National Science Fair
Display sheet

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**
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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.

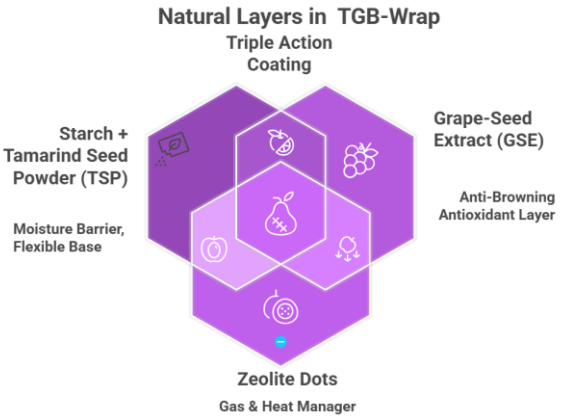
INTRODUCTION

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?



THE PROBLEM:

Cut fruits spoil very quickly. They turn **brown**, lose **water**, and become **soft** within a few hours.

Most people use plastic wrap at home, but plastic causes two big problems:

1. **Pollution:** Plastic does not break down easily and harms the environment.
2. **Fast Spoilage:** Plastic traps warm air and ripening substances inside, which makes the fruit spoil even faster.

This cycle leads to more food waste and plastic pollution. So we need a **better and safer wrap** that can protect fruits *without* harming our environment.

HYPOTHESIS

Can my Triple-Guard BioWrap (TGB) keep cut apples fresh for longer than:

- A Plain Film,
- normal Plastic Wrap, and
- No Wrap at all?

I predicted that the **TGB Film** would keep the apple slice in the best condition because it controls **moisture**, **browning**, and **air build-up (gas + heat)** better than the other wraps.

1. **Moisture Control**
   TGB slices would lose the **least water** because the starch + TSP layer holds moisture.

2. **Browning Control**
   TGB slices would stay **brighter** because the grape-seed extract slows the browning reaction.

3**. Air Build-up (Gas + Heat)**
   TGB slices would stay **fresher** because the natural film reduces gas and heat build-up around the fruit.

PROCEDURE

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

TEST A — FINDING THE BEST DIP TIME (GSE COATING)

Goal:

To find a dip time that gives a **smooth, even GSE coating** without making the film

Dip Time Tested	Observation	Final Choice
30 seconds	Coating too thin: browning happened quickly.	Not Selected
60 seconds	Smooth coating: film stayed strong and flexible.	**Selected**
90 seconds	Film became soft and tore easily.	Not Selected

I chose the 60-second dip time because it gave the most even coating and kept the film strong and easy to use.

TEST B — FINDING THE BEST ZEOLITE DOT DENSITY

Goal:

To find the right number of dots that allow the fruit to "breathe" without weakening the film.

I chose 3 dots/cm² because it was the best balance between gas control and film strength.

Dots per cm²	Observation	Final Choice
1 dot/cm²	Too few dots: gas and heat still trapped.	Not Selected
3 dots/cm²	3 dots/cm² helped reduce gas build-up without making the film weak.	**Selected**
5 dots/cm²	Too many dots: film became weak and tore easily.	Not Selected

FINAL SELECTION USED IN THE 5-DAY EXPERIMENT

These were the best-performing values from both preliminary tests:

GSE Dip Time: 60 seconds
Zeolite Dot Density: 3 dots per cm^2

(These settings were used for all TGB slices in the 5-day test.)

HOW I RAN MY MAIN 5-DAY EXPERIMENT

I followed a clear, fair procedure to test how long the apple slices stayed fresh with each wrap.

STEP 1: Preparing All the Apple Slices

- I chose one type of apple.
- With adult help, I cut the slices to the **same size and thickness**.
- I prepared **16 slices** in total.

STEP 2: Setting Up the Four Test Groups

Each group had **4 equal slices**:

1. **Group A — TGB Film**
2. **Group B — Plain Film**
3. **Group C — Plastic Wrap**
4. **Group D — No Wrap (Control)**

All 16 slices were placed in the **same room**, at the **same height**, for fairness.

