SASTA OLIPHANT SCIENCE AWARDS

SOUTH AUSTRALIAN SCIENCE TEACHERS ASSOCIATION

Prize Winner

Scientific Inquiry

Year 3-4

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St Peter's Woodlands Grammar School

Amir Chaloob ID: 0683-003
Category: Scientific Inquiry
Maximising Micronutrients- Report
Oliphant Science Awards

Maximising Micronutrients

ID: 0683-003

Jessica Weekes

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Maximising Micronutrients

Introduction

Ascorbic acid (vitamin C) and iron are key micronutrients required for healthy functioning of the human body. However, they are also common micronutrient deficiencies, leading to anaemia, poor wound healing, lowered immunity, skin and joint disease and bleeding[1-3]. Iron is a critical micronutrient for red blood cell production and is used to carry oxygen throughout the body to cells[4]. Citrus fruits provide an excellent source of ascorbic acid with one mandarin providing on average 39% of the recommended daily intake of ascorbic acid[5-6]. Mandarins provide less than 1% of the recommended daily intake of iron[7], however this was included in the experiment as ascorbic acid increases the bodies absorption of non-haem (ferric Fe3+) iron which is found in green leafy foods by i) reducing Fe3+ to Fe2+ which is more readily absorbed, ii) binding Fe3+ to form a chelate which is a complex molecule making it easier to absorb and iii) producing a more acidic environment in the stomach which assists iron absorption[8]. Mandarins are a seasonal fruit that can be grown in many parts of Australia. I designed an investigation to determine if storage conditions of mandarins affect their ascorbic acid and iron content. I will determine the ideal short-term storage of mandarins for maximal micronutrient content as well as give an insight into the best way to store mandarins for out of season consumption.

Table 1: Recommended daily intake of Ascorbic acid[9]

Age group	mg/day
0-6 months	40
7-12 months	50
1-3 years	15
4-8 years	25
9-13 years	45
14-18 year old male	65
14-18 year old female	75
≥19 year male	90
≥19 year female	75
Pregnant female	85
Breastfeeding female	120

Table 2: Recommended daily Intake of Iron[10]		
Age	**Male**	**Female**
9-13	8mg	8mg
14-18	11mg	15mg
19-50	8mg	18mg
51+	8mg	8mg

Aim: To determine if storage conditions of mandarins can affect the level of iron and ascorbic acid. The effects of sunlight light exposure, temperature, material covering and cut mandarins will be the altered conditions for comparison.

Hypothesis: The whole mandarins exposed to sunlight at room temperature with no coverings will contain the highest ascorbic acid and iron levels.

Materials

Table 1: Materials
- 24 Mandarins - Plastic and paper bags - Freezer -15^{o}c - Fridge 4^{o}c - Microwave 1000W - 48x 30ml containers - Eye protection - Gloves - Thermometer - Quantofix ® Iron Sensitive test kit - HI 3850 Ascorbic Acid Test Kit

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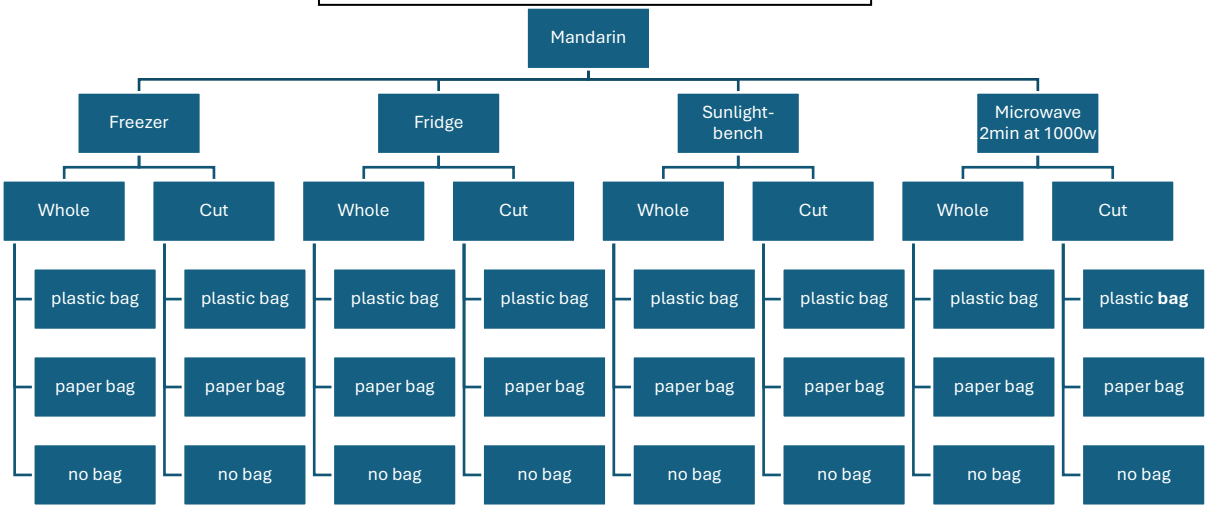
Figure 1: Mandarin Storage Conditions



Method

1. Place 1 whole mandarin in a plastic bag, paper bag and no bag (set 1)- repeat x4
2. Place a cut mandarin in a plastic bag, paper bag and no bag (set 2)- repeat x4
3. Place in the freezer (-15°c) a set of cut and uncut mandarins, do the same for the fridge (4 °c) and bench (15 °c) with direct sunlight. Leave these specimens for 5 days.
4. Microwave each specimen (set 1 and 2) for 2 minutes in a 1000 watt microwave. Juice each sample into 2 separate labelled specimen jar.
5. Complete step 8 and 9 for the microwaved samples and record.
6. After 5 days, squeeze the juice from the mandarins in the freezer, fridge and bench into labelled specimen jars- 2 jars for each mandarin (iron and ascorbic acid testing).
7. Ascorbic acid testing
    i. Fill the test tube to 10ml with the juice sample.
    ii. Add deionized water to the 50ml mark.
    iv. Add 1mL of HI3850A-0 reagent, swirl to mix.
    v. Add 4 drops of starch indicator, swirl to mix
    vi. Add drops of H13850C-0 reagent, swirling and counting the drops until a persistent blue colour appears.

vii. Count the drops needed for the colour change. Concentration of ascorbic acid= number of drops of H13850C-0 x10= ppm $C_6H_8O_6$.

