DO BANANAS SPEED FRUIT RIPENING?

I. Introduction and Background:

You've bought a ton of apricots to make apricot pie for guests coming in two days. The problem is, the apricots are still very unripe. You decide to place apricots into a bag to speed up the process, but should you add bananas as well?

Climacteric fruits, such as bananas, apricots, and apples, continue to ripen after being picked. These fruits naturally produce ethylene gas, which speeds up the ripening process. A known process of speeding up ripening is by placing fruits in a paper bag with a banana; the banana in the paper bag will produce more ethylene gas along with the other fruit, and the paper bag will trap the ethylene gas, speeding the ripening. However, is this more effective than just putting a fruit by itself in a paper bag? Will the amount of ethylene gas produced by a banana affect the ripening process of the target fruit?

Because fruits increase in sugar concentration as they ripen, we measured sugar concentration with a refractometer in units of Brix, which allowed us to quantify sugar ripeness

II. Statistical Question:

Does a banana significantly speed the ripening process of an apricot when bundled with an apricot already in a brown paper bag?

Definitions:

- μ_0 is the mean Brix score of apricots from my local Costco ripened for 48 hours each in a separate paper bag
- μ_1 is the mean Brix score of apricots from my local Costco ripened for 48 hours each in a separate paper bag with one ripe banana from Costco per bag.

Hypotheses:

