Blackberries, Mold, and Rinses, Oh My!

I. Introduction

At the end of the day, it is a gray fuzzy fungus– mold – that prevents humans from prolonging the fridge life of food and saving it for later consumption. Berries, particularly delicate ones such as blackberries and raspberries, are especially prone to molding due to their genetically rich and delicate skins, as well as preexisting mold spores, which grow rapidly under the right conditions: plenty of moisture and a warm environment. Since berries can be expensive, it is important to extend their shelf life for as long as possible.

Some consumers swear by a simple water wash, to “rinse away” dirt and other mold-prone particles. Many websites, however, advocate for a homemade vinegar rinse – three cups of water and one cup of white vinegar – as the most effective rinse in reducing the amount of mold on berries, thereby increasing a berry’s lifespan on the counter. The vinegar is said to kill the preexisting microscopic mold spores, effectively eliminating them before they can start to develop. However, both a water rinse and vinegar rinse are timely activities and require materials, such as white vinegar, that might not be easily accessible or found around the house. Moreover, both of these rinses introduce moisture, which is said to stimulate mold growth. Do these two types of rinses actually make a difference compared to doing nothing at all?

II. Statistical Question

Is there a difference between the number of blackberries that mold when washed with water, a vinegar rinse, or nothing?

Hypotheses

Ho: There is no difference in the true distribution of molding organic blackberries when rinsed with water, vinegar solution, or nothing.

Ha: There is a difference in the true distribution of molding organic blackberries when rinsed with water, vinegar solution, or nothing.

III. Data Collection

First, we randomly sampled organic blackberries using the cluster sampling method, as we did not want to be limited to the scope of inference of "berries with characteristics similar to those in the experiment." Random sampling would enable us to generalize our results to organic blackberries sold at Von's shopping center in Lomas Santa Fe. A cluster sample seemed the most appropriate sampling method, as we were unable to randomly select individual berries, and it is safe to assume crates are similar to each other–all contain berries that vary in size and ripeness–and thus, our sample would be closely representative of the population. At Vons, there were 39 crates of organic blackberries in total. We assigned each crate a unique number from 1-39, and using a random number generator from 1-39 (with no skips or repeats), generated three numbers and purchased the corresponding crates. These were crates 7, 11, and 20–a total of 123 berries.

Similarly, we randomly assigned our three treatments using a random number generator with no skips or repeats and assigned each berry a unique number from 1-123. Random assignment was essential, as to perform this experiment, we needed to account for the fact that the blackberries were not identical, meaning they all consisted of different sizes, ripeness, skin type, delicacy, etc. Random assignment enabled us to create three roughly homogenous groups, thus allowing us to more confidently attribute any differences in molding after the experiment to the different treatments (rinses). With each randomization, the first 41 numbers and their corresponding berries were assigned Treatment 1: no water or vinegar wash (control). The next 41 berries were assigned Treatment 2: place in water for two minutes. The remaining 41 berries by default were assigned Treatment 3: place in the vinegar rinse for two minutes. After being assigned treatments, berries were assigned a new number from 1-41 and either W (water), V (vinegar), or N (no rinse) for the sake of organization in the raw data table. It is important to note that we decided to assign berries to no wash, the control group, to determine whether or not the vinegar rinse and water rinse produced better results than nothing at all.

Before beginning the experiment, the selected blackberries were checked for previously developed mold, which could interfere with the results, as we would be unsure whether or not mold found after the experiment was due to the rinse or preexisting mold–no moldy berries were found. Each of the three treatments was kept separated on a tray, with no berry touching another, to prevent mold from spreading from one berry to the other. The trays were kept at room temperature to avoid inconsistent temperature ranges based on the shelf positions, often colder on the bottom and warmer on the top. Additionally, plastic wrap protected the top of each tray. This was done to control for confounding variables, such as fruit flies, which could advance the molding process in some treatments. To maintain cleanliness and avoid dirt as a confounding factor, hands were thoroughly rinsed before handling the berries. After four days, the number of blackberries with mold in each treatment was counted and recorded.

