

Detection of Artificially Ripened Fruits Using Paper-Based Indicators

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Abstract: With intensive development of agriculture, the production of fruits is increased and toxic residues of chemical used in artificial ripening of fruits are increased and entered in human diet. Artificially ripened fruits may cause many hazards to human health including Stomach and digestive problems, higher chance of food poisoning, hormonal and metabolic effect, Chronic exposure to carbide contaminants (like arsenic) may cause memory issues, reduced concentration, skin discoloration, weak immunity and possibly cancer. In his article we have developed and validated low-cost chemical impregnated paper strip method to differentiate artificial ripened fruits and naturally ripened fruits. Objective of the study is to design environmentally safe indicator strips that detect the presence of harmful chemical, ripening agents on fruits, to create a quick, inexpensive test for farmers, sellers, and consumers.

Keywords: *Fruits ripening, Artificial, Natural, Paper strips, Calcium carbide, ethylene.*

Introduction

Over the years, the fruit industry has been entirely dependent on artificial ripening of fruits to satisfy the demands of the consumers. Both in nutrition and economics, fruits play a very critical role, and hence farmers and vendors need to keep the supply optimal. In developing countries, nearly 70–80% of fruits are artificially ripened using different agents, making chemical-induced ripening a health hazard and presenting a challenge for fruit sellers in maintaining safe and healthy practices. Fruits are essential components of a healthy diet and are highly valuable commodities worldwide, both nutritionally and economically. Fruits contain essential nutrients and elements like vitamins and minerals, fiber, and antioxidants that are vital for basic body functions. Fruits are consumed all around the world, linked to lowered levels of various chronic ailments making them a vital component of a healthy lifestyle. The Food and Agriculture Organization (FAO) estimates that in 2021, the global fruit production was about 910 million tons (FAO, 2022). Furthermore, being an excellent source of nutrients, fruits are also consumed based on their supreme sensory attributes, especially taste, and aroma. However, the sensory attributes of fruits are mainly associated with their physical state or ripening status, and therefore the demands for ripe and ready-to-eat fruits may be challenging for fruit producers. Fruit ripening is a natural process that affects the quality, taste, aroma, and appearance of fruits, making them more attractive and nutritious for human consumption. Despite the natural ripening process, not all fruits ripen uniformly, and certain fruits may remain unripe even after harvesting. This inconsistency leads to reduced shelf-life, economic losses, and increased fruit waste. To resolve these challenges, various artificial ripening techniques have been developed, aiming to expedite fruit ripening,

increasing fruit availability, and prolonging fruit shelf-life. Artificial ripening refers to the artificial induction of ripening in fruits and vegetables using chemical agents. These agents mimic the natural ripening hormone—ethylene, but may introduce harmful residues or modify the fruit's chemical profile in unsafe ways. The most commonly used chemical agents include:

- Calcium carbide (commonly known as “masala”)
- Ethephon (a pesticide, sometimes misused for ripening)
- Ethylene gas (approved under controlled conditions)

Objective of Study

Develop and validate a low-cost paper-strip indicators to detect chemical associated with artificial ripening (calcium-carbide/acetylene treatment) and distinguish them from normal ethylene ripening. To create a quick, inexpensive test for farmers, sellers, and consumers and to compare naturally ripened fruits vs artificially ripened fruits.

why it works?

Calcium carbide (CaC_2) + moisture $\rightarrow$ acetylene (C_2H_2), which accelerates ripening and can leave harmful residues.

Material Required

Make paper strips impregnated with different reagents including silver nitrate, KMnO_4 , Acetic acid, Picric acid, Phenolphthalein, bromophenol blue and starch iodide paper.

Materials & equipment: Whatman No.1 filter papers
250 ml beakers with sealed lids (Watch glass) as exposure chambers.

Storage: Store dried strips in a sealed, dark container with desiccant until use.

Label batches and date.