$H_0: \mu_1 - \mu_0 = 0$

$H_a: \mu_1 - \mu_0 > 0$

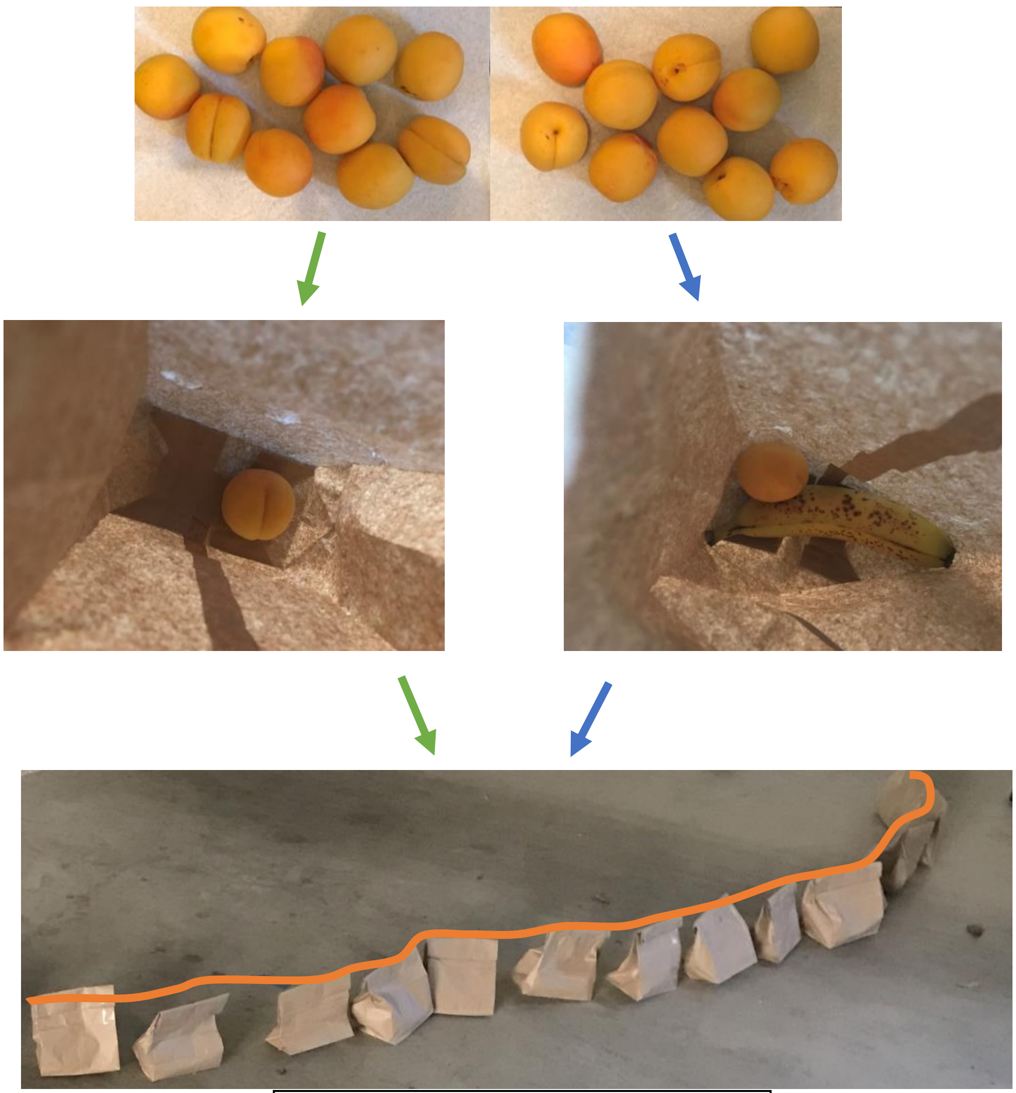
III. Data Collection

I travelled to my local Costco and randomly selected a package of apricots by labeling each package in my head and randomly selecting a number between 1 and 23 using a random number generator on my phone. I then bought the package that corresponded to that number. Additionally, I randomly selected a package of ripe bananas by labeling packages with ripe bananas (bananas that are predominantly yellow) mentally, randomly selecting a number, and buying that package. I opened the package of 20 apricots and assigned each apricot a number between 1 and 20, and using a random number generator, obtained ten random, different numbers between 1 and 20. The apricots that corresponded to the ten random numbers were each placed in a brown paper lunch bag. The other 10 apricots were each placed into a brown paper lunch bag marked with "B". I lined up all the lunch bags marked with "B," and soon after, randomly assigned all bananas a number between 1 and 10. Then, I randomly selected ten different numbers between 1 and 10. Moving down the line of bags and down the list of ten random numbers, I added the banana that corresponded to the random number into each bag. Ultimately, I had ten bags with an apricot each, and ten bags with an apricot and banana, each. Then all bags were sealed.

To maintain consistency, bags were folded similarly. Air was squeezed out of each paper bag prior to folding, and each bag was folded down to approximately the same height with 4 folds. To hold the folds, 3 pieces of tape were placed on each bag. Additionally, because temperature can affect ripening, all bags were placed in the same environment, equally affected by temperature changes.

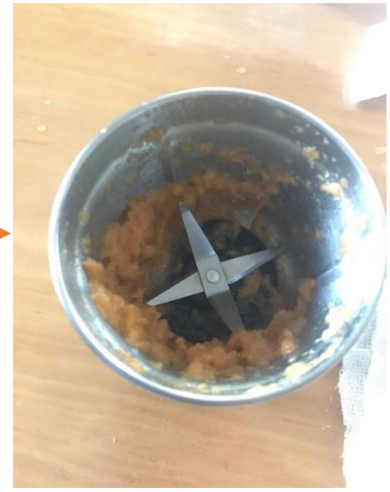
After 48 hours, each apricot was removed from its bag and then pitted. One at a time, each apricot was placed into a blender and blended into a pulp. Each apricot's pulp was strained with a cheese cloth to extract the juice into a bowl. Three drops of juice were placed on a calibrated refractometer using a different pipet each time. To maintain consistency, the blender, bowl, and refractometer were rinsed and dried after every use, and each fruit pulp was squeezed with a clean cheese cloth. The Brix value, which indicates sugar concentration, was then recorded.

10 for each treatment



I tried to fold bags to approximately the same height, as seen with the orange line.

Apricot blended



Different, clean cheesecloths used to make sure that results of one apricot do not affect results of another apricot

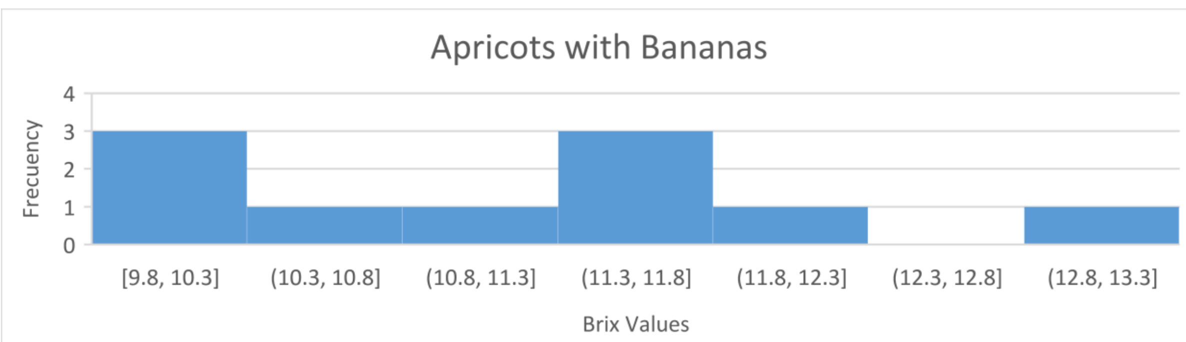
Apricot pulp placed on cheesecloth like so.