——————————————*Raw Data on the next page*——————————————

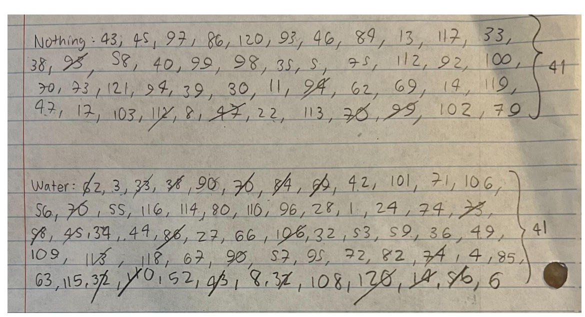
Berry #	**Visible Mold?**
1N	Y
2N	Y
3N	N
4N	Y
5N	Y
6N	Y
7N	Y
8N	N
9N	N
10N	Y
11N	N
12N	N
13N	Y
14N	Y
15N	Y
16N	Y
17N	N
18N	Y
19N	Y
20N	N
21N	N
22N	N
23N	Y
24N	Y
25N	Y
26N	N
27N	N
28N	Y
29N	Y
30N	Y
31N	N
32N	Y
33N	Y
34N	N
35N	N
36N	Y
37N	Y
38N	Y
39N	N
40N	Y
41N	N
1V	N
2V	N
3V	N
4V	N
5V	Y
6V	N
7V	N
8V	N
9V	N
10V	N
11V	N
12V	N
13V	N
14V	N
15V	N
16V	N
17V	N
18V	N
19V	N
20V	Y
21V	Y
22V	N
23V	Y
24V	N
25V	N
26V	N
27V	N
28V	N
29V	N
30V	Y
31V	N
32V	N
33V	N
34V	N
35V	N
36V	Y
37V	N
38V	N
39V	Y
40V	N
41V	N
1W	N
2W	N
3W	Y
4W	Y
5W	Y
6W	Y
7W	N
8W	Y
9W	Y
10W	Y
11W	Y
12W	Y
13W	N
14W	Y
15W	Y
16W	Y
17W	Y
18W	Y
19W	N
20W	Y
21W	N
22W	N
23W	Y
24W	Y
25W	Y
26W	Y

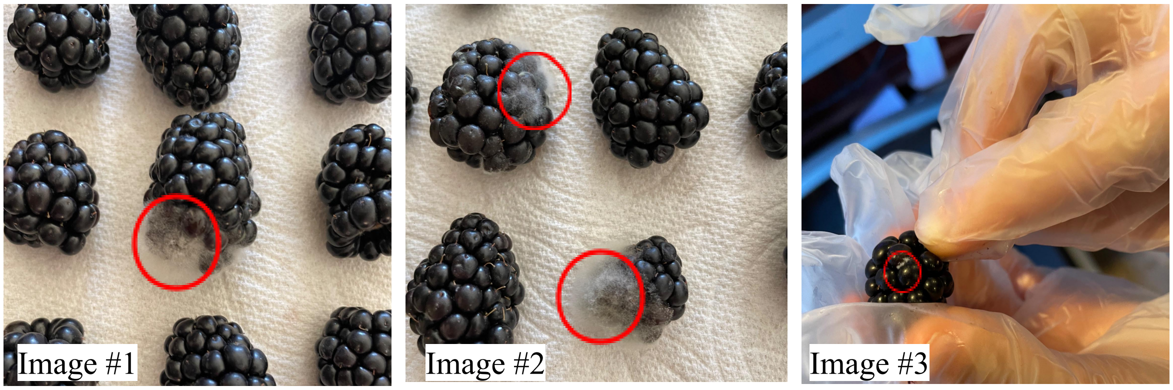
27W	Y
28W	N
29W	Y
30W	N
31W	Y
32W	Y
33W	N
34W	Y
35W	Y
36W	Y
37W	Y
38W	Y
39W	Y
40W	Y
41W	Y

Process:

