



National Science Fair Research Paper

Project ID	NSF-SCH2025-25
Project Title	Triple-Guard BioWrap (TGB): A Natural Film That Slows Browning, Moisture Loss & Heat Trapping in Cut Fruits
Level	Primary Level
Category	Environmental Science
Participant Name	MOHAMMED HARISH AHMED
School	iMAX Nursery & Primary School, Royapettah
City	Chennai – 600 0014,
State	Tamil Nadu

Table of Contents

ABSTRACT	4
INTRODUCTION	4
HYPOTHESIS	5
Why This Study Matters	5
METHODS:	5
This section describes the procedure used to prepare the TGB film and evaluate its performance	5
Base Film Preparation and GSE Dip Test:	5
A. Testing Dip Time	5
Data collected:	5
B. Dot Density Test	6
C. Main Freshness Study	6
Variables and Control Setup	7
COLLECTION OF DATA – PHOTOGRAPHS	8
Base Film Preparation With Tsp:	8
Gse Dip Time Test:	9
Zeolite Dot Density Test	10
FINAL TEST	11
RESULT:	14
Phase 1 – GSE Dip Time Test (Water Leakage and Wet-Spot Observation)	14
Phase 2 – Zeolite Dot Density Results	15
Main Freshness Study – 5 Days 3 Trials	17
Weight Loss (%)	17
Temperature (°C)	19
Color Value (0–255)	21

RESULTS SUMMARY.....	22
DISCUSSION.....	23
How Each Ingredient Helped the TGB Film.....	23
Why the 60-Second Dip Was the Best.....	23
Why 3 Dots per cm² Worked Better Than 2 or 4.....	23
Why TGB Performed Best in the 5-Day Freshness Test	24
CONCLUSION.....	25
FUTURE IMPROVEMENTS.....	25
REFERENCES.....	26
ACKNOWLEDGEMENT	27

ABSTRACT

Food spoilage after cutting fruits is a common problem at home, and plastic wraps used for storage can trap heat and moisture, making fruits spoil faster. This project aimed to make a safe, natural, and eco-friendly film that keeps cut fruits fresh for a longer time and reduces plastic usage.

A Triple-Guard BioWrap (TGB) was prepared using four natural materials. Starch formed the main film and reduced water loss. Tamarind-seed polysaccharide provided strength and flexibility. Grape-seed extract created a smooth protective coating. Zeolite dots trapped ethylene gas released by fruits during ripening. Together, these ingredients acted as a triple guard by slowing moisture loss, reducing ripening gases around the fruit, and avoiding heat trapping.

Three film samples were tested on cut apples and compared with two control conditions: plastic wrap and no wrap. Data were recorded for weight loss, colour change and temperature change. Temperature readings taken every 12 hours showed that plastic wrap trapped more heat, while TGB allowed slow breathing of heat and moisture. The best TGB sample stayed fresh longer than all other samples and showed much less browning than plastic wrap.

The results showed that natural materials can be combined to make an effective, safe and eco-friendly wrap. This project supports the use of biodegradable alternatives to reduce plastic waste and keep food fresher in a simple, low-cost way.

INTRODUCTION

Fresh fruits spoil quickly after cutting because their soft inner surface meets air. When this happens, three things start immediately: moisture escapes, oxygen causes browning, and moisture and heat can get trapped if the wrap does not allow breathing. Many families use plastic cling wrap to slow this spoilage. But plastic does not allow heat or moisture to escape, so the trapped heat often makes fruits soften faster. After use, plastic becomes waste and pollutes soil and water.

Studies show starch films reduce moisture loss but trap humidity. Research papers on GSE show antioxidant properties that may slow browning. Zeolites are used in fruit-storage systems to absorb ethylene gas, which helps slow down the ripening process. Natural films made with such materials are safer for the environment, but most of them offer only one benefit, such as reducing moisture loss or slowing oxygen contact. Very few can protect the fruit in more than one way.

This observation raised the question of whether a multi-layer natural film would work better. I wanted to design a wrap that provides three kinds of protection: slows moisture loss, reduces browning, and avoids trapping extra heat. The wrap was also intended to be safe, low-cost, and easy for students to prepare at home

Research Question

Does the Triple-Guard BioWrap (TGB) keep fruits fresh longer than a plain starch film, a plastic cling wrap, or no wrap at all under the same conditions?

HYPOTHESIS

It was expected that the Triple-Guard BioWrap (TGB) would work the best because each natural ingredient had a special job.

Tamarind-seed polysaccharide (TSP) strengthens the starch film and keeps it flexible so it does not tear while wrapping. Grape-seed extract (GSE) helps form a tighter surface layer that slows water leakage and protects the surface better. Zeolite dots trap ethylene gas, which fruits release during ripening. Because of these combined actions,

It was expected that fruits covered with TGB would stay fresh for more days and show less moisture loss and browning compared with the other wraps.

Why This Study Matters

Food spoilage at home wastes money and increases household garbage. If children can prepare a natural wrap from materials available in local shops, families can reduce plastic usage and keep food fresher in a simple, safe and eco-friendly way. Small ideas like this can help build a cleaner and more sustainable environment.

METHODS:

This section describes the procedure used to prepare the TGB film and evaluate its performance

Base Film Preparation and GSE Dip Test:

A starch-based film was prepared by heating a starch-water mixture until it gelatinized into a thick, uniform paste. Tamarind-seed polysaccharide (TSP) was incorporated into the warm mixture to improve the film's strength and flexibility. The paste was then spread as a thin layer on a flat tray and allowed to dry naturally overnight, forming a smooth, and peelable bio-film sheet.

For the coating layer, a grape-seed extract (GSE) solution was prepared by dissolving GSE powder in warm water to obtain a uniform liquid suitable for surface application on the dried film.

A. Testing Dip Time

Pieces of the dried film were dipped in the GSE liquid for **30 seconds**, **45 seconds**, and **60 seconds**. After drying, A water drop was placed on each film piece to observe how long it took for the wet spot to appear.

Data collected:

- ✓ Wet-spot time (seconds)
- ✓ Leak-time (seconds)

The 60-second dip showed the longest water-holding capacity.

B. Dot Density Test

Applying Zeolite Dots

A paste was prepared by mixing a small amount of zeolite powder with a few drops of water. Using a toothpick, dots were applied on the film in three patterns:

- **2 dots**
- **3 dots**
- **4 dots**

Each prepared film sample was wrapped around a fresh apple slice. The apple colour was measured using a phone greyscale app.

Data collected:

- ✓ Greyscale colour value (0–255)
- ✓ Weight change (optional)

The dot pattern showing the highest brightness value was selected for the final TGB film.

C. Main Freshness Study

Four samples were tested:

- 1. TGB Film**
- 2. Plain Starch Film**
- 3. Plastic Wrap**
- 4. No Wrap (Control)**

All apple pieces were cut to a similar size before testing.. Observations were taken every **24 hours** for five days. The full 5-day test was repeated three times.

