

A SMART, ECO-FRIENDLY ADULTERATION INDICATOR STRIP DEVELOPED FROM CHERRY-DERIVED ANTHOCYANINS

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ABSTRACT

Food adulteration is a major challenge that affects food safety, quality, and public health. Many adulterants commonly added to food products, such as detergents, washing soda, and alkaline chemicals, alter the natural pH of the food. The present study introduces an eco-friendly and innovative **adulteration indicator strip developed using anthocyanins extracted from cherry fruits**. Anthocyanins are natural pigments that exhibit distinct color changes in response to pH variations, making them suitable for visual detection of adulteration. In this study, anthocyanins were extracted from fresh cherries using a suitable solvent system and immobilized onto cellulose-based paper to prepare indicator strips. The fabricated strips showed rapid and noticeable color changes when exposed to adulterated samples, while pure food samples produced minimal or no color change. The color response was easily

observable with the naked eye and did not require any sophisticated analytical instruments, enabling quick on-site screening. The developed indicator strip is non-toxic, biodegradable, cost-effective, and simple to fabricate, making it suitable for household and field-level applications. Although natural pigments may show limited stability during prolonged storage, the method offers an effective preliminary screening tool for food adulteration detection. This work demonstrates the potential of cherry anthocyanins as a natural sensing material and supports the development of sustainable, green, and consumer-friendly food safety technologies.

KEYWORDS: Cherry anthocyanin; Food adulteration; Natural indicator; pH-sensitive pigment; Indicator strip; Food safety.

AIM AND OBJECTIVES

Aim

The aim of this study is to develop a natural indicator strip using anthocyanin pigments extracted from cherries and to evaluate its ability to detect pH changes and food adulteration through visible colour changes.

Objectives

- Extract anthocyanin pigment from fresh cherries using a suitable extraction method.
- Prepare indicator strips by impregnating filter paper with the extracted cherry anthocyanin solution.
- Study the colour change behaviour of the prepared indicator strips at different pH levels.
- Evaluate the effectiveness of the strips in detecting common food adulterants such as detergents or alkaline substances.
- Assess the response time and sensitivity of the indicator strips when exposed to different test solutions.
- Examine the stability of the prepared strips under different storage conditions such as light, temperature, and time.
- Compare the performance of the cherry anthocyanin indicator strip with conventional indicators such as litmus paper.

INTRODUCTION

Food adulteration is a persistent global problem that threatens food quality, consumer confidence, and public health. In many food products such as milk, fruit juices, honey, and drinking water, adulterants including detergents, washing soda, urea, starch, and other alkaline substances are intentionally added to increase profit margins. These adulterants may cause adverse health effects ranging from gastrointestinal disturbances to long-term metabolic disorders. Although advanced analytical techniques such as chromatography and spectroscopy provide accurate detection, they are expensive, time-consuming, and require well-equipped laboratories and trained personnel. Therefore, there is a growing demand for simple, rapid, and affordable methods that can be used for preliminary adulteration screening at the household or field level. In recent years, plant-derived natural pigments have gained attention as sustainable alternatives to synthetic chemical indicators. Among these pigments,

anthocyanins found abundantly in cherry fruits have shown excellent pH-sensitive properties. Anthocyanins exhibit distinct and reversible color changes when exposed to different pH conditions, appearing red in acidic environments and shifting to purple, blue, or green in neutral to alkaline media. Since many food adulterants alter the natural pH balance of food products, this color-changing behavior makes anthocyanins highly suitable for visual detection of adulteration. Cherry anthocyanins are non-toxic, biodegradable, and environmentally friendly, offering significant advantages over conventional synthetic dyes. Additionally, cherries are widely available and rich in stable anthocyanin compounds, making them a practical source for indicator development. Immobilizing cherry anthocyanins onto paper-based substrates allows the fabrication of portable indicator strips that are easy to use and interpret. When these strips meet adulterated samples, rapid and visible color changes occur, enabling instant detection without the need for instruments or technical expertise. The present study aims to develop an innovative **cherry anthocyanin-based adulteration indicator strip** as a green, low-cost, and user-friendly tool for food safety monitoring. This approach not only supports sustainable analytical practices but also encourages the use of natural bioactive compounds in smart sensing applications. The developed indicator system has the potential to serve as an effective preliminary screening method, contributing to improved food safety awareness and consumer protection.