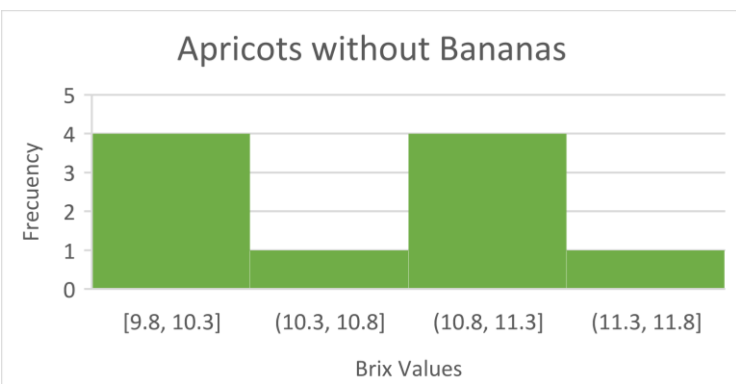
IV. Data Display

<u>Summary Statistics of Distributions of Brix values:</u>

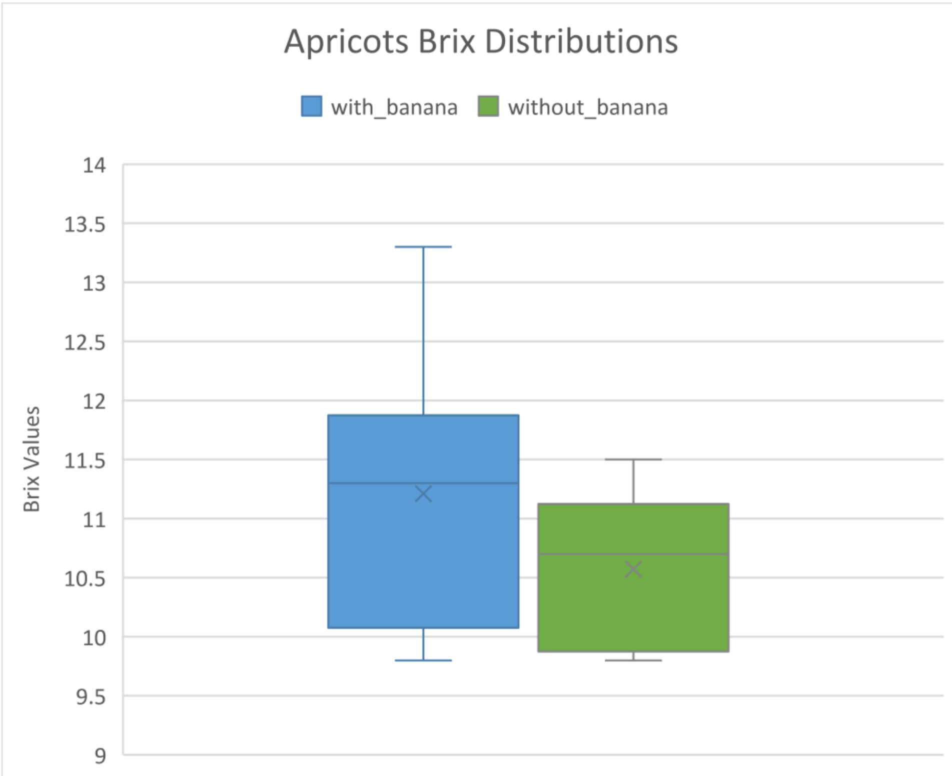
	Apricots with Bananas	**Apricots without Bananas**
Minimum	9.8	9.8
Q1	10.1	9.9
Median	11.3	10.7
Q3	11.8	11.1
Maximum	13.3	11.5
Range	3.5	1.7
Mean	11.21	10.57
Standard Deviation of Sample	1.08264	0.658365
Sample Size	10	10

<u>Histograms:</u>





Box Plot:



Neither distribution has strong skewedness or outliers. The distribution of "Apricots with Bananas" has a mean of 11.21 and a standard deviation of 1.08264, while the distribution of "Apricots without Bananas" has a mean of 10.57 and a standard deviation of 0.658365. The mean and standard deviation of "Apricots with Bananas" are greater than the mean and standard deviation of "Apricots without Bananas". An interesting observation is that both distributions have the same minimum of 9.8, but while "Apricots with Bananas" has a max of 13.3, "Apricots without Bananas" only has a max of 11.5. Overall, "Apricots with Bananas" have a much greater spread than "Apricots without Bananas."