STEP 3: Taking Day-0 Measurements

Before the test started, I recorded:

- **Colour Value (0–255)**
- **Weight (grams)**
- **Inside temperature**

To measure temperature, I inserted a kitchen thermometer through a **tiny slit in the wrap**, then **sealed the slit with tape**.

STEP 4: Daily 24-Hour Measurements

Every 24 hours for **5 days**, I measured:

- **Colour Value** — using a mobile app
- **Weight** — using a digital kitchen scale
- **Temperature** — using the sealed thermometer method

I wrote all readings in my logbook.

STEP 5: Repeating the Experiment

To make sure my results were reliable,
I repeated the experiment **more than one time** and confirmed the same pattern each time.
The only thing I changed was the **type of wrap**.
Everything else — apple type, slice size, room, temperature, timing — stayed the same. So any difference in freshness came **only** from the wrap.

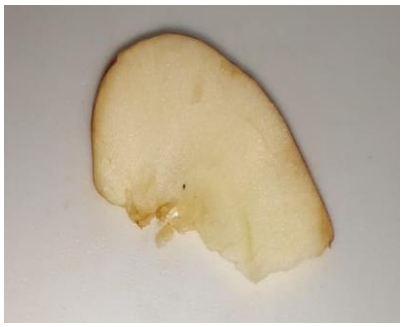
COLLECTION OF DATA

VISUAL PROOF: DAY 1 TO DAY 5 COMPARISON OF ALL FILMS

The first thing we checked was how the apple looked **after 5 days.**

This visual check helped me understand how well the Starch + TSP base film **(Layer 1) could hold moisture and keep the fruit firm.**

DAY 1 to DAY 5 VISUAL COMPARISON



Day 1 — No Wrap
Fresh with slight surface moisture.

Day 1 — Plain Film (Starch + TSP)
slight surface moisture.

Day 1 — TGB Film
Stayed the brightest and firmest

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Day 5 — No Wrap
Darkened and spoiled.

Day 5 — Plain Film (Starch + TSP)
visible shrinkage due to water loss.

Day 5 — TGB Film
Brightest and firmest; least browning among all samples.

After 5 days, the TGB Film stayed the brightest and firmest, proving the strongest moisture control

Day 1 All slices looked fresh and bright.
No wrap, Plain Film, Plastic, and TGB all started the same on Day 1.

Day 5 - TGB stayed the brightest and firmest. Plain Film shrank.

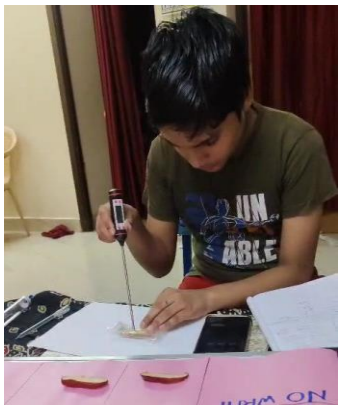


Fig 1(d): *Measuring the temperature of apples wrapped in* ***TGB film*** *using a kitchen thermometer.*

Fig 1(e): *Measuring the temperature of apples* ***NO Wrap*** *using a kitchen thermometer.*

Fig 1(f): *Measuring the temperature of apples wrapped in* ***Starch film*** *using a kitchen thermometer*