ABOUT CHERRY

- **Botanical Name:** *Prunus avium* L. (Sweet Cherry) or *Prunus cerasus* L. (Sour Cherry).

- **Kingdom:** Plantae.
- **Class:** Dicotyledonae (Magnoliopsida).
- **Order:** Rosales.
- **Family:** Rosaceae.
- **Botanical Source:** The edible fruit (a drupe) and sometimes the bark or stems of the deciduous trees *Prunus avium* and *Prunus cerasus*.

Geographical Source

- ✚ **Origin:** Native to Europe, North Africa, and Western Asia (including the Caspian and Black Sea regions).
- ✚ **Global Distribution:** Cultivated worldwide in temperate climates, including the United States, Turkey (the largest producer), and parts of Australia.

Macroscopical Structure (Morphology)

- ✚ **Fruit:** A fleshy drupe measuring 3–5 cm in diameter.
- **Epicarp:** The thin, shiny outer skin, ranging from yellow to dark mahogany or purple black.
- **Mesocarp:** The soft, juicy, and firm flesh.
- **Endocarp:** A hard, stony inner pit enclosing a single seed.
- ✚ **Leaves:** Deciduous, oval-shaped, and green with toothed (serrated) edges and pointed tips.
- ✚ **Bark:** Shiny, reddish-brown, and marked with horizontal cream-colored lenticels (breathing pores).
- ✚ **Flowers:** Clusters of white, 5-petaled blossoms appearing in early spring.

Microscopical Structure

- ✚ **Pericarp Structure:** The epicarp consists of a single layer of cells with a thick cuticle to prevent water loss. The mesocarp contains large parenchymatous cells rich in sugars and organic acids.
- ✚ **Endocarp (Pit):** Composed of highly lignified stone cells (sclereids) that provide structural rigidity to protect the seed.
- ✚ **Secretory Structures:** Some species feature extrafloral Nectarie's (red glands) located at the base of the leaf blade or on the petiole.

PHYTOCHEMICAL CONSTITUENTS

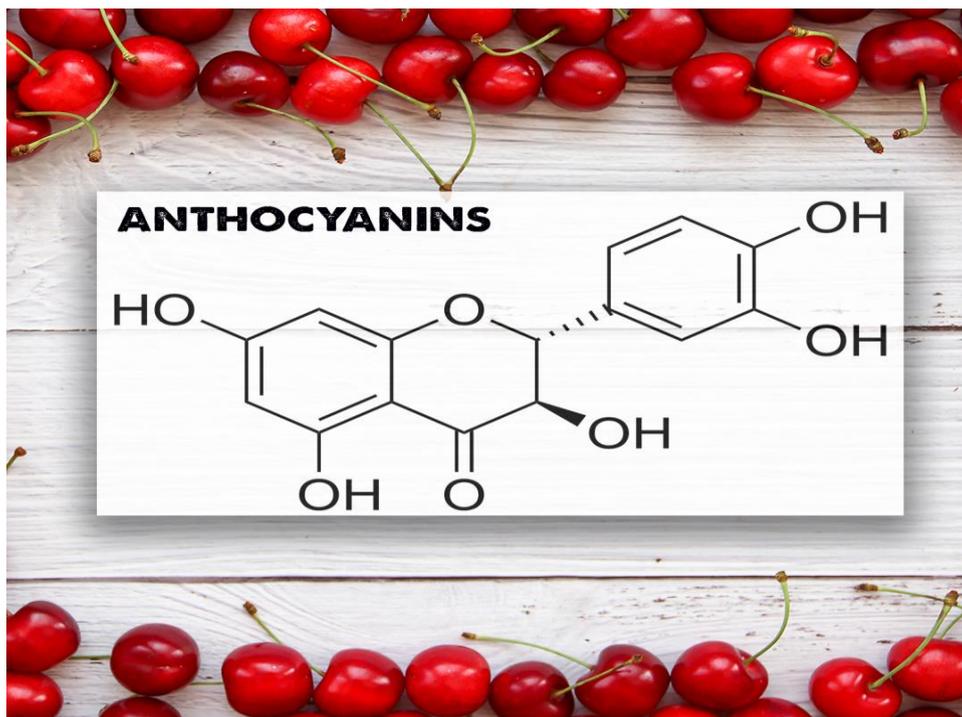
- **Anthocyanins:** These are the dominant flavonoids responsible for the red/dark color and potent antioxidant activity, including cyanidin, peonidin, and pelargonidin glycosides.
- **Phenolic acids:** Rich in hydroxycinnamic acids, such as chlorogenic acid (neochlorogenic acid) and p-coumaric acid derivatives, offering strong antioxidant effects.
- **Flavan-3-ols:** Compounds like catechin and epicatechin are also present, adding to the antioxidant profile.
- **Flavanols:** Quercetin and kaempferol derivatives are found in smaller amounts, enhancing health benefits.