8. Iron testing

ii. QUANTOFIX ® Iron Sensitive

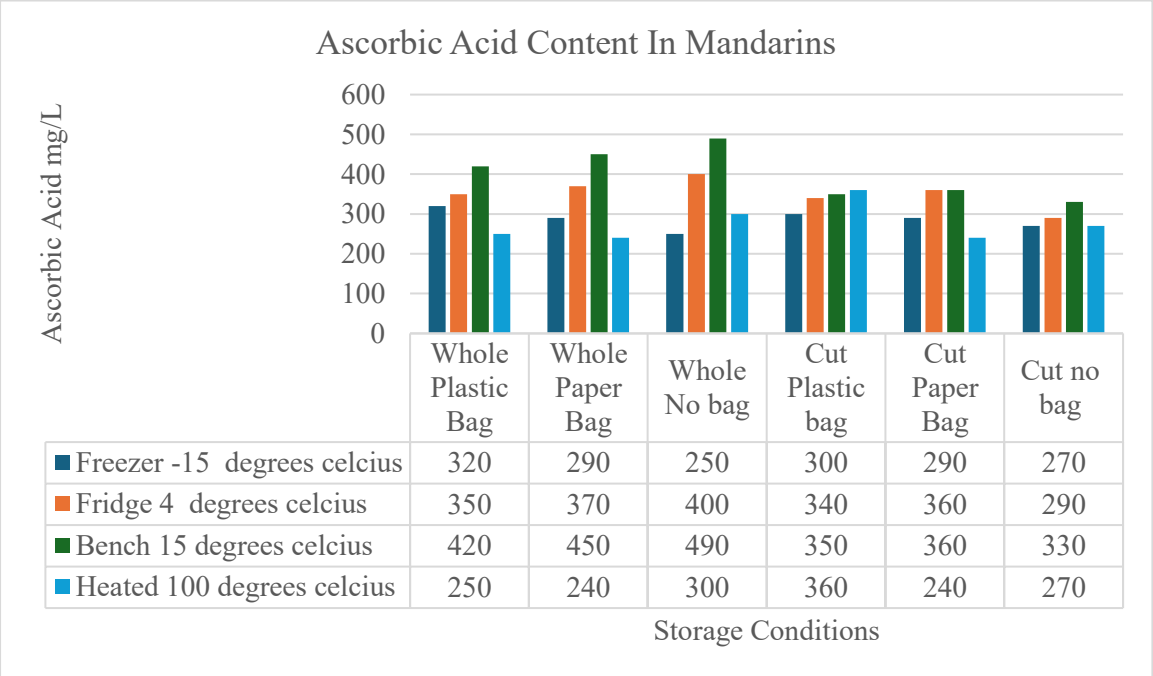
ii. Dip test strip into test solution for 30 seconds.

iii. Shake off excess liquid, wait 30 seconds.

v. Place test strip next to colour scale. Compare the test with the colour scale.

vi. If iron is present, the test tube field turns blue- range 0.05-1.0mg/L $Fe^{2+/3+}$

Results



	Whole Plastic Bag	Whole Paper Bag	Whole No bag	Cut Plastic bag	Cut Paper Bag	Cut no bag
Freezer -15 degrees celcius	320	290	250	300	290	270
Fridge 4 degrees celcius	350	370	400	340	360	290
Bench 15 degrees celcius	420	450	490	350	360	330
Heated 100 degrees celcius	250	240	300	360	240	270

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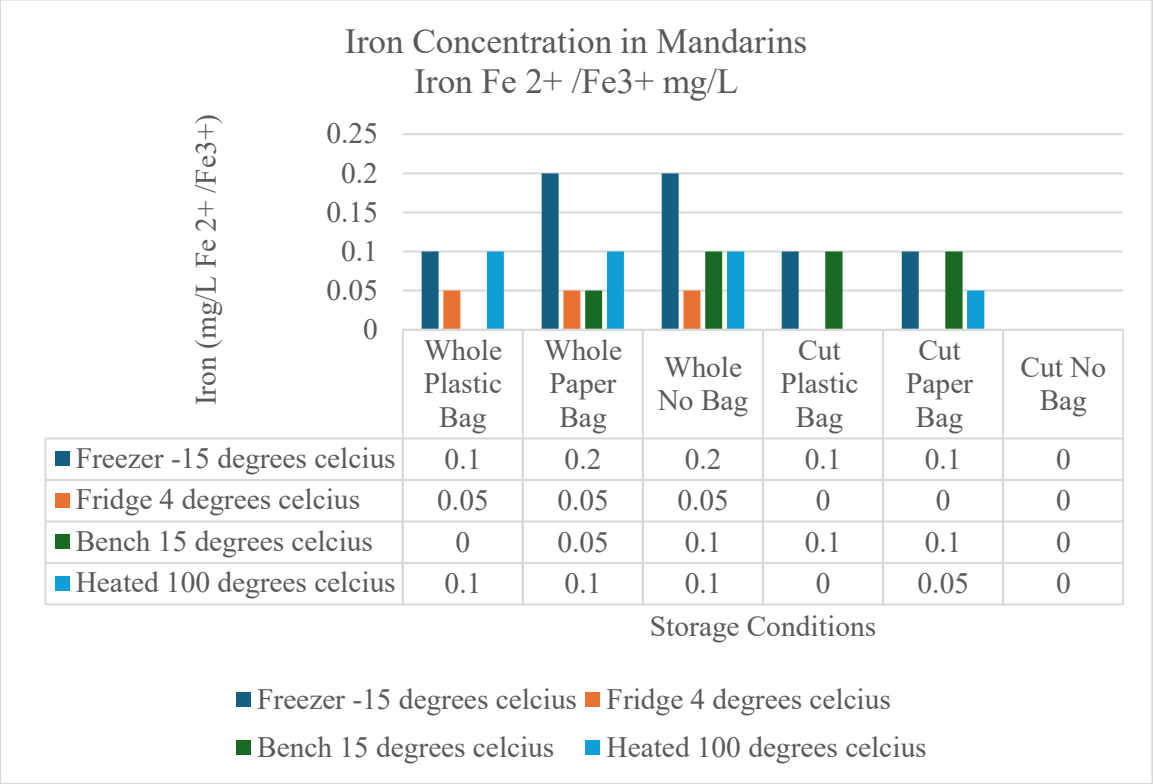

Conclusion

In general, the factors that contributed to the highest amount of ascorbic acid content were seen in mandarins that were whole, at room temperature 15ºc and no bag. The whole freezer mandarins had most iron. Iron was detected in a mixture of both whole and cut mandarins. No iron was detected in the no bag cut specimens.

Discussion

On average the highest ascorbic acid was found in the fridge 15ºc mandarins and the lowest ascorbic acid was found in the heated 100ºc mandarins. On average the highest ascorbic acid was found in the no bags in the whole mandarins and the plastic bag cut mandarins. Whole mandarin specimens tended to have more ascorbic acid than cut specimens. Overall, there was minimal iron detected in the mandarins, however the whole mandarins stored in the freezer had the highest iron result. The unbagged bench mandarin had 43mg of ascorbic acid and 0.009mg of iron.

I though the higher results of ascorbic acid and average iron content seen in the no bag bench 15ºc specimen may have been due to the direct sunlight increasing the ripeness of the mandarin, however this cannot be the case as mandarins are non-climacteric fruit and do not ripen further after harvest[11-

[12]. Mandarins have the highest level of ascorbic acid at their peak ripeness. Vitamin C content also reduces with oxygen exposure so I thought the freezer and fridge specimens would have been higher.

The freezer bagged specimens tended to have higher levels of ascorbic acid compared to the freezer no bags which may be due to less degradation from chill burn.

The heated specimens had the lowest levels of ascorbic acid. This is consistent with studies reviewed that indicate ascorbic acid content can be affected by extreme temperatures[13]. The specimens were heated for 2 minutes; it would be interesting to repeat the experiment with a higher volume of specimen so I could boil to specimen for 10 minutes above 80 degrees Celsius as evidence suggests this is the level required to breakdown the ascorbic acid in citrus juice.

In most specimens with direct comparison, the whole specimens had higher levels of ascorbic acid. This is likely because of air dehydrating the mandarin and leading to faster decay with oxidation[14].

