

Testing Which Juice Loses the Least Amount of Vitamin C Overtime

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Abstract

The experiment conducted was to see which fruit juice loses the least amount of vitamin C over time, while comparing store-bought juice to homemade juice. The juices tested were apple juice, mango juice, peach juice, grape juice, and orange juice, store-bought and homemade versions of each of them. The control variable was obtained by dissolving a vitamin C tablet in water to get 135 milligrams of vitamin C per milliliter. Using the indophenol solution, the amount of drops needed to oxidize the vitamin C in the juices were found during three periods of time: after zero days, after five days, and after ten days. In the beginning, the store-bought and homemade orange juice attributed to the highest level of vitamin C, with the store-bought orange juice having 1.19 mg/ml of vitamin C and the homemade having orange juice 1.41 mg/ml. The store-bought mango juice and peach juice came afterward. The rest of the juices attributed to very low vitamin C. After 5 days, the orange juice (both store-bought and homemade) lost 0.1 mg/ml of vitamin C, while the other juices lost 50% of their original vitamin C. After 10 days, it was concluded that orange juice had the highest vitamin C left. The store-bought orange juice lost 1 mg/ml compared to ten days prior whereas the homemade juice only lost 0.1 mg/ml. The other juices tested relatively stayed as they had five days prior, losing 50% of their original vitamin C. The conclusion reached was that orange juice loses the least amount of vitamin C over time, with store-bought juice oxidizing more than the homemade one.

Keywords

Oxidation, Vitamin C, Health and Fruit Juice.

1. Introduction

Physical health is continually changing. Working to maintain vitamins and staying healthy are sufficient goals in lives. 1 in 20 people have a vitamin C deficiency, causing fatigue, gum inflammation, and joint pain. To help combat this problem, an experiment was conducted to see which fruit juice loses the least amount of vitamin C over time, while comparing store-bought juice to homemade juice.

The change of vitamin C over time has been tested multiple times and plenty of information has been found. Specifically in juices, it has been known to drink them as soon as possible, but with our busy lives, it's near impossible. The reason scientists encourage this is due to oxidation. Joanne Kendell, a health coach states, "Oxidization is the process that takes place when produce is cut up leaving the cell walls exposed to oxygen molecules." Oxidation is the gain of oxygen or loss of hydrogen during a reaction of a molecule, atom, or ion. An example of oxidation occurs in apples. When apples are cut, it oxidizes with air, causing the inside to brown, not taste as good, and lose some of its nutrients.

In this experiment, vitamin C is measured. The chemical name of vitamin C is ascorbic acid and its chemical formula is $C_6H_8O_6$. Ascorbate is not a stable ion and tends to give away electrons, being an electron donor. When it is oxidized, it loses some of its electrons, producing $C_6H_6O_6$ (dehydroascorbic acid) + $2 e^- + H^+$ ("Vitamin"). This reaction also occurs the opposite way. As long as ascorbic acid and dehydroascorbic acid keep reacting with each other, no vitamin C will be lost. On the other hand, dehydroascorbic acid can react further in irreversible reaction, causing the vitamin C to get lost. When juices high in vitamin C are left out, their concentration of vitamin C decreases due to its exposure with oxygen. Furthermore, an increase of heat and light destroys vitamin C, as concluded in a study at Harvard T.H. Chan School of Public Health ("Vitamin C"). This is why juices are highly suggested to be put in fridges, so that the level of vitamin C is maintained. Some ways to reduce oxidation is by using organic produce, storing your juice immediately, and not adding ice. Oxidation decreases the number of nutrients in a food or drink.