Selecting 3 cluster samples of organic blackberries in Vons

Randomly assigning treatments

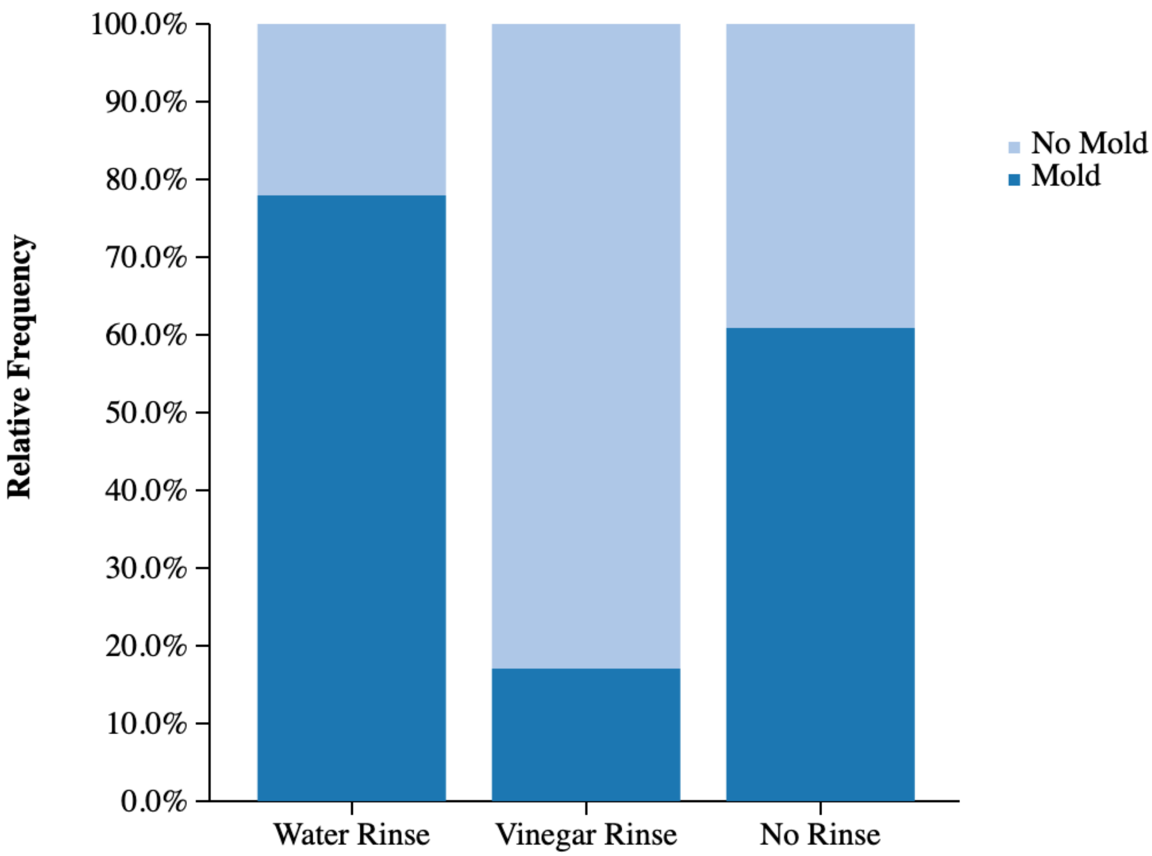




Examples of mold found in Treatment 1 (Image #1), Treatment 2 (Image #2)--most severe–, and Treatment 3 (Image #3)--least severe.

IV: Data Display

Comparing the Proportions of Mold Developed Between Rinses



V. Data Analysis

When comparing the relative frequencies between treatments, there is a clear difference between the number of blackberries that received mold in Treatment 1, 2, and 3. Treatment 1 had the highest proportion of blackberries growing mold with a relative frequency of 78%. Treatment 2 had the second highest proportion of blackberries grown mold with a relative frequency of 60.97%. Finally, Treatment 2 had the smallest proportion of blackberries growing mold with a relative frequency of 17.4%. It is clear from the stacked bar graphs that there is a difference in effectiveness between the three rinses, but was the difference just due to chance?

Performing a Chi-Square Test for Homogeneity:

<u>Observed Counts</u>

	Water Rinse	Vinegar Rinse	Nothing	Total
Mold	32	7	25	64
No Mold	9	34	16	59
Total	41	41	41	123

<u>Expected Counts</u>

	Water Rinse	Vinegar Rinse	Nothing	Total
Mold	$\frac{64*41}{123}$= 21.33	21.33	21.33	64
No Mold	$\frac{59*41}{123}$= 19.67	19.67	19.67	59
Total	41	41	41	123

Checking Conditions for a Chi-Square Test for Homogeneity:

1. **Random**: This condition was met, as the blackberries were randomly assigned via a random number generator to either Treatment 1 (No rinse), Treatment 2 (water rinse), or Treatment 3 (vinegar rinse).
2. **Independent**: Yes, this is an experiment, meaning we didn't collect a random sample, so we do not need to check the 10% condition.
3. **LCC:** All of our expected values of 21.33 and 19.67 are greater than 5, so the Large Counts Condition is met.

