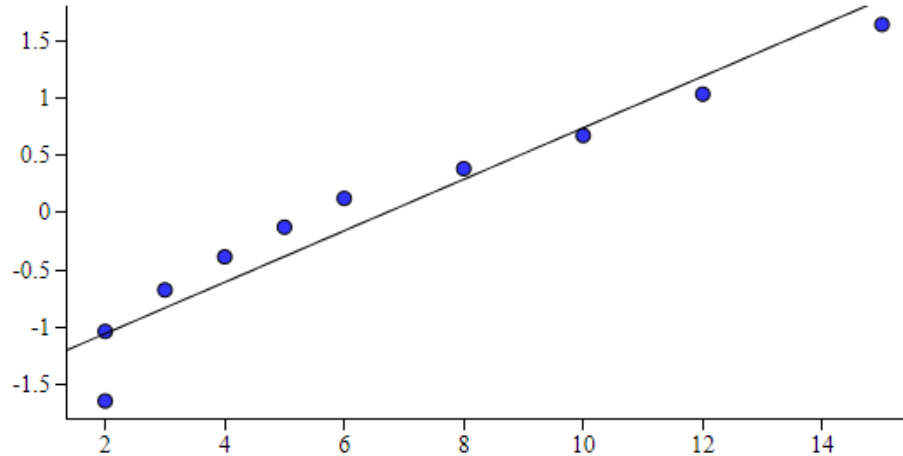


Figure 6. Normal probability plot for the name-brand popcorn sample

Since both normal probability plots were roughly linear, I can conclude that the sampling distribution is approximately normal.

All the conditions were met so I determined that it was appropriate to use a 2-sample t-test for this study.

The results of my significance test are as follows:

$$t_{17.88} = \frac{(10.9 - 6.7) - 0}{\sqrt{\frac{(4.095)^2}{10} + \frac{(4.448)^2}{10}}}$$

$$t_{17.88} = 2.197$$

$$p\text{-value} = 0.0207$$

VI. Conclusion

Since my p-value of 0.0207 is less than the significance level of $\alpha = 0.05$, I can reject the null hypothesis. There is convincing evidence that store-brand microwave popcorn results in a greater mean number of unpopped kernels than name-brand microwave popcorn.

VII. Reflection

The goal of this study was to evaluate whether or not store-brand microwave popcorn results in more unpopped kernels than name-brand microwave popcorn. Overall, I microwaved 20 bags of popcorn. To prevent confounding variables from having an impact on this study, I chose 2 brands of popcorn that were similar in their flavoring as well as in their weights, microwaved all the bags for 1 minute and 45 seconds in a random order, and gave the microwave time to cool off in between each bag. However, there were still areas that this study could have improved on.

One thing I should have done differently was that instead of counting the number of unpopped kernels in each bag, I should have calculated the percentage of kernels that were unpopped out of each bag's total. This way, even if all the bags had a different number of total kernels, the data wouldn't be impacted. This procedure would have led to more accurate data which would have led to a more accurate conclusion. In addition, a common reason that popcorn does not pop is that it is stale and dried out. This occurs when the popcorn is popped long after the manufacturing date. This is not something that a store brand or a name brand is responsible for, but rather the store that is selling the popcorn as well as the customer. To avoid this confounding variable from influencing the results of my study, I should have bought the boxes of popcorn that had the most recent manufacturing date. By accounting for this variable, I would have gotten results that were directly related to whether the popcorn was produced by a store brand or a name brand.

Although I recognize that this study had some flaws in it, I believe that the various precautions taken to get rid of the most important confounding variables allowed me to accurately conduct this study.

However, there is a possibility that I made a Type I error. In the context of this study, this would mean that I found convincing evidence that using store-brand microwave popcorn results in a greater mean number of unpopped kernels than name-brand microwave popcorn when in reality, it doesn't. The consequence of this error would be that I would waste money buying the more expensive name-brand popcorn in hopes of getting fewer unpopped kernels when that is not true. The probability of making this Type I error would be my significance level, 0.05.

Nonetheless, my research does not end here since countless different combinations of name brands and store brands could yield different results. For instance, I could compare ACT II Microwave Popcorn with Great Value Microwave Popcorn to see if this brand comparison would lead to a different result. In addition, I could compare different levels of butter in the popcorn to see if that would have an impact on the results. It would be interesting to see if extra butter popcorn or light butter popcorn would lead to a varying conclusion. Another variation of this study could include comparing the organic versions of both brands to see if the lack of preservatives has an impact on the number of unpopped kernels in a bag. All of these variations would lead to a more accurate understanding of the impact of certain variables and brands on the popping ability of microwave popcorn.

To summarize, through this study, I can conclude that there is convincing evidence that store-brand microwave popcorn results in more unpopped kernels than name-brand microwave popcorn. Therefore, although the name-brand popcorn may be a little more expensive, you will get to enjoy more popcorn than if you were to buy the store-brand popcorn. I would advise investing a little more money into your popcorn to have a more enjoyable experience eating it.

Works Cited

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No adult guidance was used in this project.