Measurements taken every 24 hours

- ❖ Color value (0–255) - using greyscale app
- ❖ Weight loss (%) -using kitchen scale
- ❖ Temperature (°C) - inside each wrap kitchen thermometer

For temperature measurement, a small slit was made in each wrap, and the thermometer bulb was inserted into the air space before sealing.

Data collected:

- ❖ Colour values
- ❖ Weight readings
- ❖ Temperature readings (°C)

The temperature table was used to record values across all trials

Variables and Control Setup

Independent variables:

- ✓ Type of wrap (TGB, starch film, plastic wrap, no wrap)
- ✓ Dip-time in GSE
- ✓ Number of zeolite dots

Dependent variables:

- ✓ Color value
- ✓ Weight loss
- ✓ Temperature inside the wrap

Control sample:

- ✓ The **no-wrap apple** was used as the control for comparison.

Controlled variables maintained throughout the experiment included: room temperature, apple size, measurement time interval (every 12 hours), film size (5×5 cm), weighing scale calibration

COLLECTION OF DATA – PHOTOGRAPHS

Base Film Preparation With Tsp:



Fig. 3(a): Measuring starch +TSP for preparing the base film.



Fig. 3(b): Adding starch powder into the mixing bowl



Fig. 3(c): Heating the starch mixture to form the film paste



Fig. 3(d): Mixing well to Make a smooth paste



Fig. 3(e): Pouring the Mixture onto the plate mould plate



Fig. 3(f): Spreading evenly Before drying



Fig. 3(g): Freshly poured film for drying.



Fig. 3(h): Dried BioWrap film showing flexibility and transparency.

Gse Dip Time Test:



Fig. 4(a): Timing each dip duration (30 s, 45 s, 60 s) using a stopwatch during GSE film test.



Fig. 4(b): Dipping BioWrap films for 30 s, 45 s, and 60 s and preparing them for wet spot observation



Fig(4c): Dip-tested film samples arranged for leakage testing.

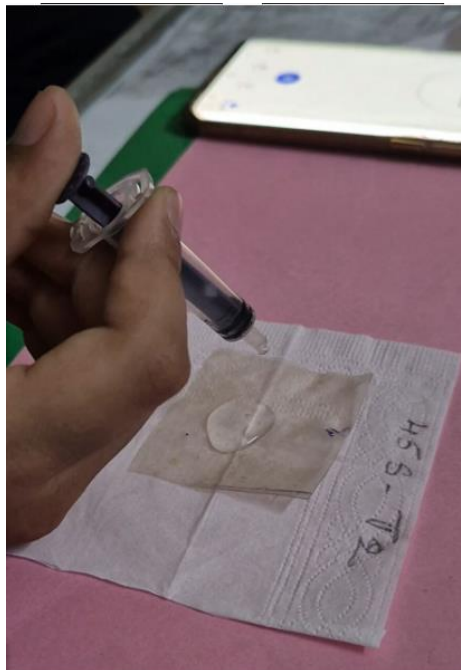


Fig. 4(d): Water-drop test on the 45-sec dipped film

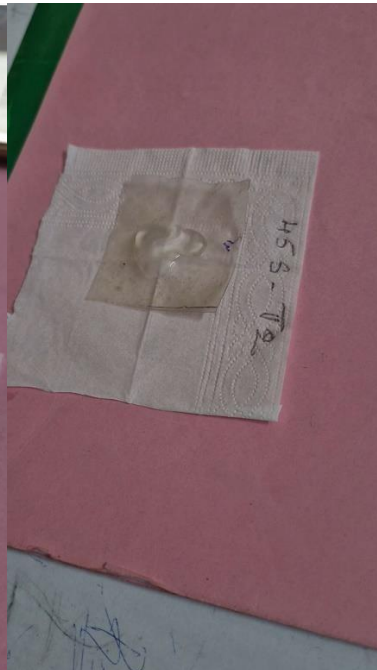


Fig. 4(e): Water-drop test on the 60-sec dipped film.

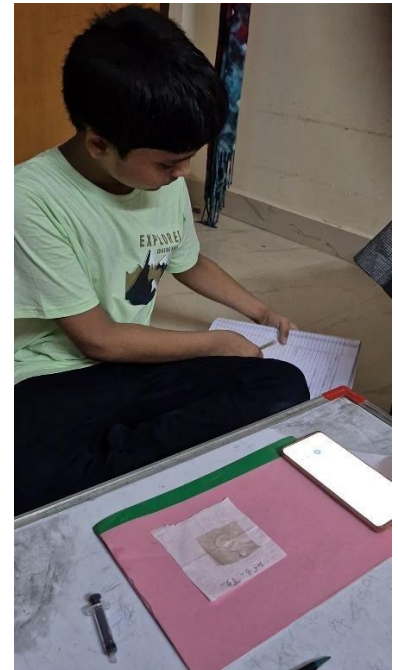


Fig 4(f): Dip-test readings being recorded in the logbook.

Zeolite Dot Density Test:



Fig.5: Preparing Dot Density Film

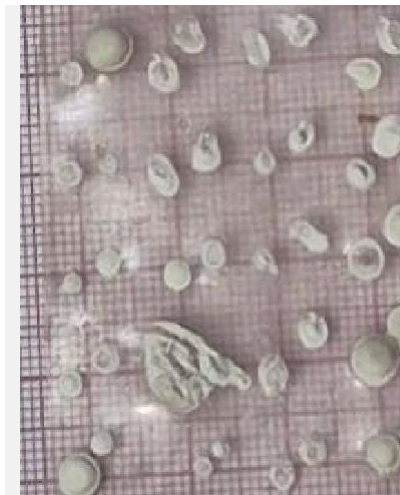


Fig.5(a): Film with 2 dots/cm² – light pattern, clear surface



Fig.5 (b): Film with 3 dots/cm² – light pattern, clear surface.



Fig.5(c): Film with 4 dots/cm² – Less flexible pattern,





















Fig. 5(d): Apple piece wrapped with the 2-dot film at the start of the weight test



Fig. 5(e): Apple piece at the start of the weight test.

FINAL TEST

FILM TYPE	TRAIL-1	TRAIL-2	TRAIL-3	FILM TYPE	TRAIL-1	TRAIL-2	TRAIL-3
TGB				TGB			
PLASTIC				PLASTIC			
STARCH				STARCH COXN			
NO WRAP				NO WRAP			

Day 1



Day 5





Fig 6(b): TGB film with zeolite and GSE coating: even dot pattern and glossy Finish.



Fig 6(c): Apple sample wrapped in TGB film: stayed firm and bright after 5 days, showing the least browning Among all wraps.