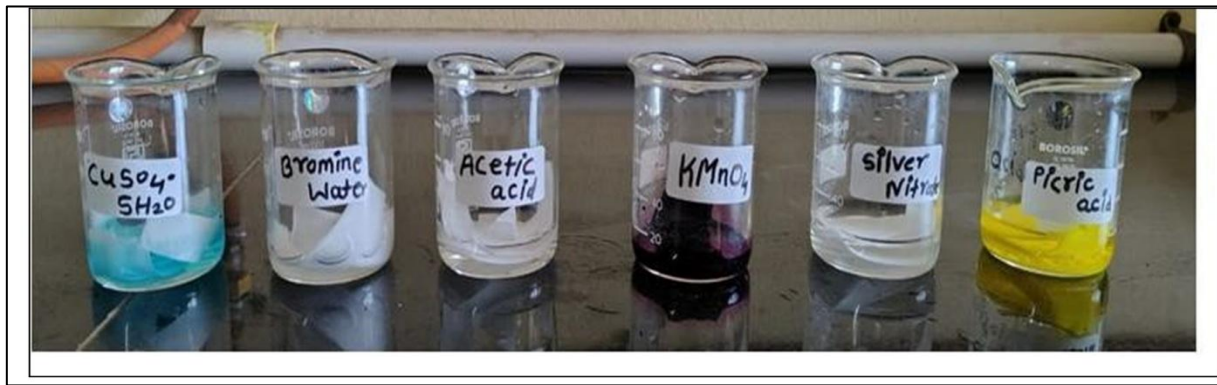


Fig1:-Preparation of paper strips

Experimental Procedure:

Making the KMnO_4 paper strip: Dip cut paper strips (2 cm $\times$ 1 cm) into KMnO_4 solution (0.01–0.1% w/v KMnO_4 (i.e., 0.1–1.0 g per liter) for 10–30 s, remove and let excess drip off, then dry flat in dark until fully dry (Fig1).

Protocol A: Place fruit in a sealed jar (with small gap so fruit not touching walls) and keeping a KMnO_4 strip inside but not touching fruit. Seal jar for a fixed period (e.g., 24 hours). Photograph strip at start and end. Record fruit appearance. Repeat at multiple timepoints (0, 1, 4, 8, 24 hours).

Protocol B: Wash fruit surface with 10 mL distilled water, collect wash; dip a fresh strip into wash and apply a drop on reagent paper (color change if CaC_2 residues present).

KMnO_4 strips should show a visible color change when exposed to reactive ripening gases (ethylene/acetylene). The magnitude and speed of change will depend on gas concentration and strip loading to discriminate acetylene vs ethylene.

Effect of Artificially repined fruits on different paper strips

Silver Nitrate (AgNO_3) Paper Test: Acetylene produced by calcium carbide reacts with silver nitrate: Color of paper changes from brown or black.

KMnO_4 : Acetylene produced by calcium carbide reacts with KMnO_4 : Color of paper changes from light pink to Brown color

Bromophenol Blue: Acetylene produced by calcium carbide reacts with bromophenol blue reagent: color changes from blue $\rightarrow$ yellowish

Dilute acetic acid test: Take a small fruit sample (peel or suspected powder from surface). Add a few drops of dilute acetic acid: Effervescence observed: - indicates presence of acetylene

Phenolphthalein paper test: Acetylene produced shows colour change white to pink

Starch iodide paper test: Crush a small sample of fruit juice. Apply a drop on iodine- impregnated strip. Observation: Dark blue/black $\rightarrow$ high acetylene $\rightarrow$ Artificial ripening

Picric acid paper:- Acetylene not shows significant brown to black color change with picric acid – Artificial repining of

fruits

Intensity Difference

Using a color-intensity scale (0–5) Natural ripening:

0–1

Calcium carbide ripening: 4–5 (strongest reaction)

Time Efficiency

Paper indicator strips placed with carbide-ripened fruits changed colour **from few minutes to 24 hrs** while natural fruits showed *no significant change even after 24 hour*.

Repeatability

Triplicate tests showed consistent results, confirming reliability of the strip method.

Scope of method

The paper-strip method proved to be:

- Simple and inexpensive
- Fast — results visible in minutes to few hrs
- Non-destructive — fruits remain untouched
- Portable — can be used in markets or storage rooms

Because calcium carbide use is illegal for ripening in many countries (due to arsenic & phosphorous impurities), this method has real-world regulatory value.