Fig. 1(a): *Measuring colour of No Wrap*

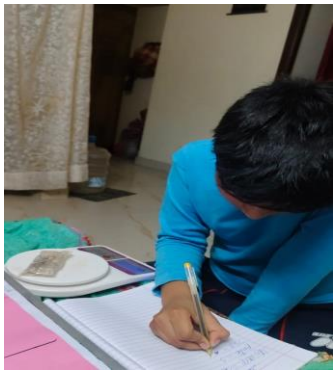


Fig. 1(b): *Measuring weigh of TGB Day 3*

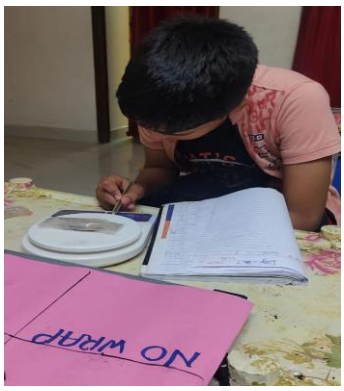


Fig. 1(c): Measuring weight of TGB Film Day 5

DATA ANALYSIS TABLE

WEIGHT LOSS (%) OVER 5 DAYS

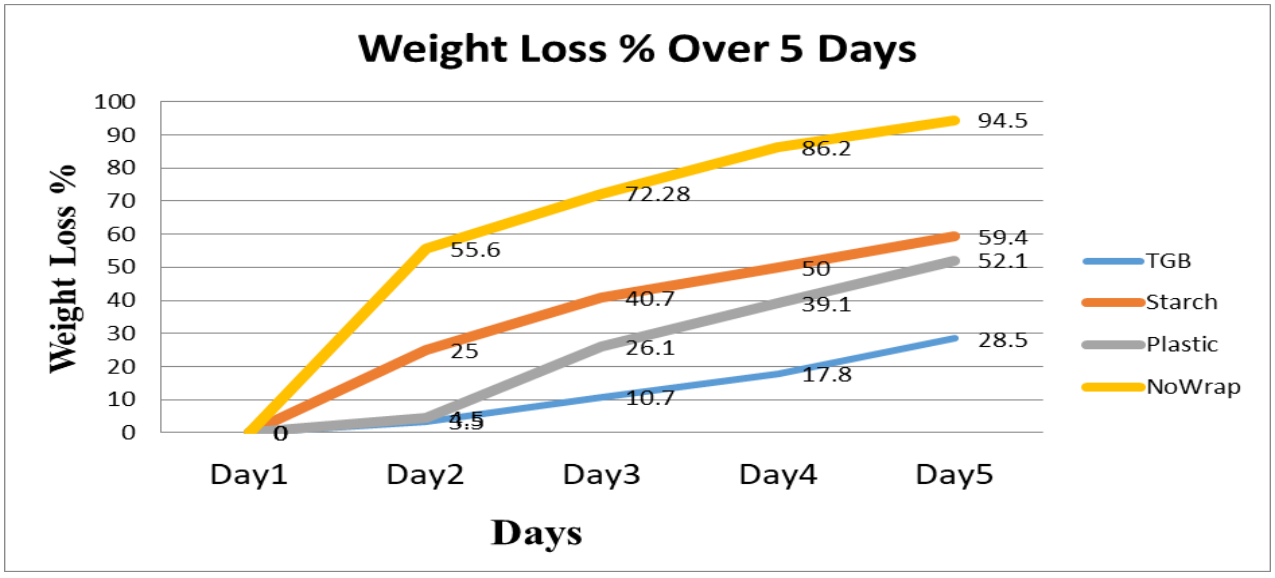
WEIGHT LOSS (%) — MOISTURE LOSS TEST (Layer 1 Result)

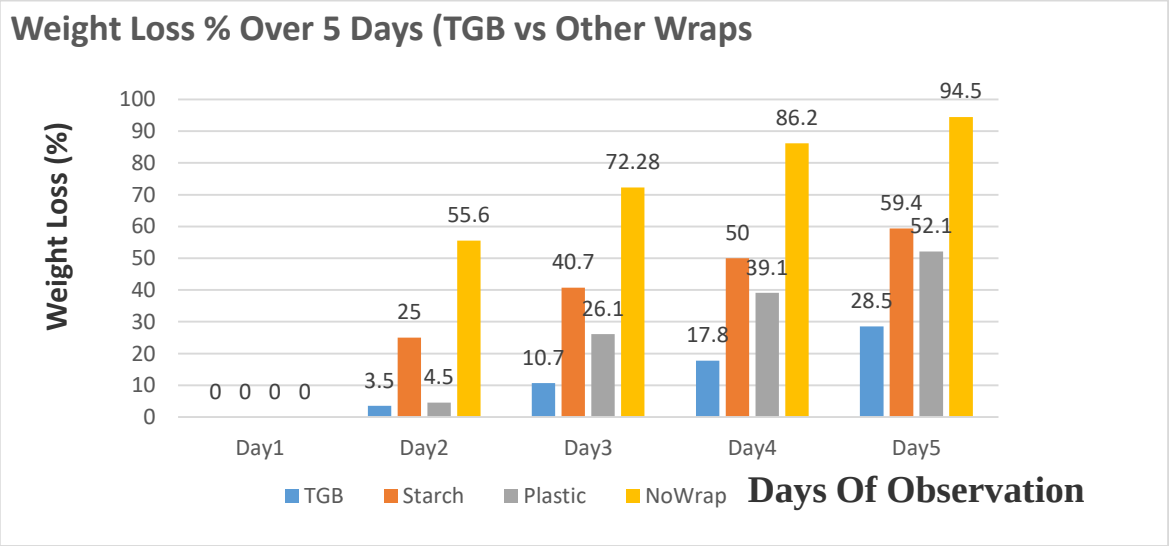
(Lower weight loss = better moisture protection)