Fig 6(d): Plastic wrapper weight-loss check digital balance reading for apple kept without any wrap



Fig 6(d): TGB film Weight loss check: digital balance reading or apple wrapped in TGB film



Fig 6(e): Plain starch film weight-loss check: digital balance reading for apple wrapped in base starch film

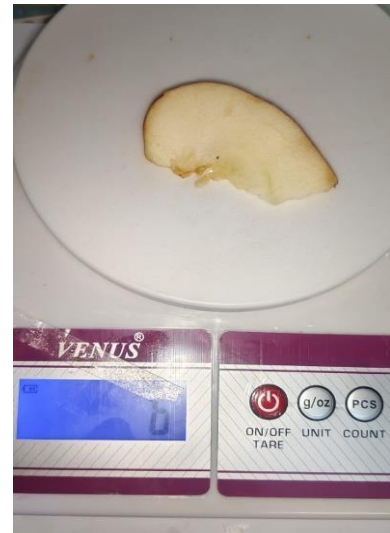


Fig 6(f): No wrapper weight-loss check: Checking weight of no-wrap apple

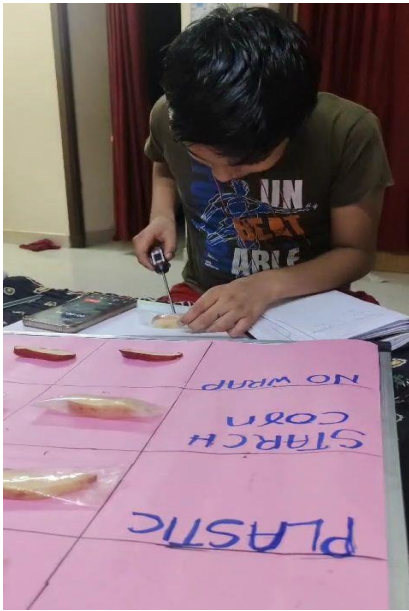


Fig 6(g): *Measuring the temperature of apples wrapped in tgb film using a kitchen thermometer.*



Fig 6(h): *Measuring the temperature of apples NO Wrapper using a kitchen thermometer.*



Fig 6(i): *Measuring the temperature of apples wrapped in Starch film using a kitchen thermometer*



Fig. 6(j): *Color value of the apple with No wrap Day 3 (using mobile app).*



Fig. 6(k): *Colour value of the apple with No wrap Day 5 (using mobile app).*



Fig. 6(l): *Colour value of the apple with TGB film Day 3 (using mobile app).*

RESULT:

Phase 1 – GSE Dip Time Test (Water Leakage and Wet-Spot Observation)

To test how the GSE coating reduced water leakage, the dried film was cut starch–TSP film into small 5 × 5 cm pieces. Each piece was dipped in the GSE liquid for 30 seconds, 45 seconds, and 60 seconds, and then kept aside to dry.

To check water leakage, each film piece was placed on clean tissue paper. Using a 0.5 mL dropper, exactly 0.5 mL of water was dropped onto the center of the film. The time taken for the first sign of water leakage was measured using a stopwatch to appear on the tissue under the film.

This test was repeated **three times** for each dip-time to make the results fair and reliable.

Data collected:

Time taken for water leakage to appear (seconds)

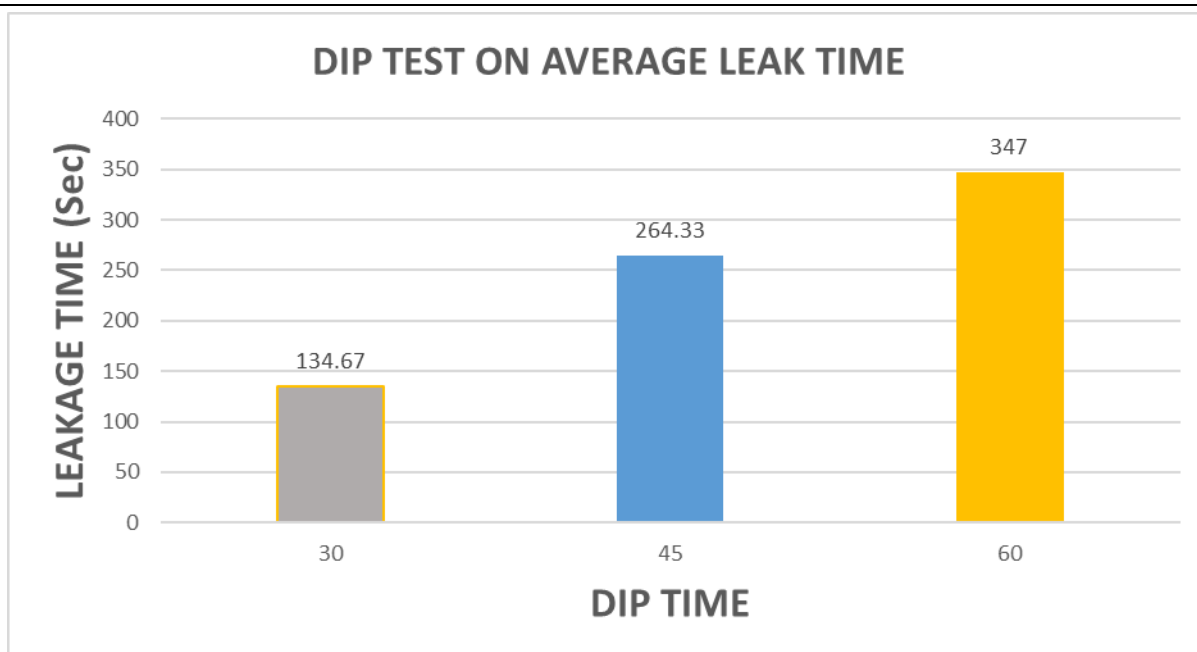
Table 1: GSE Dip-Time vs Water Leakage Time (All Trials)

Observation:

- There was **no water leakage** on any film during the first 60 seconds, which means all samples could hold the water for at least that time.
- After 60 seconds, water slowly started to pass through each film.
- The film dipped for **60 seconds** took the **longest time** for water leakage (average **347 seconds**) and also felt smoother and stronger.
- Therefore, the **60 second GSE dip-time** was selected for making the final TGB film.

Dip Time (s)	Wet-Spot @ 60 s (mm) T1	Wet-Spot @ 60 s (mm) T2	Wet-Spot @ 60 s (mm) T3	Average (mm)	Leak Time (s) T1	Leak Time (s) T2	Leak Time (s) T3	Average (s)
30	0	0	0	0	160	97	147	134.67
45	0	0	0	0	369	232	192	264.33
60	0	0	0	0	544	99	398	347.00

So, I chose the 60second film for the next part of my study.



Phase 2 – Zeolite Dot Density Results

To check how the number of zeolite dots affects the freshness of the apple, three dot densities were tested on the GSE-coated film: **2 dots/cm²**, **3 dots/cm²**, and **4 dots/cm²**.

A small amount of zeolite powder was mixed with water to make a thick paste. Using a toothpick, tiny dots were placed on each film piece at the required spacing.

Each film (5 × 5 cm) was wrapped around an apple slice of the same size. The dot side was kept facing outside so the zeolite could trap the ethylene gas released by the apple.