Other Important Bioactive Compounds

- **Melatonin:** A hormone that helps to regulate sleep, found in cherries, particularly tart varieties.
- **Carotenoids:** Beta-carotene, lutein, and zeaxanthin, which act as antioxidants.
- **Serotonin & Tryptophan:** Amino acid derivatives linked to mood and sleep regulation.

ANTHOCYANIN

Anthocyanins are natural pigments found in many fruits, vegetables, and flowers, where they give red, purple, and blue colors. Common sources of anthocyanins include berries, grapes, red cabbage, purple corn, and black rice. These compounds belong to the flavonoid group of plant chemicals and are water-soluble, which allows them to easily mix with plant cell fluids. In plants, anthocyanins help attract pollinators and protect tissues from environmental stress such as strong sunlight, cold temperatures, and oxidative damage. Chemically, anthocyanins are formed when sugar molecules attach to anthocyanidins, their basic structure. Differences in the type and position of these sugars, as well as other small chemical changes, result in a wide variety of anthocyanins. Their color and stability are strongly affected by factors such as pH, light, temperature, and the presence of metal ions. Because of this sensitivity, anthocyanins show different colors under different conditions, making them unique among natural pigments. Anthocyanins have gained increasing attention because of their potential health benefits.



Research suggests that foods rich in anthocyanins may help reduce the risk of chronic diseases, including heart disease, diabetes, and inflammation-related disorders. These beneficial effects are mainly linked to their antioxidants and anti-inflammatory properties, which help protect cells from damage caused by free radicals. In addition to their health-related importance, anthocyanins are widely studied for their use as natural colorants in food, pharmaceutical, and cosmetic products. As consumers increasingly prefer natural and plant-based ingredients over synthetic additives, interest in anthocyanins has grown rapidly. Therefore, understanding the properties, functions, and applications of anthocyanins is important for both scientific research and industrial development.

MEDICINAL USES OF CHERRY

- **Anti-Inflammatory:** Anthocyanins reduce inflammation, benefiting conditions like arthritis and gout.
- **Exercise recovery:** Reduce muscle soreness and strength loss post workout.
- **Sleep Aid** contains melatonin, helping regulate sleep cycles.
- **Heart health:** may lower blood pressure and cholesterol due to potassium and antioxidant.
- **Blood Sugar Management:** Low glycemic index helps manage blood sugar spikes.
- **Antioxidant Power:** Fights free radicals, protecting against chronic diseases.



FORMULATION

Cherry anthocyanins are natural pigments that change color when they meet acidic or alkaline substances. This property makes them useful for preparing simple indicator strips that can help detect food adulteration.

Ingredients and Quantities

Fresh ripe cherries (*Prunus avium*) – 50 g

Ethanol (70%) – 100 mL

Hydrochloric acid (0.1 N) or citric acid (food grade) – 1 mL

Distilled water – 20 mL (optional)

Glycerol (optional, for flexibility) – 0.5 g

Filter paper (Whatman No.1) – as required

Method of Preparation

First, 50 g of fresh cherries were washed thoroughly with distilled water to remove dirt and impurities. The seeds were removed, and the cherries were crushed using a mortar and pestle to obtain a smooth pulp. The pulp was then transferred into a clean conical flask containing 100 mL of 70% ethanol. To stabilize the anthocyanin pigment, 1 mL of dilute hydrochloric acid or citric acid was added. The mixture was stirred well and kept in a dark place for 24 hours at room temperature.

After extraction, the solution was filtered using Whatman No.1 filter paper to obtain a clear, reddish purple anthocyanin extract. To improve the flexibility of the indicator strip, 0.5 g of glycerol was added and mixed thoroughly.

Filter paper was cut into small strips of approximately 1 × 5 cm and soaked in the prepared

anthocyanin extract for 10 minutes. The strips were then removed and allowed to dry for 12 hours away from direct sunlight. The dried strips were stored in airtight containers until use.