Final Weight Loss (%) after 5 Days for All Four Films.

Day	TGB (%)	Starch Film (%)	Plastic Wrap (%)	No Wrap (%)
Day 1	0	0	0	0
Day 2	3.5	25.0	4.5	55.6
Day 3	10.7	40.7	26.1	72.28
Day 4	17.8	50.0	39.1	86.2
Day 5	**28.5**	**59.4**	**52.1**	**94.5**

Final Weight Loss (%) After 5 Days for All Four Films





The TGB film showed the ***lowest*** weight loss (28.5%), proving it provides the strongest moisture barrier. No Wrap lost ~95% weight, showing extreme drying.

- The TGB Film kept the apple slice moist for the longest time.
- Plain Starch Film shrank due to water loss.
- Plastic Wrap Soft and brown due to trapped heat, showing patches of dryness and wet spots
- No Wrap dried completely and became shrunken and hard.

"TGB Film provided the strongest moisture protection out of all four films."

COLOUR VALUE (0–255) — BROWNING TEST (Layer 2 Result)

(Higher value = Brighter, Less Browning)

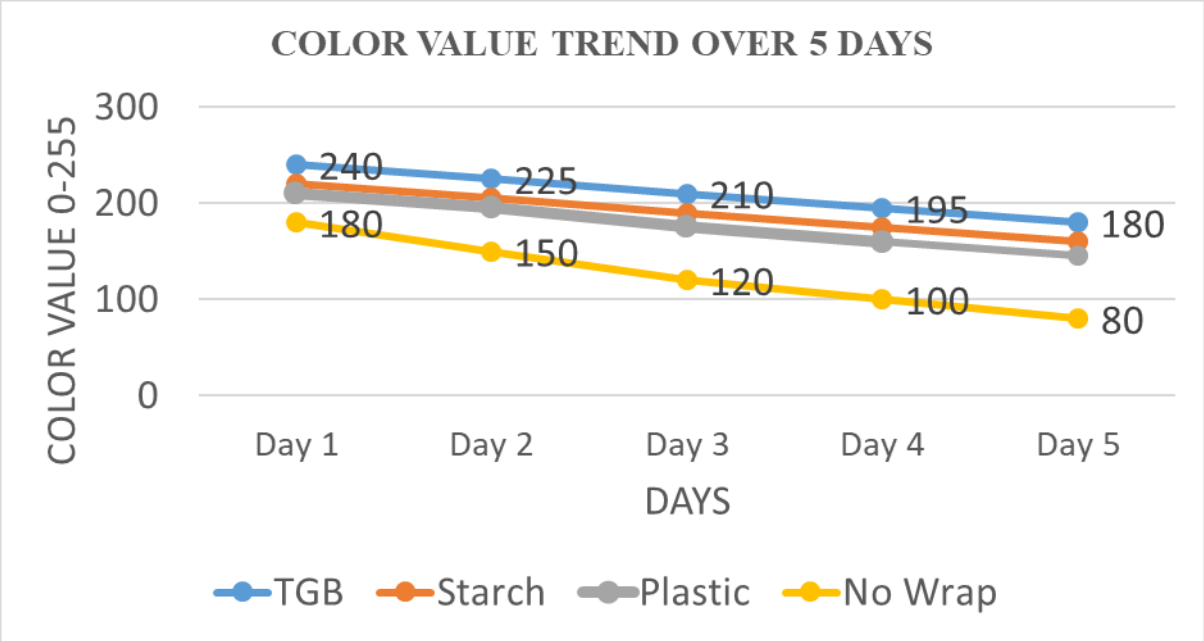
Why Colour Value Matters