V. Data Analysis

We are conducting a 2-sampe t-test for $\mu_1 - \mu_0$ at $\alpha = 0.05$

$H_0: \mu_1 - \mu_0 = 0$

$H_a: \mu_1 - \mu_0 > 0$

Conditions:

Random: We randomly selected a package of apricots and bananas. Also, each apricot was randomly assigned to a treatment. Bananas were also randomly assigned.

Independent: We are assuming that the apricots with bananas do not affect the apricots without bananas. Also, because we were sampling without replacement, we must check the 10% condition:

$total\ sample\ size = 20 \qquad 20 \leq \frac{1}{10}\ Apricots\ at\ my\ Local\ Costco? \quad Very\ Likely$

Normal: Although the central limit theorem is not satisfied because the sample size is less than 30, the distribution of "Apricots with Bananas" and "Apricots without Bananas" both do not show strong skewedness nor outliers. Thus, we will assume the sampling distributions are approximately normal. However, we will proceed with caution.

Calculations:

$$t = \frac{(\overline{x_1} - \bar{x}_0) - (\mu_1 - \mu_0)}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_0^2}{n_0}}}$$

$$t = \frac{(11.21 - 10.57) - (0)}{\sqrt{\frac{1.08264^2}{10} + \frac{0.658365^2}{10}}}$$

$t = 1.59723$

Degrees of Freedom = 14.8556

p-value = 0.065631

VI. Conclusion:

Because the p-value of 0.065631 is larger than the significance level of $\alpha = 0.05$, we fail to reject the null hypothesis; we do not have convincing evidence that the mean Brix score of apricots from the store ripened for 48 hours in a paper bag with a ripe banana is larger than the mean Brix score of apricots from the store ripened for 48 hours in a paper bag. Thus, we cannot conclude that adding a banana from Costco into a paper bag with apricots from Costco significantly increase ripeness of the apricot over 48 hours.

VII. Reflection

Throughout the project, obtaining apricot juice from each apricot went surprisingly well. After blending each apricot and placing the pulp in a cheese cloth, juice could easily be squeezed for the refractometer. A difficult part of the experiment was the procedure; rinsing and drying utensils between each use took a lot of time. Additionally, during the experiment, I really wanted to reject the null hypothesis, and this may have subconsciously affected how I read the refractometer. A feasible improvement would be to make the experiment blind to the data collectors (me). If I had instructed a friend or parent to remove apricots from the paper bags and group them by treatment without telling me which set of apricots received which treatment, the results may have been more accurate and the overall result of the experiment may have changed.

There are more improvements to make, but these were not done because of feasibility. Increasing sample size to 30 for each treatment would be ideal as it would increase the accuracy of the results; however, doing so would increase the cost. Also, a wider selection of apricots across different brands and stores would have allowed a larger scope of inference, but this was not done because of feasibility. Also, a stronger way to answer the statistical question would be to use larger brown paper bags, and in each brown paper bag, place multiple apricots and multiple bananas. This would simulate how people may actually ripen fruit, because people rarely ripen fruit one at a time; however, the costs of this would be too large to conduct.

One of the trickiest and time-consuming part of the study was testing the ripeness with a refractometer. As I was doing so, I wondered if fruit density would indicate ripeness, because I have noticed fruits become more squishy and porous as they ripen. For future study, I would test for an association between fruit density and fruit ripeness.

VIII. Appendix

Brix Values for Apricots with Bananas:
13.3, 11.4, 10.8, 11.8, 11.2, 9.8, 10.1, 12.1, 10, 11.6

Brix Values for Apricots without Bananas:
9.8, 10.4, 11.2, 11.0, 10.0, 9.8, 11.0, 9.9, 11.1, 11.5

Works Cited

Starnes, Daren S. Starnes, Daniel S. Yates, David S. Moore, and Josh Tabor. *The Practice of Statistics*. New York: W.H. Freeman, 2015. Print.