Calculations for Chi-Square Test for Homogeneity:

df = (number of rows -1)(number of columns -1) = (2-1)(3-1) = 2

$x^2 = \sum \frac{(observed - expected)^2}{expected} = \frac{(32-21.33)^2}{21.33} + \frac{(7-21.33)^2}{21.33} + ... = 32.509004$

p = .0000000872487 ≈ 0

We used a significance level of α= .05

VI. Conclusion

Since our p-value of .0000000872487 < α= .05, we reject the null hypothesis, as there is convincing evidence that there is a difference in the true distribution of molding organic blackberries when rinsed with water, vinegar solution, or nothing. A p-value of .0000000872487 means that assuming the null hypothesis is true, we have a .0000000872487 probability of observing a distance as great or greater than that seen in the sample of 123 berries.

VII. Reflection

Our project aimed to conclude whether there is a difference in the amount of moldy berries–after four days–between blackberries rinsed with water, vinegar, or nothing. We ensured that the different treatments were exposed to rously the same environment—all received plastic coverings, were exposed to the same temperatures, and were placed on paper towels. However, though we performed random assignment and ensured that berries were exposed to the same procedure, there were many aspects of our experiment that we could have improved.

We could have made a Type I error, meaning by rejecting the hypothesis that there is no difference in the true distribution of molding organic blackberries when rinsed with different methods when in reality there is indeed no difference. If we had applied this error in context, we might avoid rinsing our blackberries with vinegar, believing that it is no different from water, when it had a different effect on the molding. The probability of making a Type I error is .05–equal to our significance level. Additionally, blackberries are variable in shape and size, so it is harder to compare the amount of mold numerically. For this reason, we were limited to the amount of berries that had mold, rather than the severity of the mold. As seen in Image #1, #2, and #3, the blackberries rinsed with vinegar molded less than those rinsed with nothing or water. The design of our test, though, does not account for this. Also, since we did a chi-square test, we are only able to determine that there is a difference between the three rinses, not that any rinse is better than the next.

Looking at our chi-square statistics for the number of berries with mold, the water rinse had a statistic of 5.338, the no-rinse had a statistic of .539, and the vinegar rinse had a statistic of 9.625. When looking at our chi-square statistics for the number of berries without mold, the water rinse had a statistic of 5.788, the no-rinse had a statistic of .685, and the vinegar rinse had a statistic of 10.44. As a result, we can conclude that the amount of mold-free berries in the vinegar rinse treatment contributed the most to our chi-square statistics, meaning it deviated the most from what was expected.

However, from this statistic, we are not able to conclude that the vinegar rinse is more effective. In other words, the chi-square test gives us no sense of direction. In the future, it would be interesting to do a two-sample z-test for proportions or an inference procedure that would enable us to make more specific conclusions. We initially chose the chi-square test for homogeneity, as we did not believe that there would be such a difference between the three rinses. We also initially chose the chi-square test to compare all three rinses simultaneously, while a two-sample t-test or a two-sample z-test for proportions would have us perform many tests in order to make a comparison Now that we discovered that there is a difference, it would be interesting to observe the difference and which rinse is more effective.

←– *Blackberries are given new numbers after being randomly assigned to a treatment for the sake of organization in the raw data table.*

VIII. Works Cited

Jampel, Sarah. “A Trick for Storing Berries to Keep 'Em Fresher, Longer.” *Food52*, Food52, 22 June 2020, https://food52.com/blog/6970-how-to-keep-berries-fresh-for-longer.

Skrzypiec, Marcin. “Do Blackberries Go Bad?” *Does It Go Bad?*, 2 June 2022, https://www.doesitgobad.com/do-blackberries-go-bad/#:~:text=Blackberries%20last%20about%20a%20day,last%20up%20to%20a%20week.