Vitamin C has many benefits, which is why doctors strongly encourage the intake of it. Some of these include repairing and maintaining skin, tendons, and ligaments. It also protects cells from further problems and aids in healing bones. Sheeran Lehman, a health journalist states that citrus juices, some of which include orange, grapefruit, mango, unsweetened pineapple, and cranberry juice are very high in vitamin C (Lehman). Vitamin C is also found in vegetable juices, some examples including tomato and carrot juice. The juice that is known to have the most vitamin C is orange juice (Ipatenco). Vitamin C has many beneficial effects, which is why many people to monitor their daily intake of it

There are multiple fruits and vegetables that could have been used to test in this experiment. Only five were used to lead to further analysis of the subject. The first fruit picked was mangos, which contain many benefits to the body. Mangos are very high in vitamin C, containing approximately 60.1 mg of it in one cup. Mangos are known to reduce the chance of cancer, heart disease, and diabetes, as written by nutritionist Megan Ware. They are a good source of vitamins and minerals, including vitamin C, vitamin A, and potassium (Ware). This is why mango juice was tested to see how many of its nutrients were lost over time.

The second fruit used in the experiment were grapes. They are another fruit that have many benefits. They have 27% of the Reference Daily Intake (RDI). They prevent diseases, cancer, lowers your cholesterol, and improves sight and mood (Groves). Grapes have many physical and mental benefits that help you in your day-to-day life. These are all reasons why grape juice was tested.

Another drink tested was apple juice. Apples are very high in minerals and vitamins, but they don't contain them in high amounts. 1 cup of apples contain about 5.8 mg of vitamin C. Apples were tested even though they don't contain a large amount of vitamin C because they were essential to know how juices low in vitamin C lost it over time.

The 4th juice tested was peach juice. Peaches don't contain a significant amount of any nutrient or mineral and are relatively a fruit that don't have many benefits. On the other hand, they do contribute to the diet intake and help reduce cancer (Ware). 1 cup of peaches contain 10.2 mg of vitamin C. This is another juice tested to see how fruits with less vitamin C lose it over time.

The last juice used for this experiment was orange juice. Oranges are generally known to be one of the highest fruits that contain vitamin C. They are rich in several important nutrients, some of which include vitamin C, folate, and potassium ("Vitamin"). There are approximately 124 mg of vitamin C in 1 cup of orange juice. Orange juice is also high in antioxidants and improves heart health. Since orange juice is the juice that has the highest amount of vitamin C out of all the juices that were being tested, I hypothesized that it would lost the least amount of vitamin C over time.

Store-bought juices are extremely different than homemade ones. They smell, look, and taste different. This is because vitamin C is meant to be eaten fresh and quickly starts to spoil. Dan Myers, an editor for a nutritional website states:

“After orange juice is squeezed, it quickly starts to spoil. This doesn't give the OJ companies nearly enough time to process, bottle, ship, and sell it before it goes bad, so in order to preserve the juice, the oxygen is removed from it (which will keep it good for up to a year).”

This causes a vast amount of vitamin C, flavor, and taste to be lost. Myers then goes on to say how these companies add flavor packets to their drinks, causing store-bought juices to taste and have different nutritional value than homemade juices.

Vitamin C is essential to everyone's diets. People need a certain amount of vitamin C every day. According to the Office of Dietary Supplements, men need 90 milligrams of vitamin C daily, while women need 75 milligrams. To reach this requirement, many people drink juices, but some vitamin C is lost when it's in contact with air. With this experiment, people will be able to find which juice loses the least amount of vitamin C over time and how fresh juices compare to store-bought ones. This way, they'll be able to easily consume their needed amount of vitamin C.

1.1 Objectives

The objectives were to see which juice loses the least amount of Vitamin C over time and to see how this varies between store-bought juices and homemade ones.

1.2 Hypothesis

If different fresh and store-bought juices are tested for vitamin C, then the conclusion that will be reached is that orange juice will lose the least amount of vitamin C over time.