The wrapped apples were kept at room temperature for 24 hours. The greyscale colour value (0–255) was measured using a mobile app, and percentage weight loss was calculated from the recorded weights

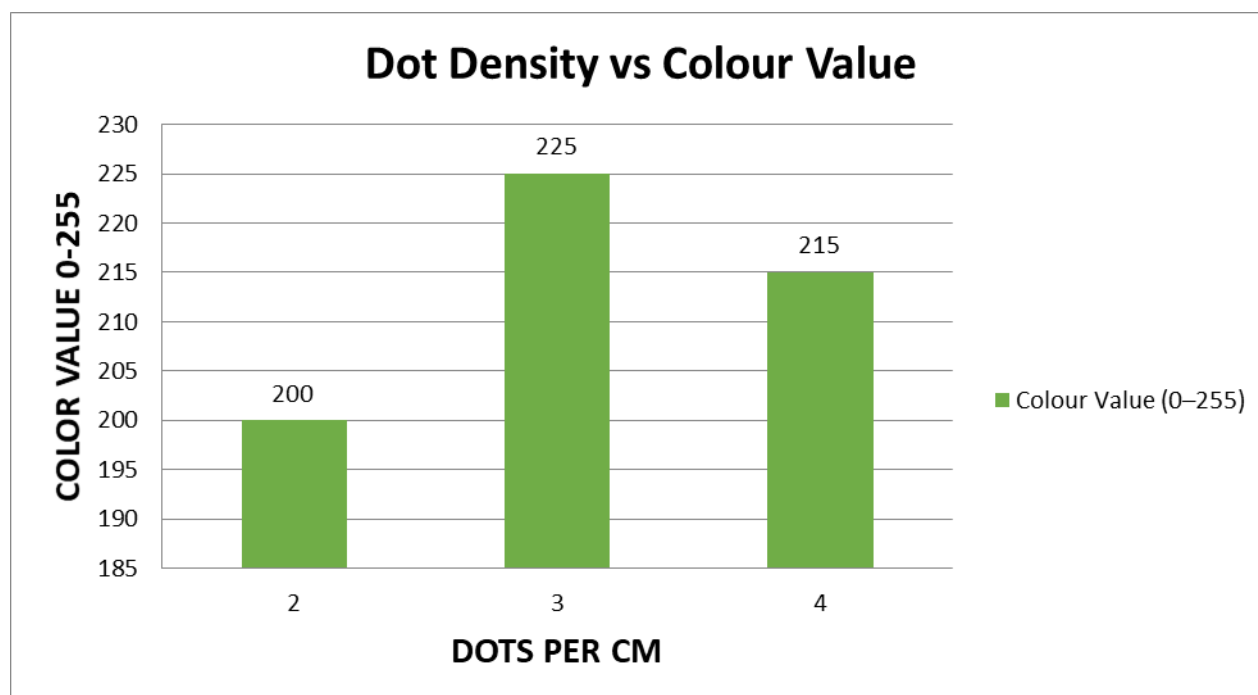
A higher Colour value means the apple stayed brighter, and **lower weight loss** means the film protected moisture better. This test was performed once because the purpose was only to select the best dot pattern for the final TGB film.

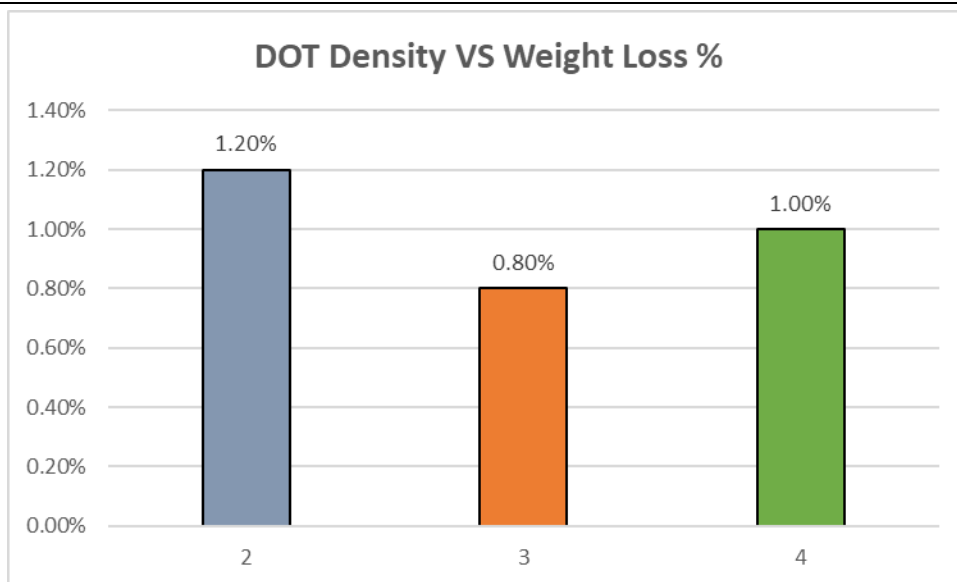
Table 2: Dot Density vs Colour Value, Weight

Dot Density (per cm ²)	Initial Weight (g)	Final Weight After 24 hrs (g)	Weight Loss (g)	Weight Loss (%)	Colour Value (0–255)
2	6	5.93	0.07	1.2%	204
3	6	5.95	0.05	0.8%	225
4	6	5.94	0.06	1.0%	215

Observation:

- When wrapped on apple slices, the films with different zeolite dot densities showed different levels of brightness.
- The **3-dots/cm²** film kept the apple brightest for longer, showing the highest greyscale colour value among the three patterns.
- The 2-dots/cm² film showed less improvement, and the 4-dots/cm² film did not increase brightness further because too many dots made the coating thicker.
- Therefore, the **3-dots/cm²** pattern was selected for the final TGB film.





Main Freshness Study – 5 Days 3 Trials

After selecting the best GSE dip-time and the best zeolite dot pattern, the final TGB film was tested along with three other wrapping conditions to find which one kept the apple slices fresh for the longest time.

The four samples tested were:

1. TGB Film
2. Plain Starch Film
3. Plastic Wrap
4. No Wrap (Control)

All apple pieces were cut to the same size and kept on separate plates at room temperature.

Measurements were taken every **24 hours** for **five days**, and the entire test was repeated **three times**.

During each observation, the following were recorded:

- ✓ Weight Loss (%)
- ✓ Temperature inside the wrapping (°C)
- ✓ Colour Value (0–255)

Weight Loss (%)

Weight loss shows how much moisture the fruit lost. Higher weight loss means the fruit became dry faster.