MATERIALS REQUIRED

A. Anthocyanin Extraction.

S.NO	INGREDIENT	QUANTITY	PURPOSE
1.	Fresh ripe cherries	50g	Natural anthocyanin source
2.	Ethanol (food grade, 70%)	100 mL	Extracting solvent
3.	Distilled water	50 mL	Dilution
4.	Citric acid	0.2 g	Stabilizes anthocyanin
5.	Mortar & pestle / blender	-	Crushing
6.	Filter paper / muslin cloth	-	Filtration

B. Indicator Strip Preparation

S.NO	INGREDIENT	QUANTITY	ROLE
1.	Whatman filter paper / blotting paper	Required size	Strip base
2.	Extracted anthocyanin solution	~40–50 mL	Indicator
3.	Glycerine	1 mL	Flexibility
4.	Corn starch	0.5 g	Film strength

CHEMICAL REACTION RESPONSIBLE FOR COLOUR CHANGE IN CHERRY ANTHOCYANIN INDICATOR STRIP

- Cherry contains anthocyanins, which are natural pigments belonging to the flavonoid group. These compounds change their molecular structure depending on the pH of the environment, which leads to visible colour changes in the indicator strip.
- Anthocyanins exist as flavylium cations in acidic conditions.
- When the pH changes, the structure of the molecule converts into different forms, each having assorted colour.

1. In Acidic Medium (Low pH)

In acidic conditions, anthocyanin exists as a flavylium ion, which gives a red colour.

Reaction

Anthocyanin (Flavylium ion) + H⁺ → Red coloured flavylium cation

This is why the indicator strip appears red or pink in acidic solutions.

2. In Neutral Medium

When the pH becomes neutral, the flavylium ion converts into a quinoidal base form, producing a purple colour.

Reaction

Flavylium cation \rightleftharpoons Quinoidal base

Colour observed: Purple / violet.

3. In Alkaline Medium (High pH)

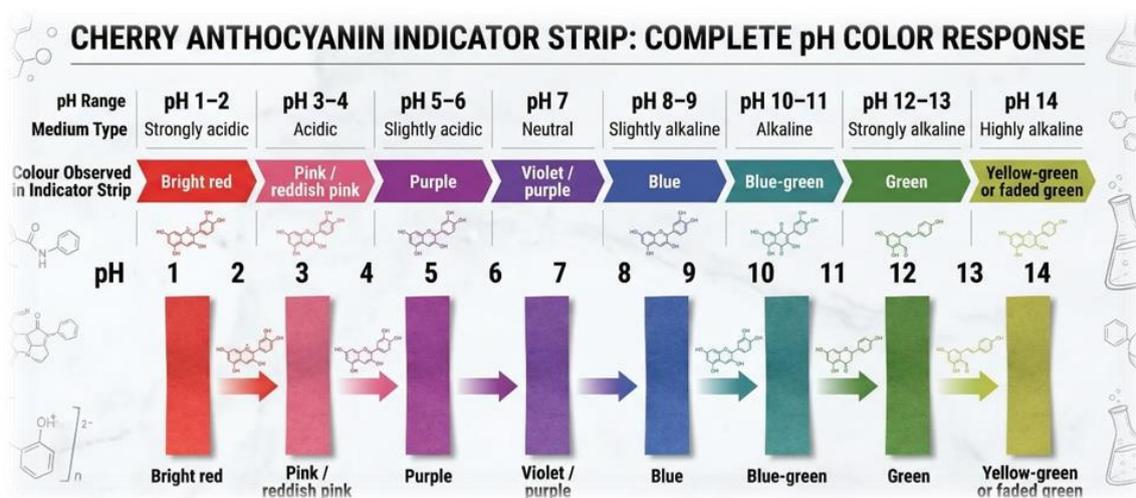
In alkaline conditions, the anthocyanin molecule undergoes hydration and structural rearrangement to form chalcone or anionic forms, producing blue, green, or yellow colours.

Reaction

Quinoidal base + $\text{OH}^- \rightarrow$ Anthocyanin anion / Chalcone form

Colour observed: Blue to green.

S.NO	Ph Condition	Colour of indicator	Anthocyanin form
1.	Acidic(ph.<7)	Red/pink	Flavylium cation
2.	Neutral(ph.=7)	Purple/violet	Quinoidal base
3.	Alkaline(ph.>7)	Blue/green	Anionic/ chalcone form



EVALUATION TESTS FOR CHERRY'S ANTHOCYANIN ADULTERATION INDICATOR STRIP

Determine how effective the prepared cherry anthocyanin indicator strips are, many evaluation tests conducted. These tests help check the sensitivity, response time, and stability of the indicator strips.