2. Literature Review

There are various studies for vitamin C contents in process juices and raw juices. Effects of the various factors are analyzed. Van Bree et al. (2012) modeled the degradation of vitamin C in fruit juice. El-Ishaq and Obirinakem (2015) discussed effect of temperature and storage on Vitamin C. Maeda and Mussa (1986) studied the stability of vitamin C (l-ascorbic acid) in bottled and canned orange juice. Rickman (2007) compared nutrition of fresh, frozen and canned fruits and vegetables. Vitamins C and B and phenolic compounds are analyzed. Del Caro et al. researched on changes of flavonoids, vitamin C and antioxidant capacity in minimally processed citrus segments and juices during storage. All those studies have similar nature for degradation of vitamin C. This paper focuses on various juices for store bought and fresh juices.

3. Methods

The following procedures are used for the experiment:

1. Prepare materials and prep experiment area
2. Take a glass filled with 500 ml of water and crush a vitamin C tablet with one 500 mg. Mix them together.
3. Take 20 ml of that water and pour it into another cup.
4. Prepare starch solution by dissolving one tablespoon of starch in a small amount of 1-2 tablespoons of cold water and bring it into a half a glass of boiling water
5. Stir until the starch dissolves and let it sit. Take 1 teaspoon of the starch solution and add it to the glass with the 20 mg of vitamin C
6. Make indophenol solution by combining 0.5 g of indophenol powder with 1 cup of water. This will oxidize the vitamin C.
7. Use the eyedropper to add a few drops of the indophenol solution into the cup with the 20 ml/mg solution. Stir it after putting in the drops. Keep adding drops until the juice becomes dark blue. Now you know how many drops it takes to oxidize vitamin C in a 1 mg/1 ml solution
8. Pour a ¼ cup of store-bought apple juice in three different cups
9. Repeat previous step for the store-bought mango, peach, grape, and orange juice. There should be 15 cups.
10. Blend each fruit so that there is enough for three ¼ cups of juice
11. Pour a ¼ cup of homemade apple juice into three different cups
12. Repeat previous step for the homemade mango, peach, grape, and orange juice. There should be 30 cups.
13. Using the eyedropper, add drops of the indophenol solution into one cup out of each homemade and store bought juices until it becomes dark blue. Record how many drops it takes.
14. To calculate the amount of vitamin C in each solution multiply the amount it took to oxidize the 20 mg/ml of vitamin C solution by 3. This will create a 60 mg/ml solution which roughly equals ¼ cup. Take the amount of drops needed to oxidize the juices and divide it by the number you got. This will calculate how much vitamin C in 1 mg/1 ml of each juice
15. Let the 20 other cups sit for 5 more days
16. Repeat the procedure from Step 13 and 14 with one of each of the store-bought and homemade juices.
17. Record the data
18. Let the last 10 cups sit for 5 more days
19. Repeat procedure from Step 13 and 14 with the rest of the cups.
20. Record data and discard the cups after use

Figure 1 shows experimental setup with various cups for various juices including indophenol powders mixing in a cup showing at the right.



Figure 1. Experimental setup including indophenol powder mixing

3.1 Materials

Following materials are used:

- Apple Juice
- Mango Juice
- Orange Juice
- Peach Juice
- Grape Juice
- Apples (enough to make a $\frac{3}{4}$ of a cup of juice)
- Mangos (enough to make a $\frac{3}{4}$ of a cup of juice)
- Peaches (enough to make a $\frac{3}{4}$ of a cup of juice)
- Grapes (enough to make a $\frac{3}{4}$ of a cup of juice)
- 500 mg Vitamin C Tablet
- Starch
- Spoon
- A multitude of foam cups
- Blender
- Indophenol Powder
- Water
- Measuring Cups
- Marker to mark cups
- Straws
- Eye-dropper
- Safe work area
- Pen and paper to record data and observations

4. Data Collection

Data from the experiments are represented in Tables 1, 2, 3 and 4.