When an apple browns, its **colour value drops**.
Using a colour-meter app (0 = very dark, 255 = very bright), I checked how fast each wrapped apple turned brown in **5 days**.

Day-wise Average Colour Value (0–255)

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

COLOUR VALUE (0–255) TREND OVER 5 DAYS



"TGB Film stayed the brightest for all 5 days, showing the slowest browning due to the antioxidant layer. No Wrap turned darkest by Day 5."

TGB stayed brightest because the GSE layer slowed browning.
Plain Film browned faster.
No Wrap turned darkest by Day 5.

"TGB Film slowed browning the most (Layer 2 — Antioxidant Protection)."

RESULT:

TEMPERATURE (°C) — BREATHABILITY TEST (Layer 3 Result)

(Smaller temperature rise = better airflow)

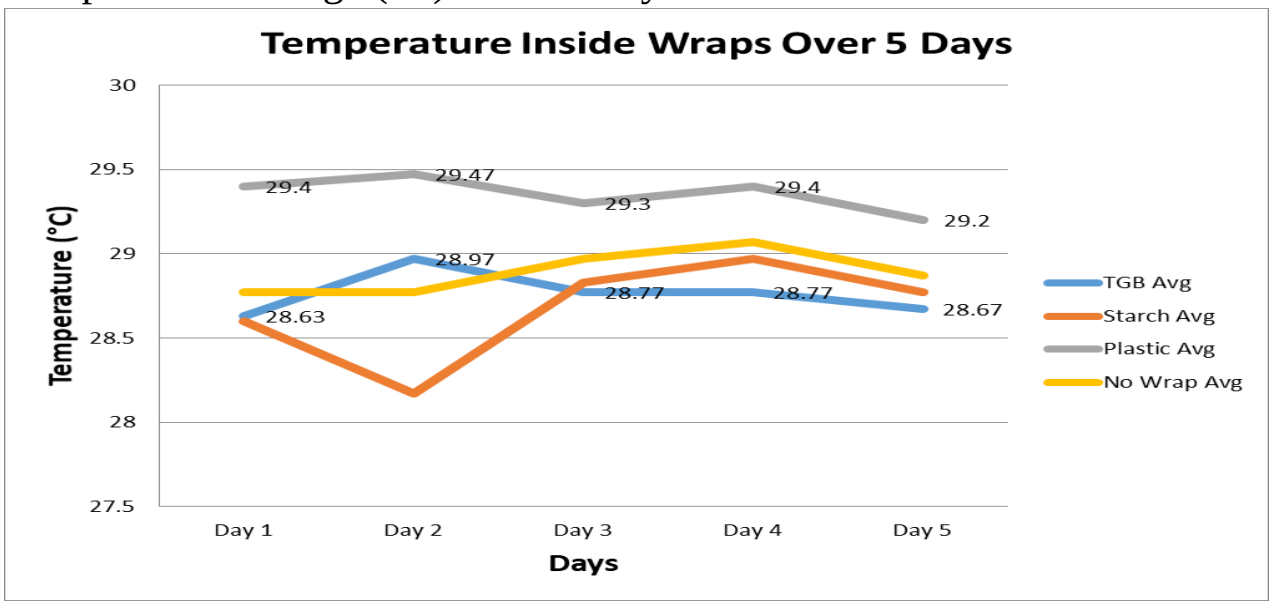
Why Temperature Matters, if warm air gets trapped inside a wrap, the fruit spoils faster.

A breathable film lets extra heat **escape** and helps keep the fruit fresh.