To reduce variables in the experiment I chose mandarins as the citrus fruit to study as I have a mandarin tree and was able to pick the mandarins at the same time and the same size, reducing the variables of growing conditions and storage that would occur if I was to buy citrus from the shops. I chose study conditions that are reproducible to be cost effective for storing mandarins. In further experiments I would harvest multiple mandarins for each storage category to produce more juice so I could heat the juice over days. I would also like to store the fruit for up to 6 months to cover potential storage time to eat the mandarins out of season. Increasing the numbers of mandarins in each category would also reduce the risk of confounding factors including if I was the harvest the mandarins at different stages of ripeness. I would like to find a way to test the mandarins without juicing as this can affect the vitamin C and iron content.

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Maximizing Micronutrients

Workbook

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20/5/2025

I am excited for the Oliphant Science Awards! I want to do a topic on food chemistry.

21/5/2025

What is involved in a science investigation?

I remember this from last year. We need the following parts:

- **Title**- what is my investigation called?
- **Aim**- why am I doing this investigation?
- **Hypothesis-** what do I think will happen?
- **Materials-** what do I need to conduct my investigation?
- **Method**- how am I going to do my investigation?
- **Results/Processing and analysing data**- collecting and arranging the data
- **Conclusion**- what is the answer to the aim?
- **Evaluation and discussion**- what was interesting about the results, what did I learn, what could I change to make it a better investigation, what else can I now investigate?
- **Possible improvements**
- **Bibliography**

What do I need to include?

From the OSA website- Scientific report including the following sections:

- Questioning and predicting
- Planning and conducting
- Equipment and materials
- Processing and analysing data and information
- Evaluating
- Communicating using scientific terms and methods
- Word count included: Year R–6: do not exceed 1000 words

- Journal / Logbook with dates for your on-going ideas, raw data, notes, completed risk assessment (signed by your science teacher or Oliphant coordinator)

22/5/2025

I am very interest in nutrition and want to find a way to increase nutrient availability in foods that are available to people and not too expensive. I looked around the shops and noticed that oranges, bananas and apples were the cheapest fruits. I know that vitamin C in present in oranges, so I started thinking about this for topics to investigate.

- Topic ideas
    - What is the effect of different types of light on fruit vitamin C content?
    - Do cooking methods effect the content of vitamin C in fruit and vegetables?
    - Does growing tomato plants under different light conditions effect the level of vitamin C in the fruit?
    - Can storage methods affect the level of vitamin C in oranges?
    - How to prevent mould growth in bread?

What topic will I choose?

- Can storage methods affect the level of vitamin C and iron in oranges?
    - Cut vs uncut orange
    - Stored in a plastic bag vs paper bag vs no bag
    - Stored in heat (boiled) vs bench vs fridge vs freezer

Why did I choose this topic?

It's important for our bodies to receive nutrients. Supplements and vitamins are a BIG industry but are expensive, I want to find a way to ensure people have enough nutrients with real food that is not expensive. Two of the most key nutrients required for the body of vitamin C and iron. They play a critical role in the body's functioning. Captain Cook's crew developed a condition known as scurvy because of the lack of vitamin C. People still develop scurvy and iron deficiency in the world all the time. I wanted to do an experiment that could try and maximise the amount of iron and vitamin C in a common fruit that is readily available to many people.

23/05/2025

- Things to consider
    - I need to use oranges of the same age from the same tree to reduce the variable factors

  - I need to learn to test for vitamin C (research)
  - I need to learn to test for iron (research)
  - I need to work out every combination of testing!
- What do I need for my experiment?
  - Oranges
  - Paper bags
  - Plastic bags
  - Freezer, fridge, bench, oven
  - Stove
  - Pan
  - Water
  - Knife
  - Beaker
  - Cup
  - Iron testing kit- QUANTOFIX® Iron Sensitive test kit
  - Ascorbic Acid Test Kit - HANNA instruments - HI3850
  - Protective gloves, eyewear, clothing

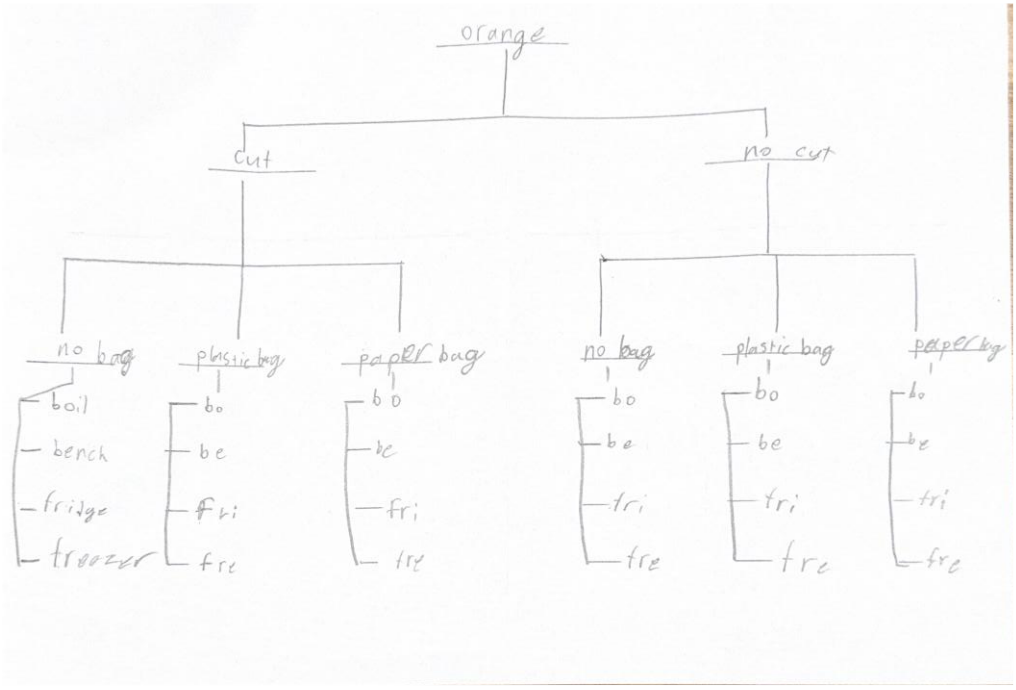

Figure 1 Sample Preparation

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This is a great way to show my method. I made this chart in word.