Table 1. Vitamin C Solution (Control Variable)

Amount of drops	45
Amount of Vitamin C in mg/ml	135 mg/ml

Table 2. Tested on 12/26/19 (First poured)

Juice	Amount of Drops	Amount of Vitamin C
Homemade Apple	10	0.07 mg/ml
Store-Bought Apple	9	0.06 mg/ml
Homemade Peach	143	1.06 mg/ml
Store-Bought Peach	75	0.55 mg/ml
Homemade Orange	190	1.41 mg/ml
Store-Bought Orange	160	1.19 mg/ml
Homemade Grape	17	0.13 mg/ml
Store-Bought Grape	23	0.17 mg/ml
Homemade Mango	115	0.85 mg/ml
Store-Bought Mango	174	1.29 mg/ml

Table 3. Tested on 12/31/19 (5 days after first pour)

Juice	Number of Drops	Amount of Vitamin C
Homemade Apple	9	0.06 mg/ml
Store-Bought Apple	8	0.06 mg/ml
Homemade Peach	123	0.91 mg/ml
Store-Bought Peach	65	0.48 mg/ml
Homemade Orange	175	1.3 mg/ml
Store-Bought Orange	155	1.15 mg/ml
Homemade Grape	15	0.11 mg/ml
Store-Bought Grape	20	0.37 mg/ml
Homemade Mango	103	0.76 mg/ml
Store-Bought Mango	170	1.26 mg/ml

Table 4. Tested on 1/5/19 (10 days after first pour)

Juice	Number of Drops	Amount of Vitamin C
Homemade Apple	7	0.05 mg/ml
Store-Bought Apple	7	0.05 mg/ml
Homemade Peach	103	0.76 mg/ml
Store-Bought Peach	50	0.37 mg/ml
Homemade Orange	170	1.26 mg/ml
Store-Bought Orange	90	0.67 mg/ml
Homemade Grape	13	0.09 mg/ml
Store-Bought Grape	15	0.11 mg/ml
Homemade Mango	73	0.54 mg/ml
Store-Bought Mango	90	0.67 mg/ml

5. Results and Discussion

In the beginning, the homemade orange juice had the most vitamin C with 1.41 mg/ml. The store-bought orange juice came in second with 1.19 mg/ml. Next was mango, with the store-bought one having more vitamin C than the homemade one. After that was the store-bought peach and then the store-bought grape. At the end was the homemade grape, both apple juices, and homemade peach. These juices barely decreased over the days, since they barely had any vitamin C. All the juices lost vitamin C overtime, with the homemade juices losing less vitamin C than the store-bought ones. The question investigated was, “Compared to its fresh juice counterpart, which store bought juice has the lowest amount of vitamin C lost over time?” The answer to this question is that fresh, homemade orange had the most amount of vitamin C and lost the least amount overtime.