Table 4: Weight Loss (%) Over 5 Days (Average of 3 Trials)

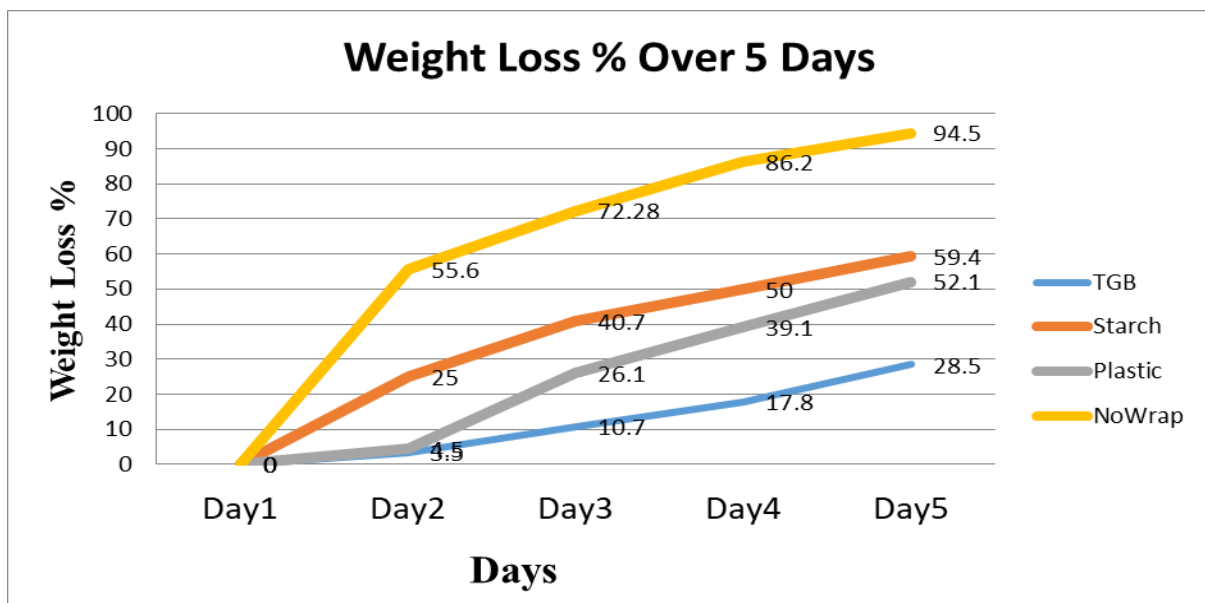
Weight Lost Percentage

Day	TGB -@ Weight in Gr				Starch- Weight in Gr						Plastic- Weight in Gr					No Wrap- Weight in Gr				
	T1	T2	T3	Avg	Wg Loss %	T1	T2	T3	Avg	Wg Loss %	T1	T2	T3	Avg	Wg Loss %	T1	T2	T3	Avg	Wg Loss %
Day 1	11	9	8	9.3	0	11	11	10	10.6	0	8	8	7	7.7	0	6	6	6	6	0
Day 2	10	9	8	9	3.5	9	8	7	8	25	8	7	7	7.3	4.5	2	3	3	2.7	55.6
Day 3	9	8	8	8.3	10.7	7	6	6	6.3	40.7	6	6	5	5.7	26.1	1	2	2	1.7	72.28
Day 4	8	8	7	7.6	17.8	6	5	5	5.3	50	5	4	4	4.7	39.1	0.5	1	1	0.8	86.2
Day 5	7	7	6	6.7	28.5	5	4	4	4.3	59.4	4	4	4	3.7	52.1	0	0.5	0.5	0.3	94.5

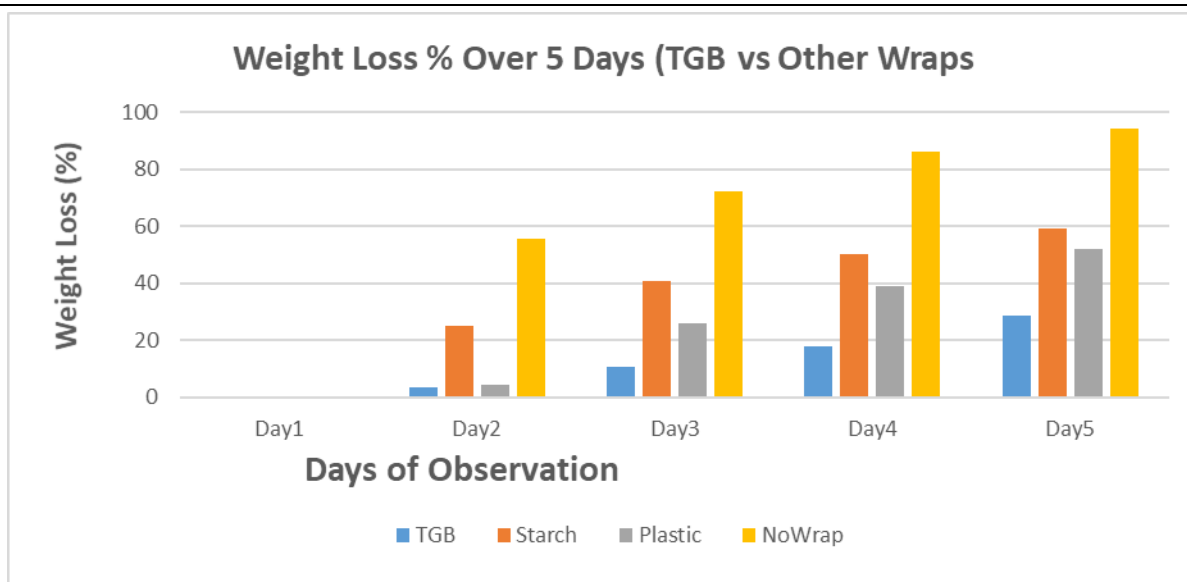
Day	TGB	Starch	Plastic	No Wrap
Day1	0	0	0	0
Day2	3.5	25	4.5	55.6
Day3	10.7	40.7	26.1	72.28
Day4	17.8	50	39.1	86.2
Day5	28.5	59.4	52.1	94.5

Weight loss percentage (%) is calculated by

$$= \frac{\text{Initial weight(Avg)} - \text{Final weight(Avg)}}{\text{Initial weight}} \times 100$$