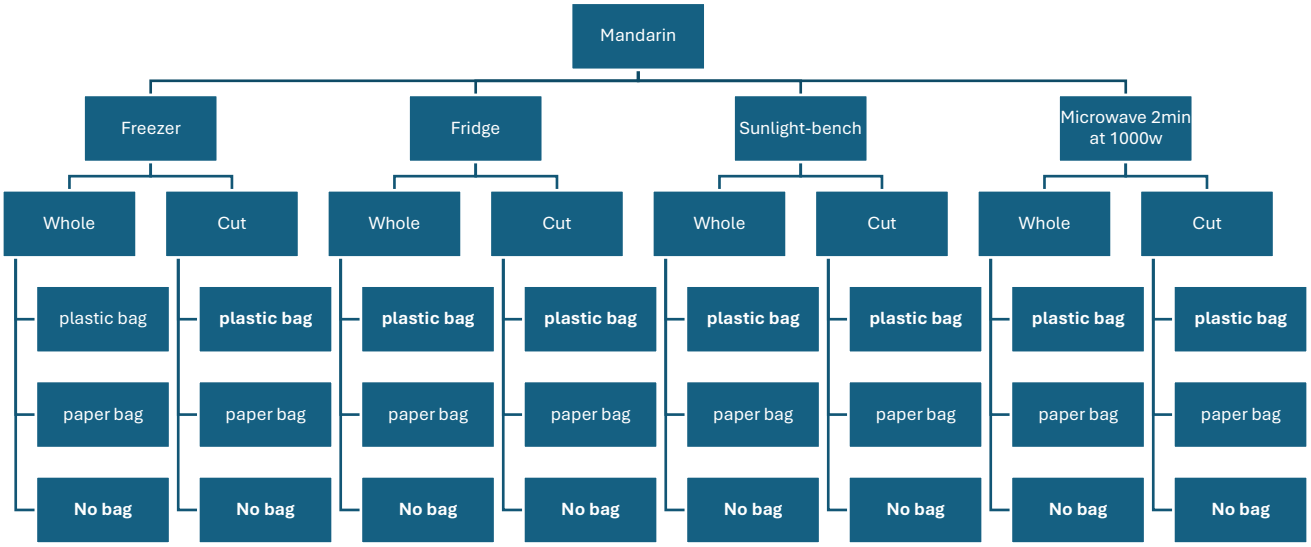

Figure 2 Sample Preparation by temperature

24/5/25 Method

1. Iron testing method
    a. Items
        i. Beaker
        ii. QUANTOFIX ® Iron Sensitive 1
    b. Method
        i. QUANTOFIX ® Iron Sensitive 1 are test strips for the semi quantitative determination of the iron content in the concentration range of 0.05 to 1.0 milligrams per litre in aqueous solutions
        ii. Dip test strip into test solution, moving back and forth for approximately 30 seconds.

iii. Shake off excess liquid.
iv. .Wait 30 seconds.
v. Place test strip next to colour scale on the label. Compare the test field through the hole with the colour scale. The opening at the end of this trip is not used for interpretation.
vi. Interpretation: if iron is present, the test tube field turns blue.
vii. Measuring range 0.05 to 1.0mg/L $Fe^{2+/3+}$
viii. Colour gradients; zero, 0.05, 0.1, 0.2, 0.5, 1.0mg/L $Fe^{2+/3+}$

2. Ascorbic acid testing
   a. Items
      i. HI 3850A-0 Ascorbic Acid Reagent (1 bottle 100 ml)
      ii. Starch indicator, bottle with dropper (25 mL)
      iii. HI 3850C-0 Ascorbic Acid Reagent (1 bottle 100 ml)
      iv. 2 calibrated plastic vessels (50 mL)
      v. 1 plastic pipette (3 mL);
      vi. 2 plastic pipettes (1 mL);
      vii. 1 plastic test tube, graduated with cap
      viii. Deionized water
   b. Method
      i. Fill the graduated plastic test tube up to the 10 ml mark with the orange juice sample and pour it into the calibrated vessel.
      ii. Add deionized water up to the 50-mil mark to dilute.
      iii. Prepare another sample using the other calibrated vessel and keep it as a reference for the initial colour.
      iv. Using the plastic dropper at 1ml of HI3850A-0 reagent to 1 sample only swell to mix.
      v. Add 4 drops of starch indicator and swirl to mix
      vi. Add drops of H13850C-0 reagent, while swirling and counting the drops until a persistent blue colour is developed. Compare the solution to the unreacted sample to be sure of a colour change.
      vii. Count the drops needed to obtain the colour change. To calculate the concentration of ascorbic acid multiply by 10 the number of drops of H13850 C-0 titration reagent used. **# of drops x10= ppm $C_6H_8O_6$**

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27/5/2025 sample preparation

- I changed to mandarins as I have a mandarin tree.
- I collected the mandarins from the tree in the backyard
- All mandarins were picked at the same time from the same tree to minimise variations in growing conditions and trees that may impact my experiment- this is why I did not use store bought oranges as I would not know:
    - How old they were
    - When they were picked
    - If they were all from the same tree or orchard
- Pre storage
    - Each mandarin weighed between 85-95g, average 88g
    - All mandarins were similar in size, shape, colour, smell and juice production overall
- I used my experiment diagram to work out how many specimens I needed and to make sure I did not miss any specimens.
- I labelled all my specimens and put them in the correct storage area
    - Bag: no bag, plastic, paper
    - Cut vs uncut
    - Temperature: freezer (-15 ºc), fridge (4 ºc), bench (15 ºc), heat (100 ºc)

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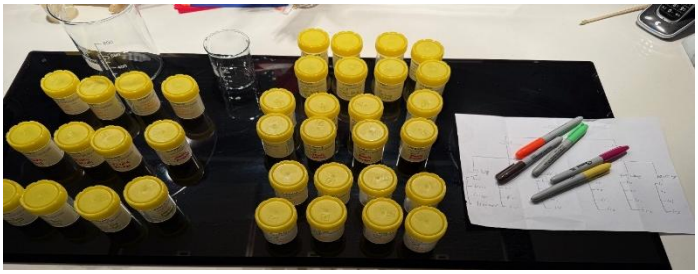
Figure 3 Sample Preparation- experiment practical

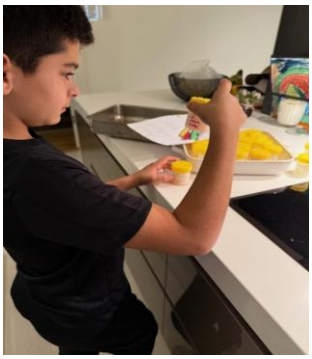
1/6/2025 sample preparation

- I collected all my samples that have been under specific storage conditions for 5 days
- I used my hands to squeeze the juice from the mandarins and for each sample split the juice amongst 2 sterile containers for each
    - Iron testing
    - Vitamin C testing
- This was a lot harder than I thought it would be and took a lot of time
- The heated mandarins were heated in the microwave as I was worried the juice may leak out if I boiled them.
- I had to wait for the frozen specimens to defrost to squeeze the juice out
- I placed the samples in the sterile containers back into the same conditions

Observations

- Pre storage
    - Each mandarin weighed between 85-95g, average 88g
    - All mandarins were similar in size, shape, colour, smell and juice production overall
    - All mandarins were picked at the same time from the same tree to minimise variations in growing conditions and trees that may impact my experiment- this is why I did not use store bought oranges as I would not know
        - How old they were?
        - When were they picked?
        - If they were all from the same tree or orchard?
- Post storage
    - The weight of the mandarins did not change after the 5 day storage period except the cut mandarin on the bench
    - The cut mandarin on the bench weight 3g lighter at the end of the 5 days storage
    - The most juice was produced by the heated mandarins
    - The least juice was produced by the cut mandarin on the bench
    - The average amount of juice produced per mandarin was 30-40mL





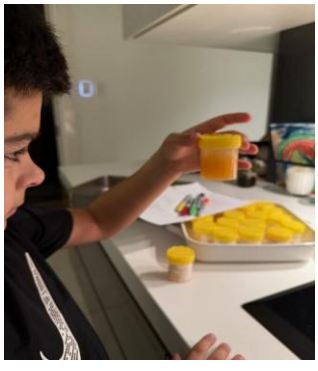


Figure 4 Preparing the juice

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1/6/2025 Testing

1. Iron testing method
    a. Items
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        ii. QUANTOFIX ® Iron Sensitive 1
    b. Method
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        ii. Dip test strip into test solution, moving back and forth for approximately 30 seconds.
        iii. Shake off excess liquid.
        iv. Wait 30 seconds.
        v. Place test strip next to colour scale on the label. Compare the test field through the hole with the colour scale. The opening at the end of this trip is not used for interpretation.
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        viii. Colour gradients; zero, 0.05, 0.1, 0.2, 0.5, 1.0mg/L $Fe^{2+/3+}$

2. Ascorbic acid testing
    a. Items
        i. HI 3850A-0 Ascorbic Acid Reagent (1 bottle 100 ml)
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        iii. HI 3850C-0 Ascorbic Acid Reagent (1 bottle 100 ml)
        iv. 2 calibrated plastic vessels (50 mL)
        v. 1 plastic pipette (3 mL);
        vi. 2 plastic pipettes (1 mL);
        vii. 1 plastic test tube, graduated with cap
        viii. Deionized water
    b. Method
        i. Fill the graduated plastic test tube up to the 10 ml mark with the orange juice sample and pour it into the calibrated vessel.