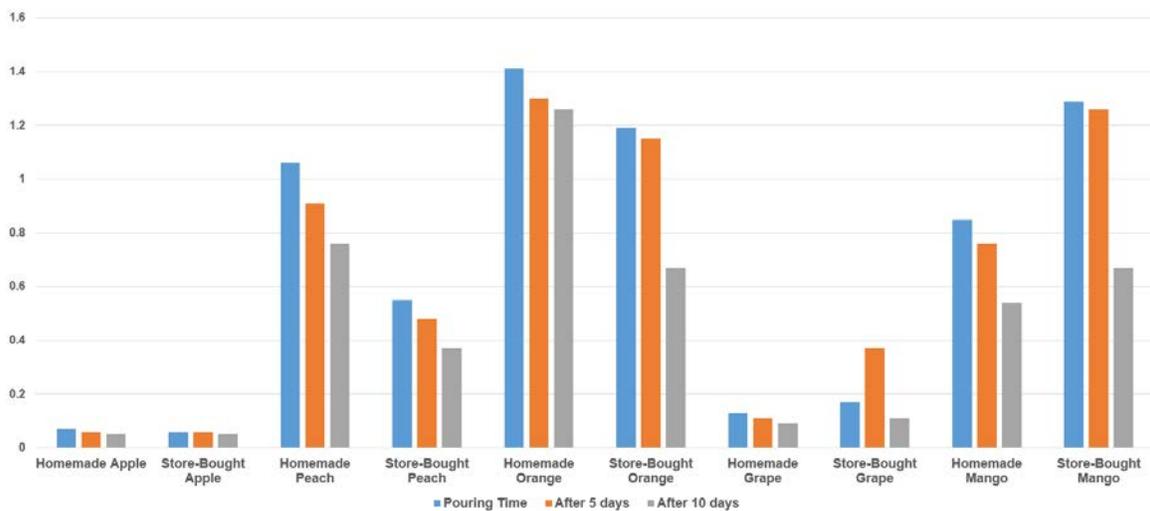


Figure 2. Change in Vitamin C Overtime

On the other hand, the store-bought version still had a lot of vitamin C, but lost it overtime. After some further research, Dan Myers, a health writer claims that, “After orange juice is squeezed, it quickly starts to spoil.” He then goes on to say that companies remove the oxygen from the juice to preserve it for up to a year, but removes nearly all flavor and some nutrients from the juice. These companies then hire flavor and fragrance companies to make orange juice taste like itself again, which is why each company’s juice tastes different (Myer). This can possibly explain why the store-bought juice lost more vitamin C over time than the homemade one. Homemade juices are freshly squeezed, which helps preserve its nutrients and are overall better. Figure 2 shows in bard chart vitamin C drop over time.