Apple slices weighed 6g. Small weight makes percentage loss appear large



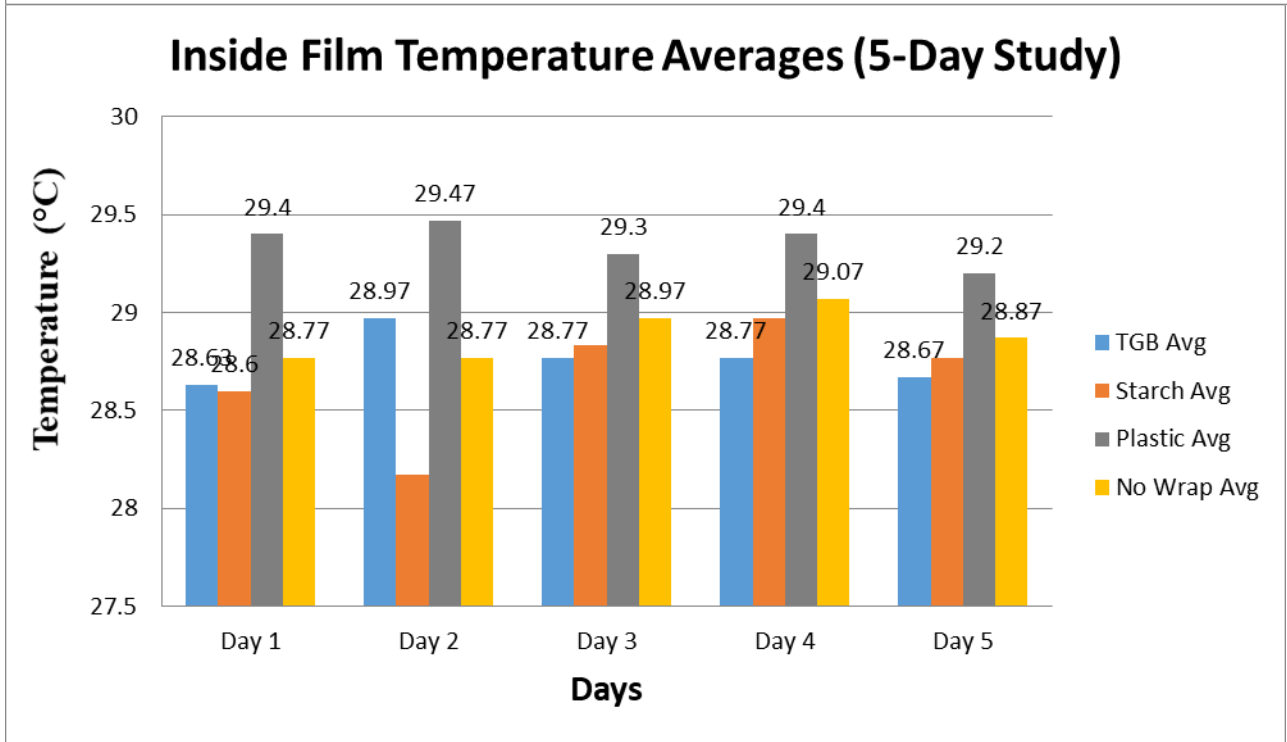
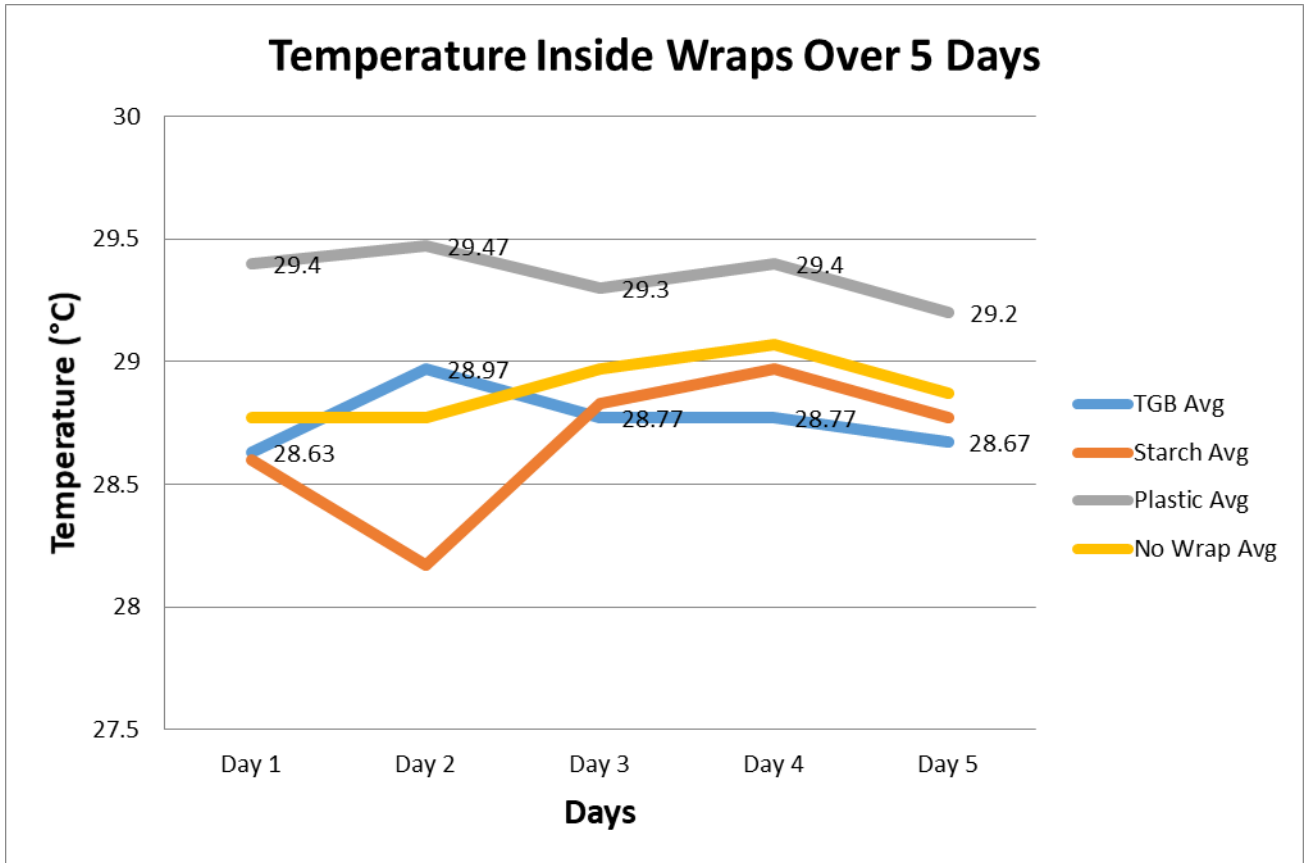
Temperature (°C)

A very small slit was made on the top of each wrapped sample, and the thermometer bulb was gently placed inside the empty air space without touching the fruit. This helped measure whether the wrap was trapping heat or allowing heat to escape slowly.

Table 5: Temperature Readings

Day	Film Type	Room Temp (°C)	Film Inside Temp T1 @60Sec	Film Inside Temp T2@60Sec	Film Inside Temp T3@60Sec	Inside Film Temp Avg
Day1	TGB	29.2	28.1	28.9	28.9	28.63
	Starch	29.2	28.2	28.7	28.9	28.60
	Plastic	29.2	29.3	29.9	29.0	29.4
	No Wrap	29.2	29.2	28.5	28.6	28.77
Day2	TGB	28.9	29.0	29.0	28.9	28.97
	Starch	28.9	29.1	29.8	28.6	29.17
	Plastic	28.9	29.0	29.8	29.6	29.47
	No Wrap	28.9	28.9	28.6	28.8	28.77
Day3	TGB	29	28.8	28.7	28.8	28.77
	Starch	29	28.9	28.8	28.8	28.83
	Plastic	29	29.4	29.2	29.3	29.30
	No Wrap	29	29.0	28.9	29.0	28.97
Day4	TGB	29.1	28.9	28.8	28.9	28.77
	Starch	29.1	29.0	28.9	29.0	28.97
	Plastic	29.1	29.5	29.3	29.4	29.40
	No Wrap	29.1	29.1	29.0	29.1	29.07
Day5	TGB	28.9	28.7	28.6	28.7	28.67
	Starch	28.9	28.8	28.7	28.8	28.77
	Plastic	28.9	29.3	29.1	29.2	29.20
	No Wrap	28.9	28.9	28.8	28.9	28.87