Limitations

- The test cannot quantify the exact amount of ripening agent.
- High humidity may slightly interfere, causing mild background colour.
- It is specific for phosphine-producing agents like carbide, but not a perfect detector for ethylene-based agent

Fruits applied for study are Papaya, Custard Apple, Banana and Tomato Fig 2 and Fig 3 and Fig 4 explain result of protocol B and protocol A respectively



Fig 2: Fruits applied for study are Papaya, Custard Apple, Banana and Tomato

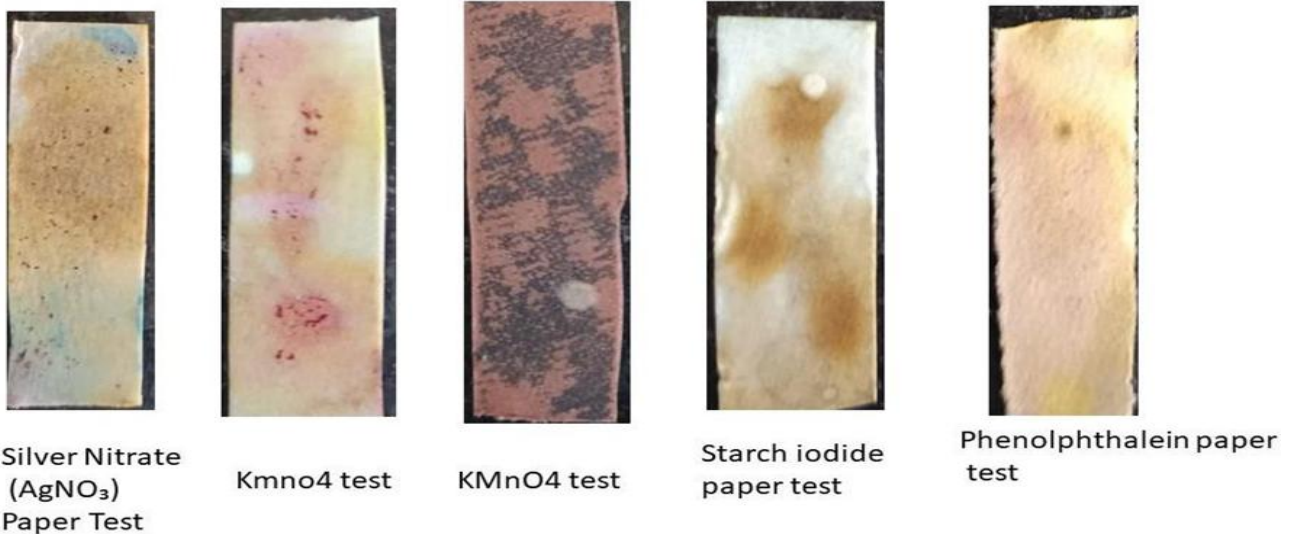


Fig 3:- Prtocol B Visual color change after applying a drop on reagent paper

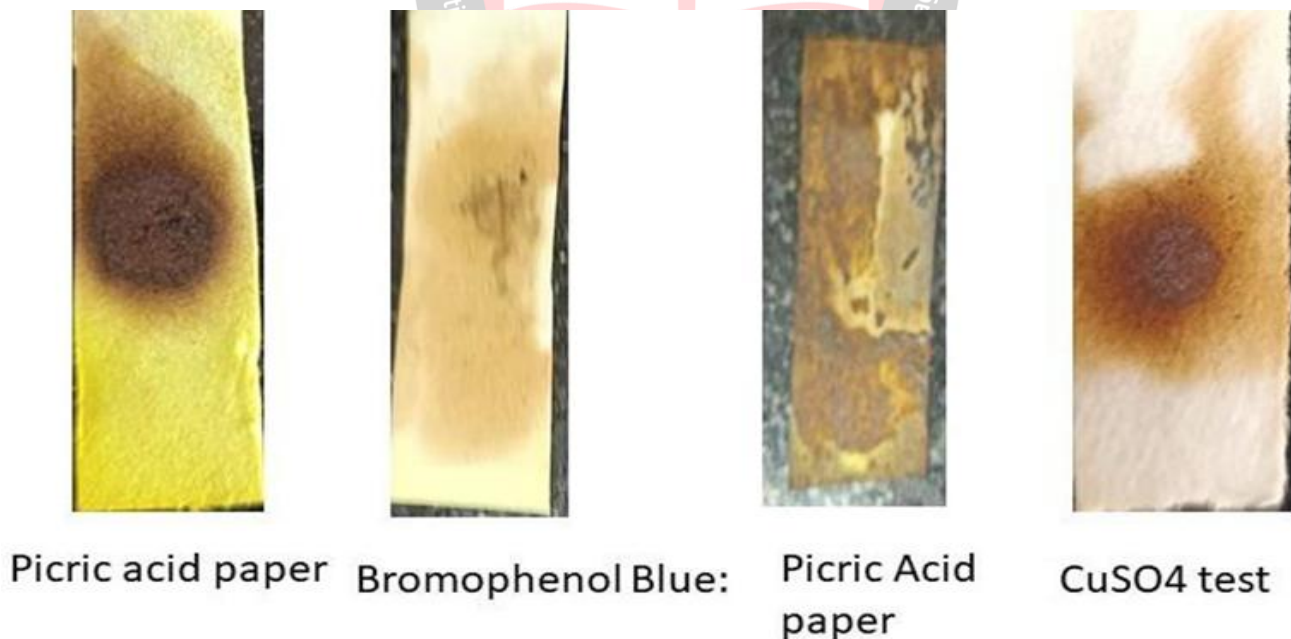


Fig. 4. Protocol A Visual color change after applying a strip of paper in closed beaker containing fruit peel (Papaya fruit)

CONCLUSION

The study on artificial ripening of fruits shows that while chemicals like calcium carbide and ethylene can accelerate the ripening process, their effects differ greatly in terms of

safety and quality. Calcium carbide produces harmful residues such as arsenic and phosphine, making fruits unsafe for consumption and reducing their nutritional value. In contrast, ethylene-based ripening is safer, more

controlled, and preserves the natural taste, texture, and color of fruits.

The project highlights the importance of using simple, efficient, cost-effective method for proper monitoring, awareness among farmers and consumers, and strict enforcement of food safety laws are essential to ensure that fruits reach the market in a safe and healthy form. The present study highlighted validated low-cost chemical impregnated paper strip method to differentiate artificial refined fruits and naturally refined fruits. Objective of the study is to design environmentally safe indicator strips that detect the presence of harmful chemical, ripening agents on fruits, to create a quick, inexpensive test for farmers, sellers, and consumers.

References