Inside Temperature (°C) After 5 Days

Day	TGB Film(Avg °C)	Plain Film (Starch + TSP)(Avg °C)	Plastic Wrap(Avg °C)	No Wrap (Control)(Avg °C)
Day 1	28.63	28.60	29.40	28.77
Day 2	28.97	29.17	29.47	28.77
Day 3	28.77	28.83	29.30	28.97
Day 4	28.77	28.97	29.40	29.07
Day 5	28.67	28.77	29.20	28.87

Temperature Change (°C) After 5 Days



"TGB Film stayed closest to room temperature. Plastic Wrap trapped the most heat."

- ❖ TGB Film showed the smallest temperature rise (+0.7°C) because it allowed heat to escape.
- ❖ Plain Film warmed a little more (+1.2°C).
- ❖ Plastic Wrap warmed the most (+2.4°C) as it trapped heat inside.
- ❖ No Wrap stayed at room temperature (0°C change).

TGB Film *showed the best breathability (Layer 3).*

COMBINED RESULTS SUMMARY (All Three Tests)

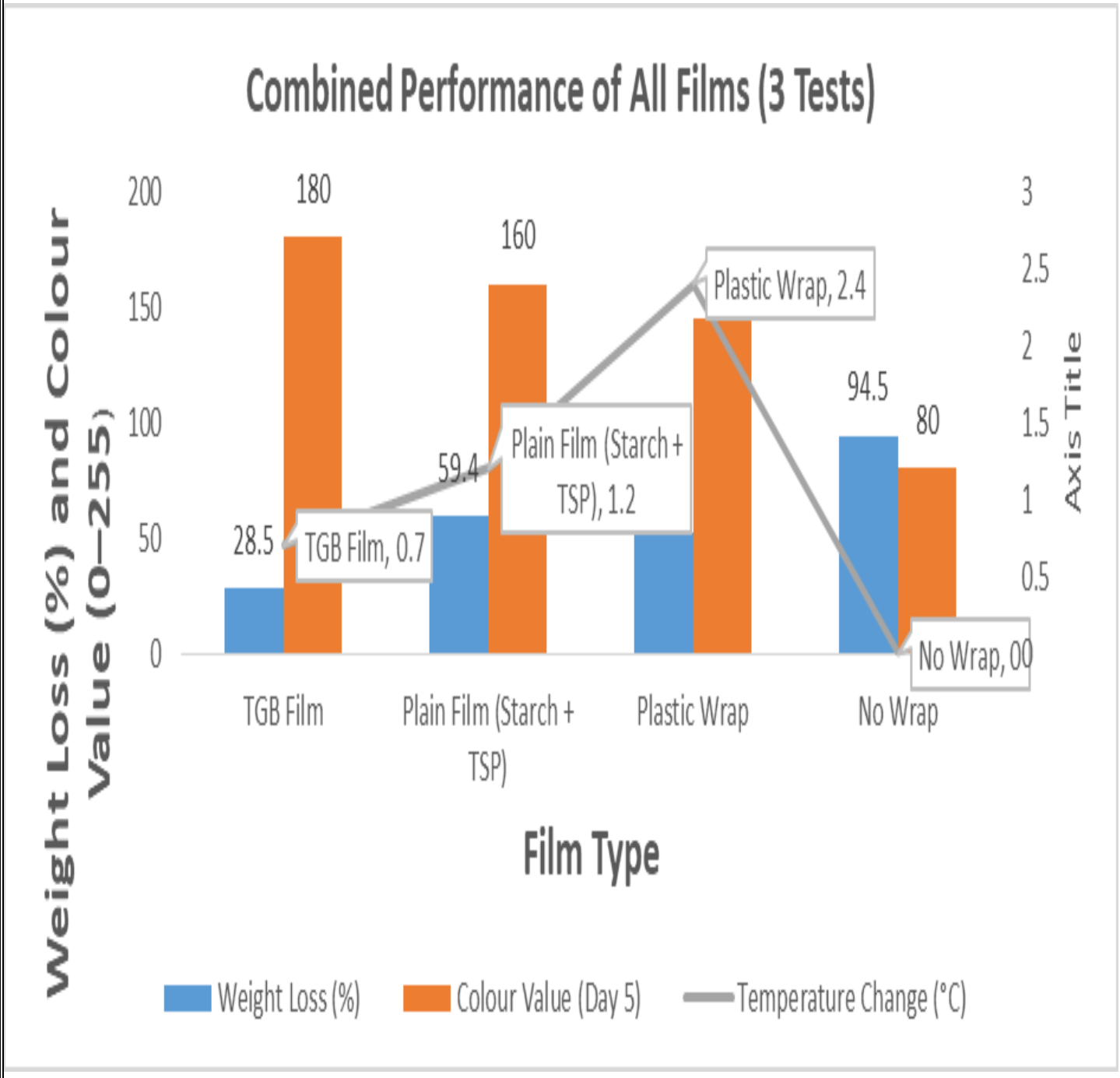
(Comparison of Weight Loss, Colour Value, and Temperature)