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vi. Add drops of H13850C-0 reagent, while swirling and counting the drops until a persistent blue colour is developed. Compare the solution to the unreacted sample to be sure of a colour change.
vii. Count the drops needed to obtain the colour change. To calculate the concentration of ascorbic acid multiply by 10 the number of drops of H13850 C-0 titration reagent used. **# of drops x10= ppm $C_6H_8O_6$**

1/6/2025 Results

Mandarin specimen	**Ascorbic acid**		**Iron (mg/L Fe^{2+} /Fe^{3+})**
	Drops of H13850C-0 reagent	Parts per million # of drops x10= ppm $C_6H_8O_6$ *equivalent to mg/L	
Whole plastic bag freezer	32	320	0.1
Whole paper bag freezer	29	290	0.2
Whole no bag freezer	25	250	0.2
Cut plastic bag freezer	30	300	0.1
Cut paper bag freezer	29	290	0.1
Cut no bag freezer	27	270	0
Whole plastic bag fridge	35	350	0.05
Whole paper bag fridge	37	370	0.05
Whole no bag fridge	40	400	0.05
Cut plastic bag fridge	34	340	0
Cut paper bag fridge	36	360	0
Cut no bag fridge	29	290	0

Whole plastic bag bench	42	420	0
Whole paper bag bench	45	450	0.05
Whole no bag bench	49	490	0.1
Cut plastic bag bench	35	350	0.1
Cut paper bag bench	36	360	0.1
Cut no bag bench	33	330	0
Whole plastic bag heated	25	250	0.1
Whole paper bag heated	24	240	0.1
Whole no bag heated	30	300	0.1
Cut plastic bag heated	26	360	0
Cut paper bag heated	24	240	0.05
Cut no bag heated	27	270	0

Colour coding for easier analysis

0-100

101-200

201-300

301-400

401-500

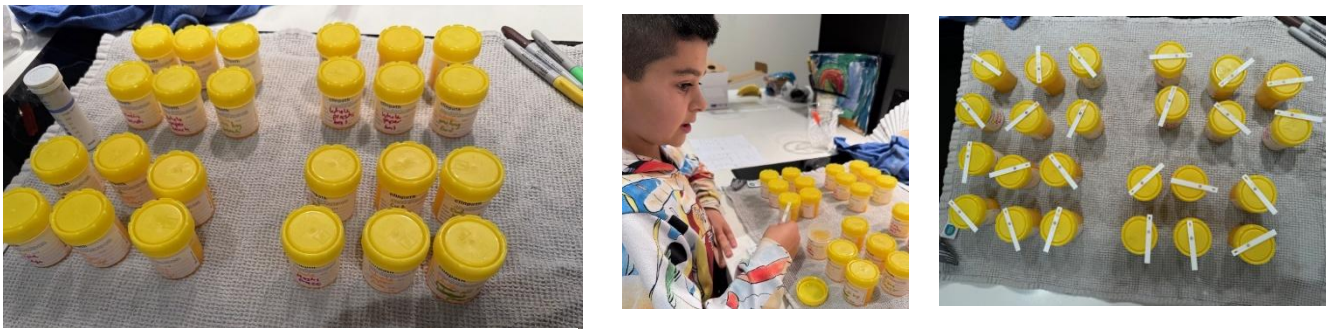

Figure 5 Juice samples and iron testing

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Figure 6 Iron testing- blue indicates iron presence

4/6/2025 interpretation

- Freezer vs fridge vs bench vs heat
    - Bench 15°c had higher vitamin C in whole specimens
    - Bench 15°c had higher vitamin C in cut specimens except for the heat cut plastic bag specimen
- Whole vs cut
    - Except for no bag, the whole freezer was higher than cut versions
    - Whole fridge 4°c was higher than cut versions
    - Whole bench 15°c was higher than cut versions
    - Except for the plastic bag, the whole heated specimens had higher vitamin C than the cut versions
- Plastic bag vs paper bag vs no bag
    - In the whole specimens, no bag had higher vitamin C except for the freezer specimen
    - In the cut specimen the results were mixed but the heated plastic bag and fridge and bench paper bag had the highest vitamin C
- On average the highest vitamin C was found in the fridge specimens
- On average the lowest vitamin C was found in the heated samples
- On average the highest vitamin C was found in the no bags in the whole specimens and the plastic bag cut specimens
- The whole specimens had more vitamin C than the cut specimens

- The iron results were very mixed
- The whole freezer mandarins had most iron
- The was iron detected in a mixture of both cut and whole mandarins
- Most of the whole specimens had iron
- There was no iron recorded in the no bag cut specimens

Mandarins stored at room temperature 15ºc recorded the most vitamin C in all whole specimens and most cut specimens. At -15ºc, most of the whole specimens had higher vitamin C than the cut specimens. Both the 4 ºc and 15 ºc whole specimens had higher vitamin C content than the cut specimens. Overall the lowest vitamin C was seen in the 100 ºc. Most of the 100 ºc whole specimens had higher vitamin C content than the cut specimens.
In the whole specimens, no bag had higher vitamin C except for the freezer -15ºc specimen. In the cut specimen the results were mixed but the heated plastic bag and fridge and bench paper bag had the highest vitamin C.
The iron results were very mixed. The whole freezer mandarins had most iron. Iron was detected in a mixture of both cut and whole mandarins. Most of the whole specimens had iron. There was no iron recorded in the no bag cut specimens

5/6/2025 Conclusion

In general, the factors that contributed to the highest amount of vitamin C content were seen in mandarins that were whole, at room temperature 15ºc and no bag. The whole freezer mandarins had most iron. Iron was detected in a mixture of both whole and cut mandarins. No iron was detected in the no bag cut specimens.

6/6/2025 Questions

1. What is iron?

   Wikipedia Contributors (2019). *Iron*. [online] Wikipedia. Available at: https://en.wikipedia.org/wiki/Iron.