Day	TGB Avg	Starch Avg	Plastic Avg	No Wrap Avg
Day 1	28.63	28.6	29.4	28.77
Day 2	28.97	29.17	29.47	28.77
Day 3	28.77	28.83	29.3	28.97
Day 4	28.77	28.97	29.4	29.07
Day 5	28.67	28.77	29.2	28.87



Lower internal temperature indicates better freshness. TGB shows the lowest temperature trend across 5 days

Observation

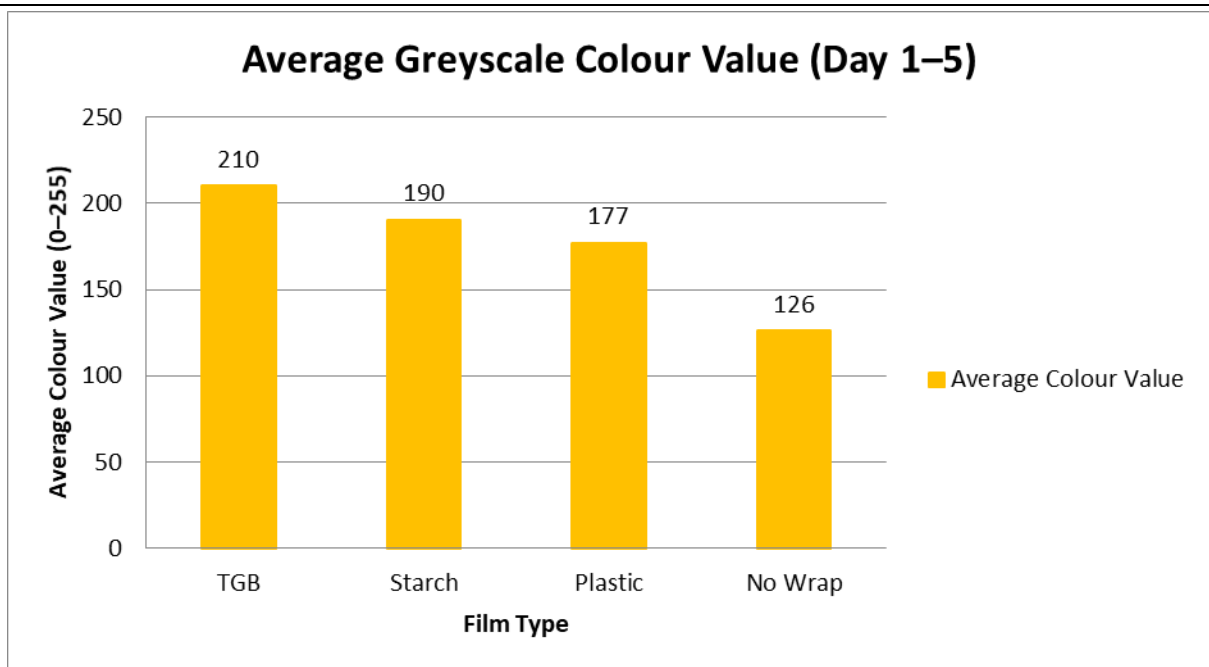
- ✓ The TGB-wrapped apple stayed bright for the longest time and showed the highest colour values across all five days. Its browning was slower compared to the other samples.
- ✓ The TGB sample also lost the least weight, which means it kept its moisture better and did not dry out quickly.
- ✓ The plastic wrap showed higher temperature readings during most observations. This means it trapped more heat and moisture inside, which made the apple soften faster.
- ✓ The plain starch film showed medium performance. It offered some protection but still allowed browning and weight loss faster than TGB.
- ✓ The no-wrap apple spoiled the fastest. It browned quickly, became soft, and lost the most weight within two days.
- ✓ Across all three trials, the results were similar, showing that the TGB film consistently kept the apples fresher than the other wraps.

Color Value (0–255)

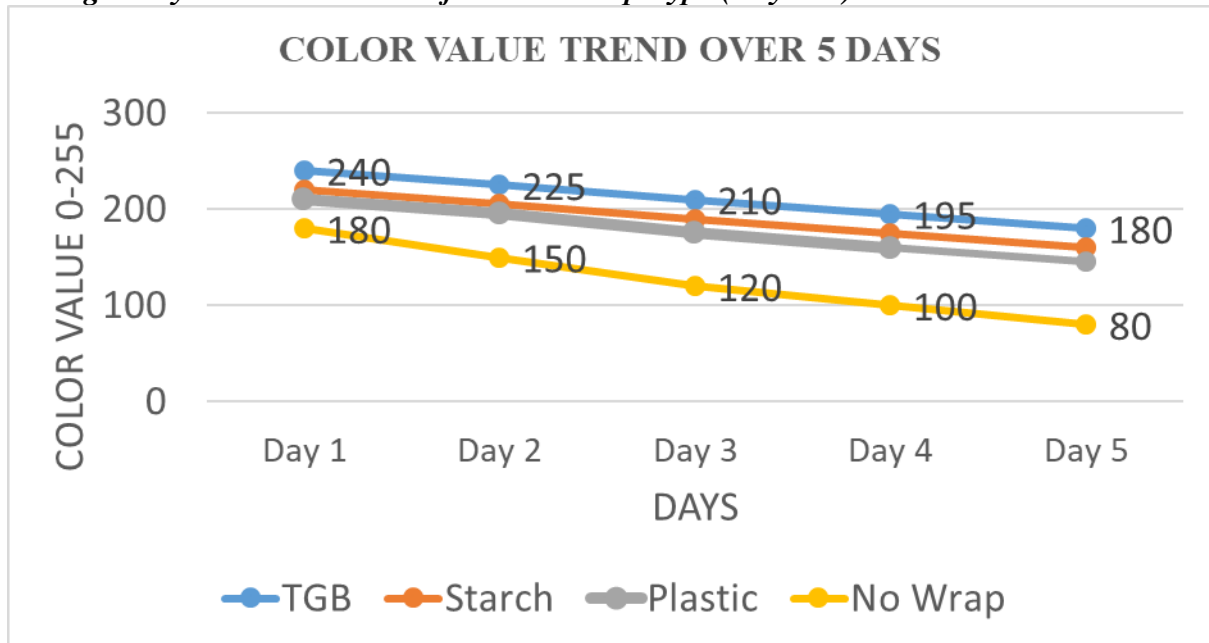
This shows how quickly each wrapped apple slice turned brown. A higher Colour value means the apple stayed bright and browned more slowly.