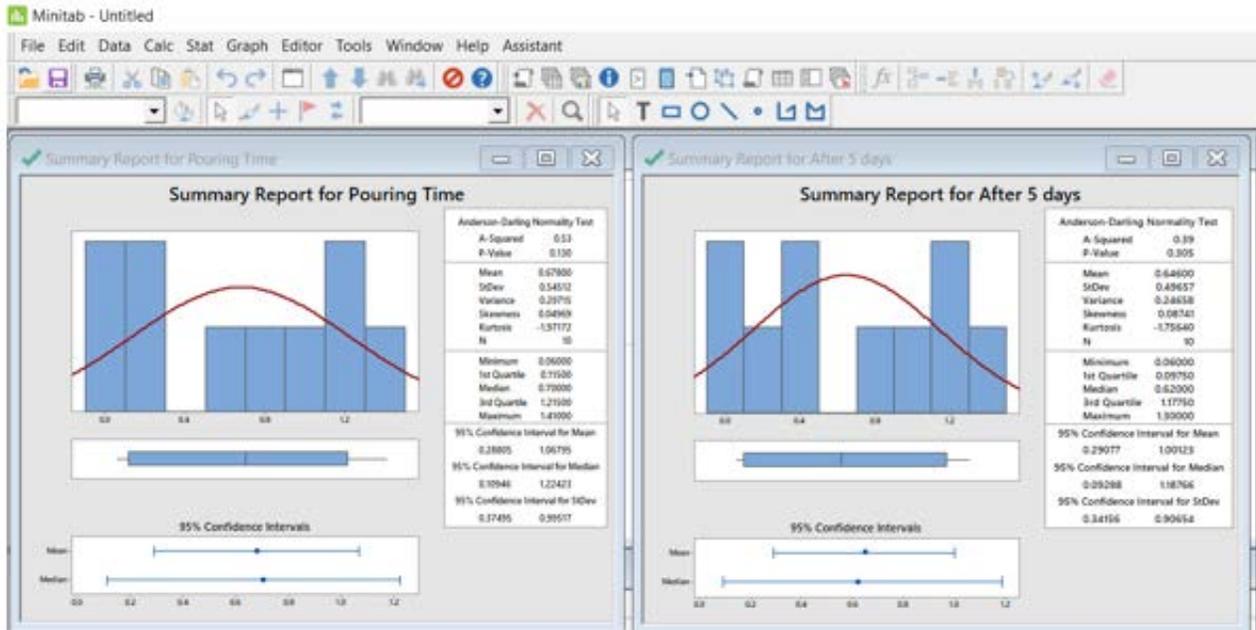


Figure 3. Statistical Analysis I

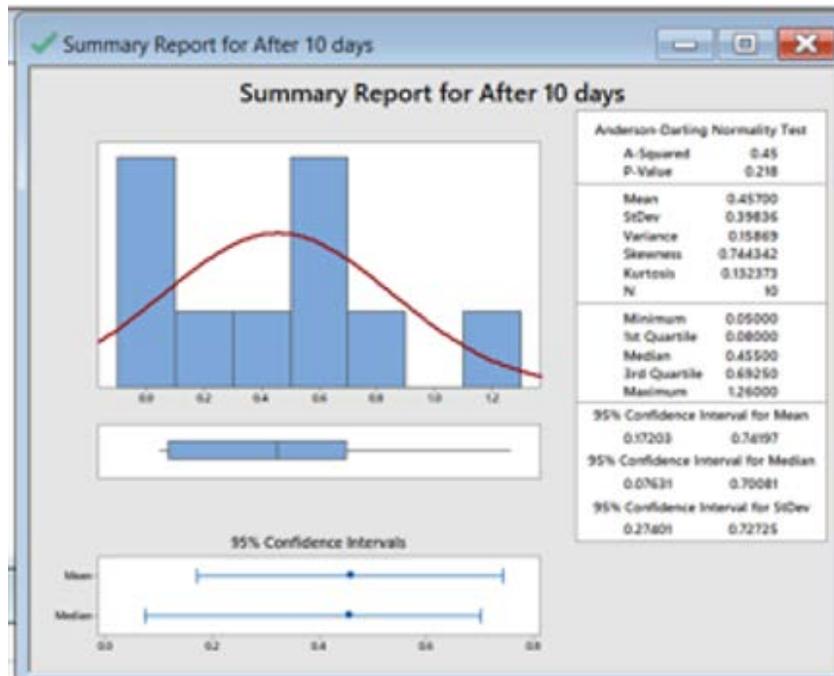


Figure 4. Statistical Analysis II