   Iron is an element with a symbol of Fe (from Lanintferrum ‘iron’) with the atomic number 26. This is a metal that is in the first transition series and is part of group 8 in the periodic table of elements. It is, by mass, the most common element on Earth, forming most of Earth’s outer core and Earth’s inner most, inner core.

a. There are two types of iron in food, heme iron (Ferrous Fe2+) and non-heme iron (Fe3+). Heme iron is commonly found in meat products and is easily absorbed by the body, with 15-35% absorbed. Sources of heme iron include red meat, beef, lamb, pork, seafood, chicken and eggs. Non heme iron (ferric Fe3+) is found in green leafy foods, eggs, dried fruits, beans, tofu and foods engineered with fortified iron like Weetbix. Approximately 2-10% of non heme iron is absorbed.
b. To be absorbed from the gastrointestinal tract, ferric iron must be converted to ferrous iron or bound to a protein like heme. Ascorbic acid (vitamin C) increases non heme iron absorption through three main mechanisms
    i. Ascorbic acid reduces Fe3+ to Fe2+ and prevents Fe2+ being oxidised back to Fe3+
        1. Lynch, S. and Cook, J. (1980). *Interaction of Vitamin C and Iron*. [online] Annals of the New York Academy of Sciences. Available at: https://pubmed.ncbi.nlm.nih.gov/6940487/.
    ii. Chelation: ascorbic acid binds Fe3+, forming a chelate (complex molecule) that enhances its absorption
    iii. Ascorbic acid creates a more acidic environment in the stomach which assists with iron absorption

7/6/2025 Questions

2. Why does the human body need iron?
    a. Iron is essential for multiple different functions in the body including DNA synthesis, electron transport and oxygen transport.
    b. Iron is used to produce haemoglobin, which is the part of the red blood cell that carries the oxygen from the lungs to all the other tissues in the body.
    c. Iron is used to form myoglobin which stores and releases oxygen in muscles which helps muscles to function.
    d. Iron is important for brain development and neurotransmitter production. Iron helps the body fight infections and maintain health.
    e. Iron is used in energy production

Ref: American Red Cross (2021). *The Importance of Iron in Your Body*. [online] www.redcrossblood.org. Available at: https://www.redcrossblood.org/local-homepage/news/article/iron-in-blood.html.

3. What happens with iron deficiency in humans?
    a. As iron is needed to make haemoglobin, a deficiency of iron can lead to anaemia which is insufficient red blood cells. This leads to fatigue, shortness of breath.
    b. Headache, tinnitus, taste disturbance, mental changes, sore tongue, glossitis, angular stomatitis, nail changes, difficulty swallowing, hair loss and thinning, heart failure.
    c. Team, A. (2022). *Clinical features*. [online] Gpnotebook.com. Available at: https://gpnotebook.com/en-AU/pages/ear-nose-and-throat/iron-deficiency/clinical-features [Accessed 29 Jun. 2025].

4. How much iron do you need?
    a. The recommended daily intake of iron ranges from 8-27mg (table 1).
    b. Insert table

Age	Male	Female
9-13	8mg	8mg
14-18	11mg	15mg
19-50	8mg	18mg
51+	8mg	8mg

5. Why does the body need iron every day?
    a. Iron is lost in sweat, bleeding and is making new cells.
    b. Ems, T., Huecker, M.R. and St Lucia, K. (2023). *Biochemistry, Iron Absorption*. [online] National Library of Medicine. Available at: https://www.ncbi.nlm.nih.gov/books/NBK448204/.

8/6/2025 Questions

6. **What foods have the most iron?**

- American Red Cross (2019). *Iron-Rich Foods*. [online] Redcrossblood.org. Available at: https://www.redcrossblood.org/donate-blood/blood-donation-process/before-during-after/iron-blood-donation/iron-rich-foods.html.
- Health, Q. (2024). *Iron in the body Non-haem iron*. [online] Available at: https://www.health.qld.gov.au/__data/assets/pdf_file/0032/147974/general_iron.pdf.

Haem Iron Rich Foods	Non Haem Iron Rich Foods
Meat: Beef, lamb, pork, kangaroo Poultry: Chicken and turkey Fish: salmon, sardines, tuna Offal: liver, kidney Eggs	Iron fortified cereals Legumes: kidney beans, baked beans, chickpeas Green leafy vegetable Nuts/nut pastes and dried fruit Eggs

7. Do mandarins have iron?

- Healthline. (2020). *Mandarin Orange: Nutrition Facts, Benefits, and Types*. [online] Available at: https://www.healthline.com/nutrition/mandarin-orange.
- Yes mandarins do have iron inside them but not significant amounts.

9/6/2025 Questions

8. Is there any link between iron and vitamin C absorption?
    a. Yes

9. What is ascorbic acid (vitamin C)?
    a. To be absorbed from the gastrointestinal tract, ferric iron must be converted to ferrous iron or bound to a protein like heme. Ascorbic acid (vitamin C) increases non heme iron absorption through three main mechanisms
        i. Ascorbic acid reduces Fe3+ to Fe2+ and prevents Fe2+ being oxidised back to Fe3+
        ii. **Lynch, S.R. and Cook, J.D. (1980). Interaction of vitamin C and iron. *Annals of the New York Academy of Sciences*, [online] 355(1), pp.32–44. doi:https://doi.org/10.1111/j.1749-6632.1980.tb21325.x.**
        iii. Chelation: ascorbic acid binds Fe3+, forming a chelate (complex molecule) that enhances its absorption
        iv. Ascorbic acid creates a more acidic environment in the stomach which assists with iron absorption

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10/6/2025 Questions

10. Why does the human body need vitamin C?
    a. For growth, development, collagen formation, iron absorption, wound healing and cell repair, renewal of cartilage, bones and teeth.
    b. Vitamin C is used in the formation of collagen which is used in making cells for skin, tendons, ligaments and blood vessels. This makes it a critical micronutrient for wound healing and cell repair.
    c. Vitamin C is an antioxidant that prevents cell damage by free radicals which are unstable molecules that are produced in the body during exposure to normal body processes and environmental factors including ultraviolet exposure from the sun.
    d. Vitamin C is used in the formation of leukocytes (white bloods cells) which are the main cells of the immune system.
    e. Vitamin C assists with iron absorption by binding non haem iron from plant based iron sources, converting it to the more readily absorbable haem iron.
    f. Medline Plus (2023). *Vitamin C: MedlinePlus Medical Encyclopedia*. [online] Medlineplus.gov. Available at: https://medlineplus.gov/ency/article/002404.htm.

11. How much vitamin C does a human need?

Recommended daily intake of Vitamin C	
Age group	mg/day
0-6 months	40
7-12 months	50
1-3 years	15
4-8 years	25
9-13 years	45
14-18 year old male	65
14-18 year old female	75
≥19 year male	90
≥19 year female	75
Pregnant female	85
Breastfeeding female	120

Medline Plus (2023). *Vitamin C: MedlinePlus Medical Encyclopedia*. [online] Medlineplus.gov. Available at: https://medlineplus.gov/ency/article/002404.htm.

Recommended Dietary Allowance (RDA): The average daily level of intake that is enough to meet the nutrient needs of nearly all (97% to 98%) healthy people. An RDA is an intake level based on scientific research evidence.

Adequate Intake (AI): This level is established when there is not enough scientific research evidence to develop an RDA. It is set at a level that is thought to ensure enough nutrition.

11/6/2025 Questions

12. What happens with vitamin C deficiency in humans?
    a. Anaemia, bleeding inflamed gums (gingivitis), poor wound healing and immune deficiency, dry and splitting hair, easy bruising, nose bleeding (epistaxis), dry rough skin, swollen painful joints, weakened tooth enamel.
    b. Scurvy is a condition that occurs with severe vitamin C deficiency and was known to afflict many sailors. It causes generalised weakness, anaemia, gingivitis, poor wound healing and skin haemorrhages. Captain Cook reduced scurvy on his ships by making his crew eat large amounts of sauerkraut (cabbage) and fresh produce where possible.
    c. Britannica. How did James Cook prevent scurvy on his ships?
    d. www.britannica.com. (n.d.). *How did James Cook prevent scurvy on his ships? | Britannica*. [online] Available at: https://www.britannica.com/question/How-did-James-Cook-prevent-scurvy-on-his-ships.
    e. Blogs.bl.uk. (2018). *Sauerkraut, sugar, and salt pork – the diet on board Cook's 'Resolution'*. [online] Available at: https://blogs.bl.uk/untoldlives/2018/06/sauerkraut-sugar-and-salt-pork-the-diet-on-board-cooks-resolution.html.
    f. Cleveland Clinic (2022). *Scurvy: Symptoms, Causes & Treatment*. [online] Cleveland Clinic. Available at: https://my.clevelandclinic.org/health/diseases/24318-scurvy.