1. Visual Colour Change Test

The prepared strips dipped into solutions with different pH levels. In acidic solutions, the strips appeared red or pink, while in neutral solutions they showed a purple colour. When

placed in alkaline solutions, the colour changed to blue or green. This clear change in colour confirmed that cherry anthocyanins are sensitive to pH variations and can function as natural indicators.

2. Adulterant Detection Test

The indicator strips evaluated with common adulterants such as detergent solution, sodium carbonate, and urea. When the strip met these substances, a noticeable colour changes from reddish-purple to bluish or greenish observed. This indicates that the strip can help detect alkaline adulterants present in food samples.

3. Response Time Test

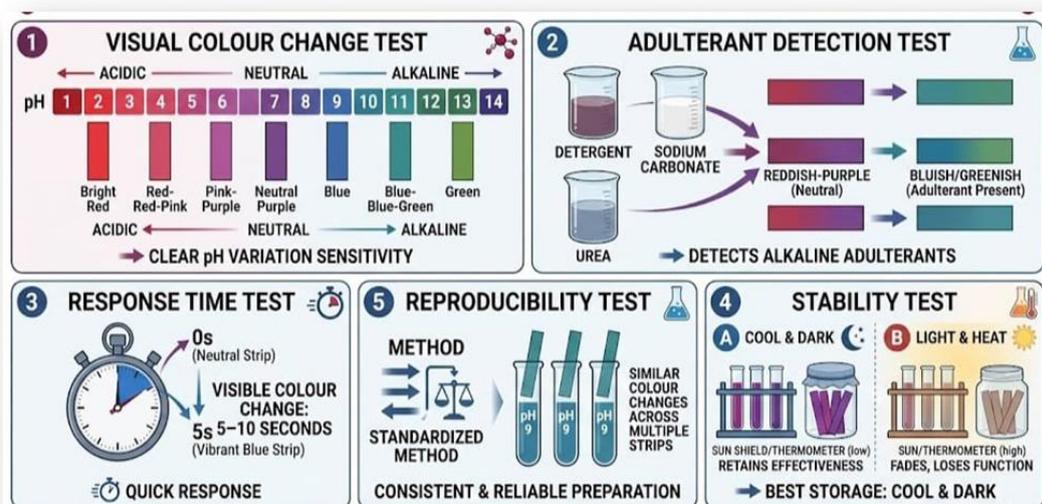
The time required for the strip to show a colour change after exposure to the test solution recorded. The strips showed visible changes within 5–10 seconds, indicating a quick response.

4. Stability Test

The prepared strips stored in different conditions to check their stability. Strips stored in cool and dark conditions retained their colour and effectiveness for a longer time compared to those exposed to light and heat.

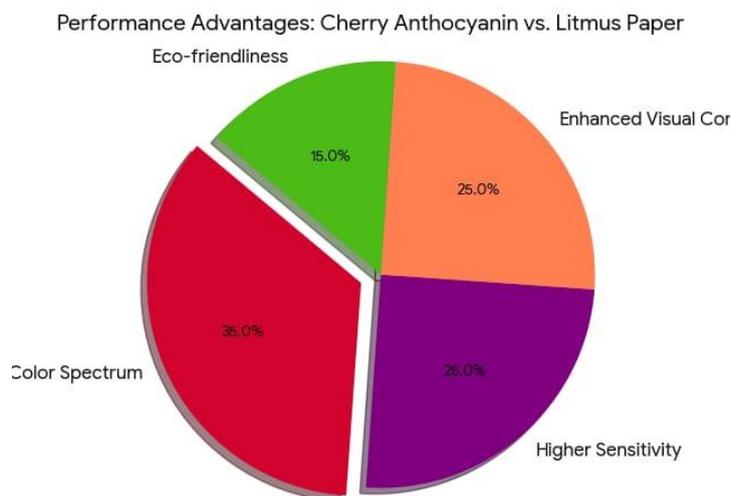
5. Reproducibility Test

Multiple strips prepared using the same method produced similar colour changes, showing that the preparation method is dependable and consistent.