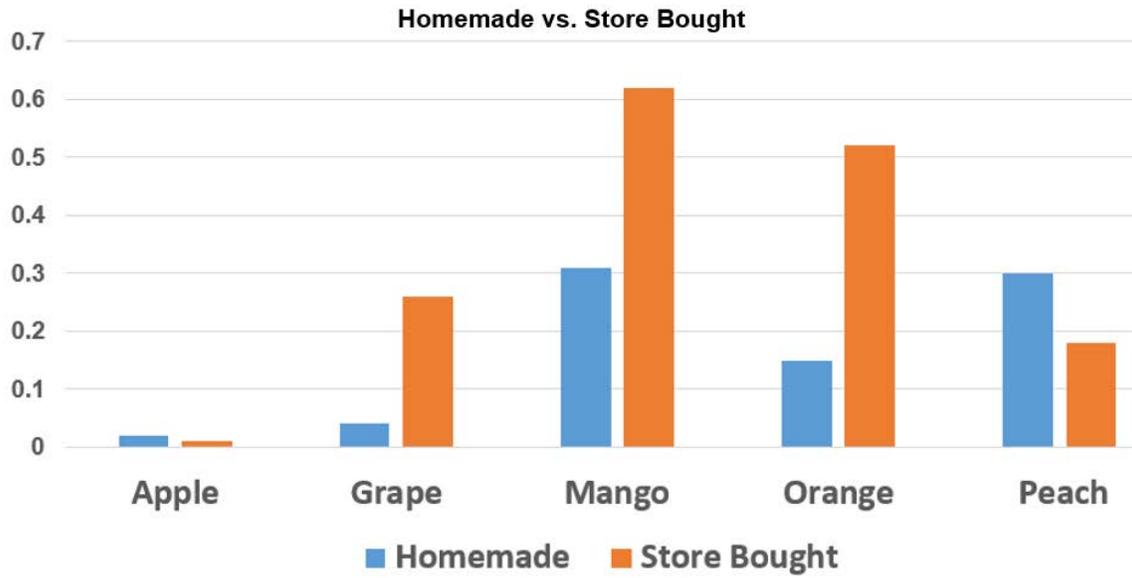


Figure 5. Results of homemade juice vs. store bought juice

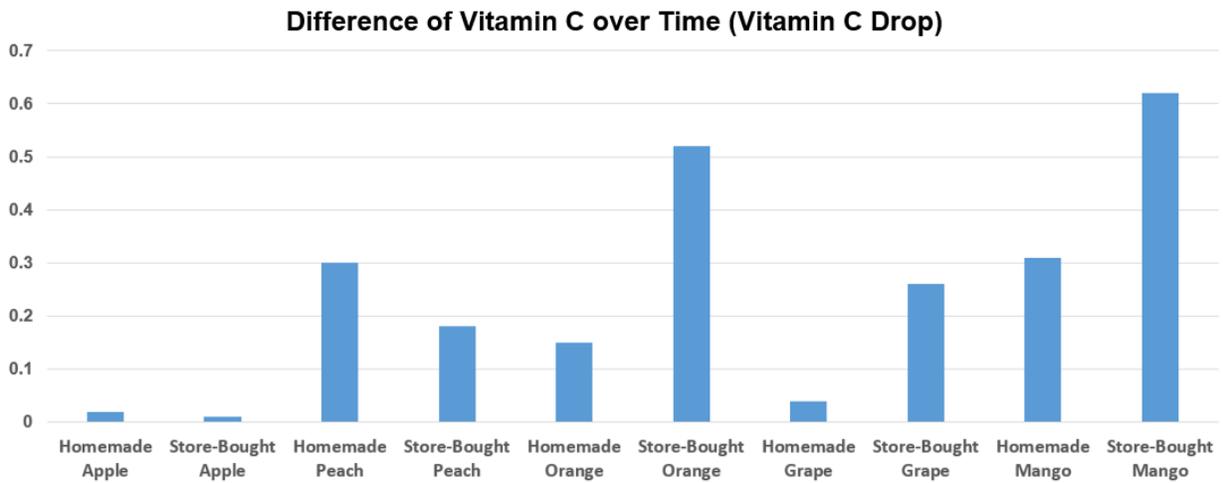
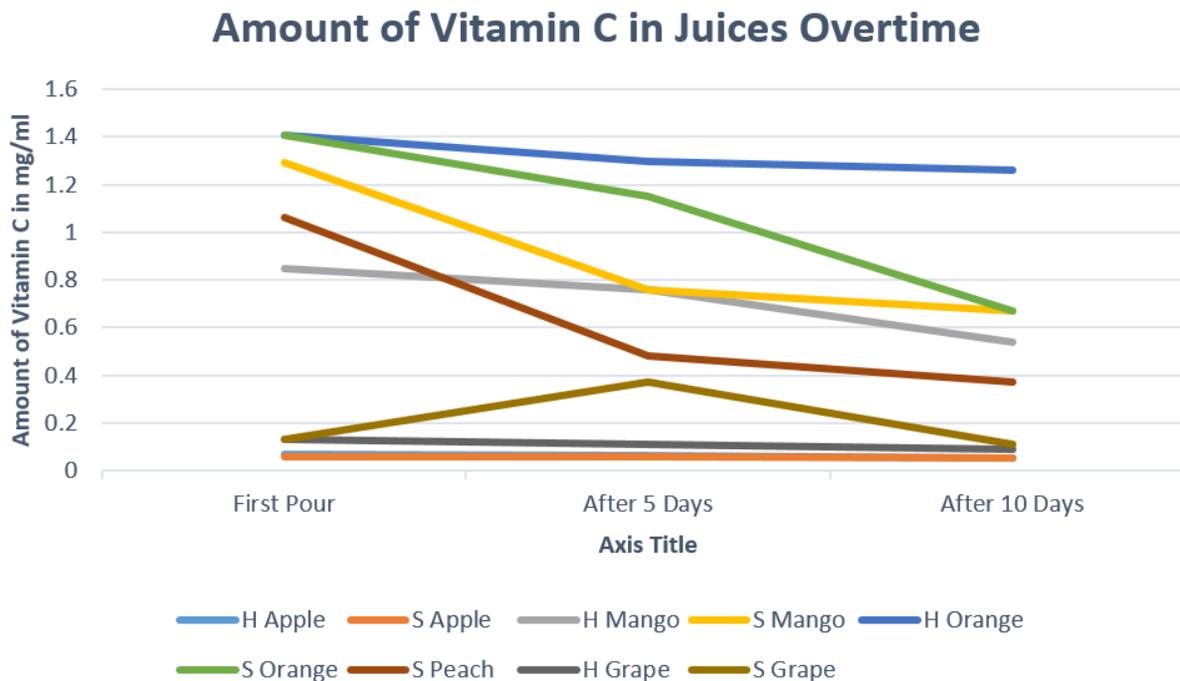