13. What foods have the most vitamin C?
    a. Cantaloupe, citrus fruits and juices, mandarins, oranges, grapefruit, kiwi fruit, mango, papaya, pineapple, strawberries, raspberries, blueberries, cranberries, watermelon
    b. Broccoli, brussel sprouts, cauliflower, spinach, cabbage, leafy green vegetables, tomatoes, tomato juice,

c. The best sources of vitamin C are uncooked raw fruits and vegetables. Cooking vitamin C rich foods or storing them a long time can reduce the vitamin C content. Exposure to light can also reduce vitamin C content.
d. This is consistent with my experiment which showed the highest concentration vitamin C in the mandarins stored in paper bags which would have blocked out the light more than the mandarins in no bags or in plastic bags. My experiment also showed that highest concentration of vitamin C in the fridge specimens, with the highest in the paper bag specimen.
e. Medline Plus (2023). *Vitamin C: MedlinePlus Medical Encyclopedia*. [online] Medlineplus.gov. Available at: https://medlineplus.gov/ency/article/002404.htm.
f. National Institute of Health (2021). *Vitamin C*. [online] National Institutes of Health. Available at: https://ods.od.nih.gov/factsheets/VitaminC-HealthProfessional/.

12/6/2025 Questions

14. Do mandarins have vitamin C?
    a. Mandarins and oranges are also a key source of vitamin C.
    b. The average amount of vitamin C in a mandarin is 23.5mg in a 88g mandarin, this represents 39% of the recommended daily intake of vitamin C, benefits and types.
    c. Calculation: if I assume that 1g of mandarin (which is mostly water) is equal to 1mL of water, then 88g= 88mL or 0.088L (1000ml= 1L), so 23.5mg/0.088/l= 267.045mg/L
    d. Wartenberg L. Healthline. (2020). *Mandarin Orange: Nutrition Facts, Benefits, and Types*. [online] Available at: https://www.healthline.com/nutrition/mandarin-orange.
    e. WebMD. (n.d.). *Health Benefits of Mandarin Oranges*. [online] Available at: https://www.webmd.com/diet/health-benefits-mandarin-oranges.

15. Does the storage of mandarins affect micronutrient levels
    a. Freezing?
        i. 85% of the mandarin is water which may affect the nutritional value of the mandarin with freezing or cooking. Mandarins can be stored at room temperature for a week or in the fridge for 6 weeks.
        ii. https://www.healthline.com/nutrition/mandarin-orange#storage
        iii. Cooking above 80 degrees for more than 10 minutes can reduce vitamin C content
        iv. Less likely to be affected if not chill, so bags should help

b. Fridge?
    i. Storing mandarins in the fridge slows the degradation of vitamin C.
c. Room temperature?
    i. Light and oxygen can cause increased breakdown of vitamin C in the mandarins/citrus.
d. Boiling?
    i. Yes, it is water soluble and vitamin C easily degrades at high temperatures. However microwaving has less effect on the concentrations of vitamin C than boiling because of the reduced contact with water at relatively low temperatures.
    ii. Lee, S., Choi, Y., Jeong, H.S., Lee, J. and Sung, J. (2017). Effect of different cooking methods on the content of vitamins and true retention in selected vegetables. *Food Science and Biotechnology*, [online] 27(2), pp.333–342. doi:https://doi.org/10.1007/s10068-017-0281-1.
e. Plastic cover? Paper cover? No cover?
    i. oxygen can cause increased breakdown of vitamin C in the mandarins/citrus.
f. Whole vs Cut?
    i. Cut specimens have increased surface are so they Dry out and lose nutritional value due to oxygen exposure and enzymes which increase vitamin C degradation.
    ii. Truegeometry.com. (2025). *Vitamin C stability in citrus fruits*. [online] Available at: https://blog.truegeometry.com/api/exploreHTML/6527b7f14e16e895c477c20fe4e0641f.exploreHTML

14/6/2025 Discussion

On average the highest vitamin C was found in the fridge 15ºc mandarins and the lowest vitamin C was found in the heated 100ºc mandarins. On average the highest vitamin C was found in the no bags in the whole mandarins and the plastic bag cut mandarins. Whole mandarin specimens tended to have more vitamin C than cut specimens. Overall, there was minimal iron detected in the mandarins, however the whole mandarins stored in the freezer had the highest iron result.

I though the higher results of vitamin C and average iron content seen in the no bag bench 15ºc specimen may have been due to the direct sunlight increasing the ripeness of the mandarin, however

this cannot be the case as mandarins are non-climacteric fruit and do not ripen further after harvest. Mandarins have the highest level of vitamin C at their peak ripeness.

The freezer specimens with bags tended to have higher levels of vitamin C compared to the freezer specimens without bags which may be due to less chill burn which may lead to decay on the mandarins.

The heated specimens had the lowest levels of vitamin C. This is consistent with studies reviewed that indicate vitamin C content can be affected by extreme temperatures. The specimens were heated for 2 minutes; it would be interesting to repeat the experiment with a higher volume of specimen so I could boil to specimen for 10 minutes above 80 degrees Celsius as evidence suggests this is the level required to breakdown the vitamin C in citrus juice.

In most specimens with direct comparison, the whole specimens had higher levels of vitamin C. This is likely because of air dehydrating the mandarin and leading to faster decay.

To reduce variables in the experiment I chose mandarins as the citrus fruit to study as I have a mandarin tree and was able to pick the mandarins at the same time and the same size, thus eliminating variables of growing conditions and storage that would occur if I was to buy citrus from the shops. I chose study conditions that are readily reproducible to be cost effective for storing mandarins. In further experiments I would harvest multiple mandarins for each storage category to produce more juice so as I could heat the juice over days. I would also like to store the fruit for up to 6 months to cover potential storage time to eat the mandarins out of season. Increasing the numbers of mandarins in each category would also reduce the risk of confounding factors including if I was the harvest the mandarins at different stages of ripeness.