1. J.A. Adaskaveg *et al.* Targeting ripening regulators to develop fruit with high quality and extended shelf life, *Current Opinion in Biotechnology* (2023)
2. O.C. Aworh Food safety issues in fresh produce supply chain with particular reference to sub-Saharan Africa Food Control (2021)
3. E.E. Bafor *et al.* Disruptions in the female reproductive system on consumption of calcium carbide ripened fruit in mouse models, *Helion* (2019)
4. A. Botton *et al.* Biology and biochemistry of ethylene J. Brumos Gene regulation in climacteric fruit ripening. *Current Opinion in Plant Biology* (2021)
5. C.M. Concha *et al.* Methyl jasmonate treatment induces changes in fruit ripening by modifying the expression of several ripening genes in *Fragaria chiloensis* fruit, *Plant Physiology and Biochemistry* (2013)
6. P.A. Dabesor *et al.* Changes in physicochemical properties and enzymes associated with ripening of snake tomato (*Trichosanthes Cucumerina* L.) fruit, *Biocatalysis and Agricultural Biotechnology* (2022)
7. Shah M, Naik S, Identification of artificially ripened mango using aroma and texture features. In: 2021 *International Conference on Intelligent Technologies* (CONIT). IEEE, pp 1–6
8. Shelke MP, Ranjan NM, Jha P, Chavan AB, Thakare K, Pandey S (2023) Detection of artificially ripened fruits using machine learning. In: 2023 *International Conference on Sustainable Computing and Smart Systems (ICSCSS)*. IEEE, pp 401–406
9. N. RenugadeviCherukuri V. L. N. KartheekKarthik Nivedhan, Vikash Baabhu, An analysis on detection of artificially ripened fruits March 2025, *Journal of Food Science and Technology -Mysore-* 62(3), DOI:10.1007/s13197-025-06250-x
10. The Use of Calcium Carbide in Fruit Ripening: Health Risks and Arsenic Index as a Quantitative Marker for Calcium Carbide Residue Akolade R. Oladipupo, Moshood O. Akinleye, Herbert A.B. Coker, *Progress in Chemical and Biochemical Research* 2022, 5(2), 125-132