Figure 6. Difference of vitamin C over time

Table 5. Overall vitamin drop over time

Overall how much Vitamin C Drop Overtime

	Pouring Time	After 5 days	After 10 days
Mean	6.78	6.46	4.57
Standard Deviation	0.55	0.50	0.40



*H stands for Homemade and S stands for Store-Bought

Figure 7. Line plot of amount of vitamin over time

Figures 3 and 4 shows various statistical analysis. Figure 5 shows homemade juice vs. store bought juice results. Figure 6 depicts the difference of vitamin C over time. Store bought juice has more drop. Table 5 shows overall numerical results for vitamin drop over time. Figure 7 provide graphical comparisons of all juices about the amount of vitamin C in juices over time. Orange juice had the most in the beginning, but over time you can see that the store-bought orange juice decreases, whereas the homemade one stays relatively the same.

From the research, it was discovered that orange juice contains the most amount of vitamin C compared to other juices. Through this, it is inferred that it would probably lose the least amount of vitamin C over time.

Some possible sources of error include a changing of destination of the experiment, due to the fact that people were disturbing it, causing it to almost fall over. This may have affected the results since there is a slight temperature variation between the two places.

6. Conclusion

The conclusion reached was that orange juice loses the least amount of vitamin C over time, with the homemade one losing less than the store-bought one. Overall, the orange juice had more vitamin C than the other juices, but after some time, the store-bought orange juice neared the level of vitamin C of the other juices. Some ways to improve future experiments is by testing more of a variety of juices or testing different brands of orange juice over a period of time. Another possible experiment could be doing the exact same experiment, but putting the juices in different temperatures. This experiment was to help ensure others' vitamin C level is reached and this could be done by finding out which juice had the least lost over time. Implementing this could lower the chance of fatigue, joint pain, and overall, the quality of life.

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Biography

Takiyah Ali is high school student at Michigan Islamic Academy, Ann Arbor, Michigan, USA. She has completed middle school from Crescent Academy International, Canton, Michigan, USA. Takiyah has received presidential award and participated in the IEOM Middle School and High School STEM Poster Competition at Lawrence Tech in 2017, 2018, 2019 and 2020. Takiyah also joined the STEM poster competition of the Science and Engineering Fair of Metro Detroit in 2017, 2019 and 2020. She served in various clubs including Honor Society, MIST, Yearbook, and Peer-to-Peer at her school and served as a secretary for one them. Takiyah attended the Peer-to-Peer Depression Awareness Program Conference on Monday, November 4 and the 2020 Girls Who Code Virtual Summer Immersion Project from August 10-14, 2020. She is also a member of the Teen Leadership Council at the Canton Public Library and of the Teen Advisory Board at the William P. Faust Westland Public Library. She has also completed an online course at the University of Sydney, University of Michigan, and Duke University.