15/5/2024 report writing

- Introduction
- Equipment

16/6/2024 report writing

- Method
- Results with tables and pictures

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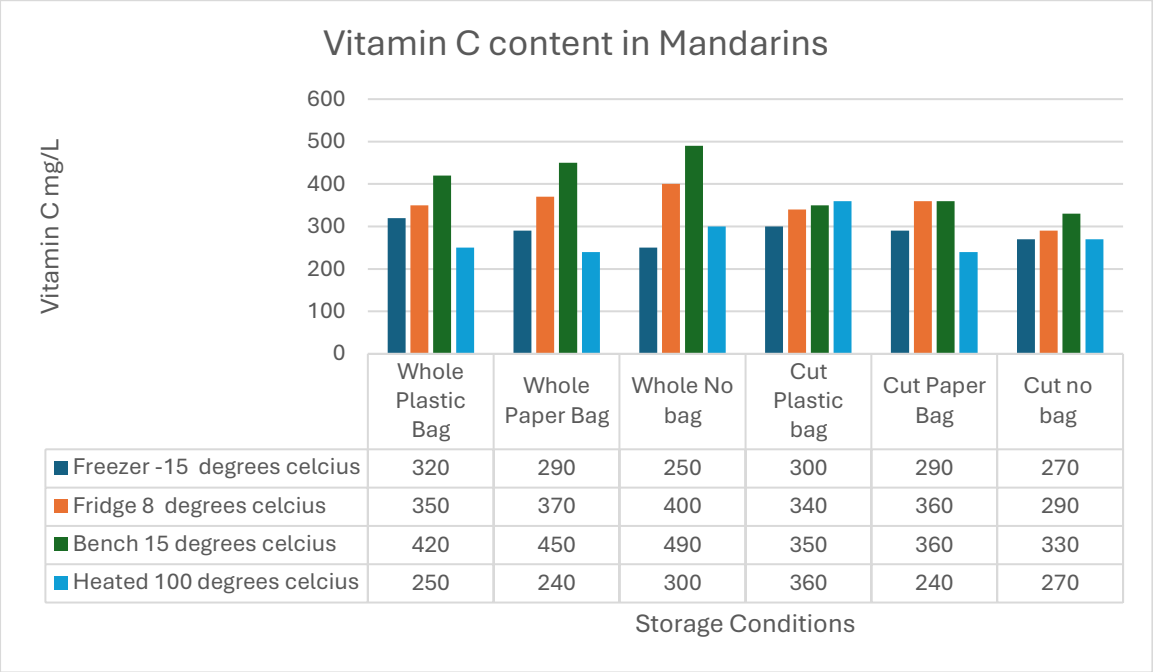
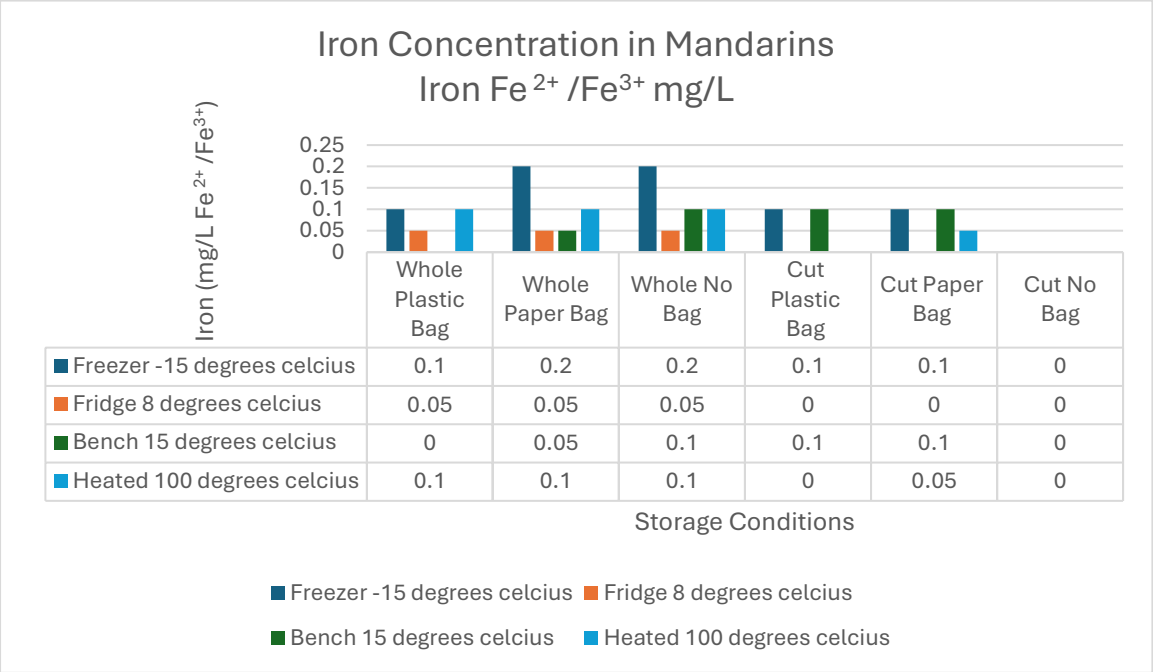


	Whole Plastic Bag	Whole Paper Bag	Whole No bag	Cut Plastic bag	Cut Paper Bag	Cut no bag
Freezer -15 degrees celcius	320	290	250	300	290	270
Fridge 8 degrees celcius	350	370	400	340	360	290
Bench 15 degrees celcius	420	450	490	350	360	330
Heated 100 degrees celcius	250	240	300	360	240	270



	Whole Plastic Bag	Whole Paper Bag	Whole No Bag	Cut Plastic Bag	Cut Paper Bag	Cut No Bag
Freezer -15 degrees celcius	0.1	0.2	0.2	0.1	0.1	0
Fridge 8 degrees celcius	0.05	0.05	0.05	0	0	0
Bench 15 degrees celcius	0	0.05	0.1	0.1	0.1	0
Heated 100 degrees celcius	0.1	0.1	0.1	0	0.05	0

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17-18/6/25 report writing

- Discussion

19/6/2025 report writing

- Bibliography

20/6/21 report writing

- Check and proofread

21/6/2025 Bibliography

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Acknowledgement

My mum helped me with the understanding iron absorption and monitored my online research and experiment for safety. I used voice to text to help me record my ideas and then edited my work. I learnt how to make graphs with word and how to add captions and group photos.

OSA RISK ASSESSMENT FORM

for all entries in (✓) ☐ Models & Inventions and ☑ Scientific Inquiry

This must be included with your report, logbook or entry. One form per entry.

STUDENT(S) NAME: Amir Chaloob ID: 0683003

SCHOOL: St Peter's Woodlands Grammar Sched

Activity: Give a brief outline of what you are planning to do.

I am going to test the vitamin C content of oranges under multiple different conditions

Are there possible risks? Consider the following:

- Chemical risks: Are you using chemicals? If so, check with your teacher that any chemicals to be used are on the approved list for schools. Check the safety requirements for their use, such as eye protection and eyewash facilities, availability of running water, use of gloves, a well-ventilated area or fume cupboard.
- Thermal risks: Are you heating things? Could you be burnt?
- Biological risks: Are you working with micro-organisms such as mould and bacteria?
- Sharps risks: Are you cutting things, and is there a risk of injury from sharp objects?
- Electrical risks: Are you using mains (240 volt) electricity? How will you make sure that this is safe? Could you use a battery instead? **Only batteries can be used for Models & Inventions entries*
- Radiation risks: Does your entry use potentially harmful radiation such as UV or lasers?
- Other hazards

Also, if you are using other people as subjects in an investigation you must get them to sign a note consenting to be part of your experiment.

Risks	How I will control / manage the risk
knives chemical test kit	use under supervision gloves, goggles and protective clothing

(Attach another sheet if needed.)

Risk Assessment indicates that this activity can be safely carried out

RISK ASSESSMENT COMPLETED BY (student name(s)): Amir Chaloob

SIGNATURE(S): Amir

☑ By ticking this box, I/we state that my/our project adheres to the listed criteria for this Category

TEACHER'S NAME: Lisa Itami

SIGNATURE: [signature] DATE: 23/06/2025