Final Comparison of All Films across the Three Tests

Film Type	Weight Loss (%)	Colour Value (Day 5)	Temperature Change (°C)	Overall Rank
TGB Film	28.5%	180	+0.7°C	1st
Plain Film (Starch + TSP)	59.4%	160	+1.2°C	2nd
Plastic Wrap	52.1%	145	+2.4°C	3rd
No Wrap (Control)	94.5%	80	0.0°C	4th

(Values represent averages from 3 trials.)

Combined Performance of All Films (3 Tests)



"This combined graph shows that TGB Film performed best in all three tests lowest weight loss, highest colour value, and smallest temperature rise."

DISCUSSION

The goal of my experiment was to see which wrap kept cut apples fresh for five days by observing **browning**, **moisture loss**, and **temperature changes**.

Across all three measurements, one clear pattern appeared:

1. TGB Performed Best Across All Indicators

The TGB film consistently stayed:

Brightest in colour
Firmest with the least drying
Coolest with the least heat build-up

This shows that the natural ingredients in TGB worked together more effectively than any single-layer wrap.

2. Plain Film Helped, but Not Enough

The Plain Film (Starch + TSP only):

- ✓ slowed drying slightly
- ✓ but still browned faster
- ✓ and offered no protection against trapped gas or heat

This proves that a single natural layer cannot protect the fruit fully.

3. Plastic Wrap Protected Moisture but Failed Overall

Plastic wrap:

- ✓ kept the water in
- ✓ but trapped heat and ethylene gas
- ✓ which made the apple brown and soften earlier

This shows that moisture protection alone cannot keep fruit fresh.

4. No Wrap Performed the Worst

No Wrap apples:

- ✓ dried extremely fast
- ✓ browned quickly
- ✓ spoiled the most

This confirms that fresh-cut fruit needs an active protective layer.

Looking at all results together, the strongest scientific conclusion is:

Freshness is not controlled by one factor (only moisture / only colour / only temperature).

Freshness improves only when all three factors are controlled at the same time.

The TGB film is the only wrap that managed to keep **all three parameters low** over five days, which is why it showed the best freshness.

CONCLUSION

The Triple-Guard BioWrap (TGB Film) protected the apple slices better than all other wraps.
It slowed drying, reduced browning, and stayed closest to room temperature.
The three layers worked together to keep the fruit fresher for longer.
Plain Film gave medium protection, and Plastic Wrap trapped heat.
The unwrapped apple spoiled the fastest.
Overall,
TGB Film was the best natural wrap in all three tests.

FUTURE IMPROVEMENTS

- Test the TGB Film on more fruits and vegetables.
- Try adding other natural antioxidants for stronger protection.
- Measure the film thickness using simple school-level tools.
- Test shelf-life for 7–10 days instead of just 5 days.
- Try making a stronger version for real-world packaging.
- Record microbial changes using basic school microbiology methods.

APPLICATIONS

- Helps fruit sellers keep cut fruits fresh without plastic.
- Useful for lunch boxes to prevent quick browning.
- Can reduce food waste at home.
- Helpful for farmers during short-distance transport.
- Can become a low-cost, biodegradable packaging option.

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