Table 6: Color scores for 5 days

Film Type	Day 1 (Avg of 3 Trials)	Day 2 (Avg of 3 Trials)	Day 3 (Avg of 3 Trials)	Day 4 (Avg of 3 Trials)	Day 5 (Avg of 3 Trials)	Overall Average
TGB	240	225	210	195	180	210
Starch	220	205	190	175	160	190
Plastic	210	195	175	160	145	177
No Wrap	180	150	120	100	80	126



Average Greyscale Colour Score for Each Wrap Type (Day 1–5)



RESULTS SUMMARY

After completing all three trials of the 5-day study, the results clearly showed the following:

- ✓ The TGB film kept the apple **slices fresh for the longest time**. It showed higher colour values, which means slower browning.
- ✓ The TGB-wrapped apple also showed **the lowest weight loss**, so it did not dry out quickly.
- ✓ The plastic wrap recorded **higher temperature values** in almost every reading. This means plastic trapped more heat and moisture inside the wrap.

- ✓ The plain starch film gave medium performance. It slowed down browning a little, but not as well as TGB.
- ✓ The no-wrap sample spoiled the fastest. It turned brown **within one day and became soft with the highest weight loss**

DISCUSSION

The results from all three phases showed why the Triple-Guard BioWrap (TGB) worked better than the other wraps. Each natural material in the TGB film had a special job, and together they protected the apple in three different ways.

How Each Ingredient Helped the TGB Film

Grape-Seed Extract (GSE)

The GSE coating formed a smooth surface on the film. This helped reduce **water leakage**, so the apple did not lose moisture quickly. It also made the film surface even, which protected the cut area of the fruit better.

Tamarind-Seed Polysaccharide (TSP)

TSP mixed with starch made the base film strong, flexible, and less likely to tear. Because of this, the wrap covered the apple tightly and did not break during the 5-day test.

Zeolite Dots

The zeolite dots helped by trapping ethylene gas, which fruits naturally release while ripening. When this gas is controlled, browning slows down.

Together, these three parts created a film that could protect against moisture loss, extra ripening gases, and unwanted heat trapping.

Why the 60-Second Dip Was the Best

The 60-second dip in GSE gave the **best water-holding ability**.

Longer dipping allowed more GSE to seal tiny pores in the film.

Shorter dips (30 s or 45 s) did not cover the surface as well, so water leaked through faster. This is why the 60-second film had the **longest leakage time** and was chosen for the main test

Why 3 Dots per cm² Worked Better Than 2 or 4

When different dot densities were tested:

- ✓ 2 dots/cm² left too much open space, so browning happened sooner.
- ✓ 4 dots/cm² made the film stiff, and too many dots did not improve colour.

- ✓ 3 dots/cm² gave the best balance. It allowed slow breathing and still blocked extra gas.

The 3-dot/cm² design kept the apple the brightest in the test, so it was selected for the final TGB film.

Why TGB Performed Best in the 5-Day Freshness Test

Across all three trials:

- ✓ TGB had the highest Colour value, meaning it slowed browning.
- ✓ TGB had the lowest weight loss, so moisture stayed inside the fruit.
- ✓ TGB had lower temperature readings compared to plastic, showing that it allowed slow breathing of heat and moisture.

The plastic wrap trapped more heat, which made the apple soften faster.

The plain starch film protected only for a short time.

The no-wrap sample dried and browned the fastest.

This shows that the triple-layer action of TGB (GSE + TSP + Zeolite) worked together to keep the apple fresh for more days.

What This Means

The TGB film is a simple, child-made wrap using only natural materials.

It can be prepared at home safely and can reduce the use of plastic wraps.

Even with simple tools, the TGB film showed:

- ✓ better Colour retention
- ✓ better moisture control
- ✓ better temperature behavior

This makes it a useful eco-friendly option for short-term food storage.

Although the results were clear, a few small limitations were noticed:

- ✓ The film thickness varied slightly because it was hand-spread.
- ✓ Light conditions during colour measurement changed sometimes.
- ✓ The stopwatch reading could vary by a few seconds.

These limitations are normal for a Primary-level study and do not affect the main finding.

How the Study Can Improve Further

In future experiments, the study can be improved by:

- ✓ using a fixed-light box for Colour readings,
- ✓ spreading the film with a small measurement tool for even thickness,
- ✓ and using a digital timer for more accurate timing.

CONCLUSION

The Triple-Guard Bio Wrap (TGB) kept apple slices fresh for the longest time in all three trials of the 5 day study. The 60-second GSE coating reduced water leakage, the TSP-starch base film gave strength and flexibility, and the zeolite dots helped control ripening gas.

Together, these three natural layers slowed down browning, reduced weight loss, and avoided trapping extra heat compared with the plastic wrap, plain starch film, and the no-wrap sample.

This project shows that simple, safe materials available at home can be used to make an eco-friendly wrap for short-term food storage. TGB can help reduce plastic usage and encourage children to explore natural, sustainable solutions for everyday problems.

FUTURE IMPROVEMENTS

This project can be improved further by adding a few more measurements and refining the testing process:

- I can make the film thickness more even by spreading the paste with a small roller.
- A fixed light setup or a simple light box can be used to get more accurate Colour readings during the greyscale test.
- A digital timer can be used for better accuracy in water leakage and temperature readings.
- **Tensile-strength testing can be done in a laboratory to measure how much force the film can take before tearing. This will help compare the strength of TGB with plain starch film and plastic wrap.**
- More fruits such as banana, pear, or tomato can be tested to see how the TGB film works with different ripening speeds.
- Larger sheets of the TGB film can be prepared to explore if it can be used for small household food storage.

These improvements will make the experiment more accurate and help study the TGB film in a wider range of conditions.

REFERENCES

1. Handbook for Project Preparation – *Dr Qazi Azher*, OMEIAT – National Science Foundation 2024 Edition.
2. Sample Synopsis for Science Projects – Primary Level Format, OMEIAT – NSF 2024 Official Document.
3. *Research articles on the antioxidant and water-barrier properties of Grape-Seed Extract (GSE)* – Science Direct and NCBI abstracts, viewed in September 2025.
4. *General notes on Zeolite minerals and ethylene gas absorption in fruits* – School Science Texts and Science Class notes, 2025.
5. *Discussions and technical guidance* provided by Ms Farhana, Research Mentor – OMEIAT NSF 2025.

ACKNOWLEDGEMENT

- Praising the Almighty, for giving me good strength throughout my research work and enabling me to complete the fair project successfully.
- I have taken efforts in this project .However, it would not have been possible without the kind support and help of many individuals and organizations.
- I would like to extend my sincere thanks to all of them. I would like to express my deep thanks to my Correspondent Mr. Sadique Batcha.
- I express my deep sense of gratitude to my Principal Mrs. Sogra Jabeen, Vice Principal Mrs. Rabia Basri and Guide teacher Mrs. Farhana Nasuha for their guidance and valuable suggestions & developing my interest in the investigation and in the presentation of this report.
- I would like to thank my parents who helped and motivated me a lot for doing a science fair project