ADVANTAGES

S.NO	CHERRY INDICATOR STRIP	LITMUS PAPER
1.	Made from natural cherry pigments (anthocyanins), which are eco-friendly and biodegradable.	Made from processed dye extracted from lichens.
2.	Shows multiple colour changes (red, purple, blue, green) depending on the pH level.	Shows only two-colour changes: red in acid and blue in base
3.	Can help detect food adulterants such as detergents, alkalis, and chemicals.	Mainly used only to identify acidic or basic substances.
4.	More sensitive to small pH changes, allowing better detection.	Less sensitive compared to anthocyanin indicators.
5.	Can used in food safety applications and smart packaging.	Mostly used in laboratory experiments for simple pH testing.
6.	Made from food-safe plant materials, making it safer for food-related testing.	Not specifically designed for food adulteration detection.
7.	Can be prepared easily from natural sources like cherries.	Requires commercial preparation and processing.

**BENEFITS OF CHERRY ANTHOCYANIN ADULTERATION INDICATOR STRIP****✓ Natural and Eco-friendly**

The indicator strip made from natural pigments (anthocyanins) extracted from cherries, so it is biodegradable and environmentally friendly.

✓ Safe for Food Testing

Since it uses plant-based materials, it is safer for applications related to food adulteration detection.

✓ Easy to Use

The strip gives a visible colour change, so adulteration can be detected easily without using complex instruments.

✓ Low Cost

The materials required, such as cherries and filter paper, are easily available and inexpensive, making the method affordable.

✓ Rapid Detection

The strip shows a quick colour change within few seconds when it meets adulterants.

✓ Sensitive to pH Changes

Anthocyanins are extremely sensitive to small pH changes, which helps in detecting even lesser amounts of adulterants.

✓ Multiple Colour Indication

Unlike simple indicators, it shows assorted colour such as red, purple, blue, or green, depending on the chemical condition.

✓ Simple Preparation Method

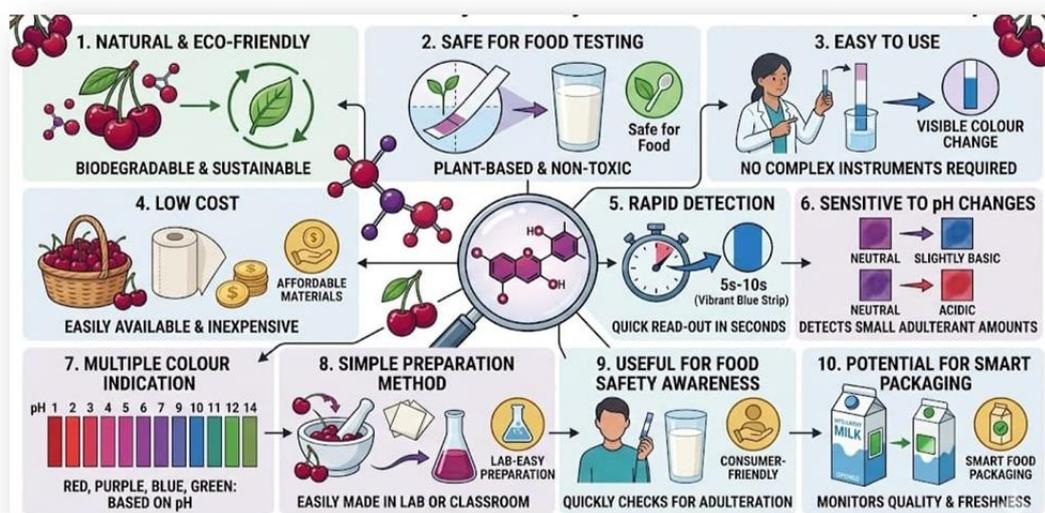
The indicator strips can be prepared easily in a laboratory or educational setting.

✓ Useful for Food Safety Awareness

These strips can help consumers quickly check for adulteration in food products.

✓ Potential for Smart Packaging

The indicator can also use in intelligent food packaging to monitor food quality and freshness.



DISCUSSION

The aim of this study was to prepare a natural indicator strip using anthocyanin pigments extracted from cherries and to evaluate its ability to detect food adulteration. Anthocyanins are known for their sensitivity to pH changes, which makes them useful as natural indicators. In this experiment, cherry extract was successfully prepared using an acidified ethanol extraction method and then applied to filter paper to create indicator strips.

During the evaluation tests, the prepared strips showed clear and noticeable colour changes when exposed to different pH conditions and adulterant solutions. In acidic environments, the strips remained reddish in colour, while neutral solutions produced a purple shade. When exposed to alkaline substances such as detergent or sodium carbonate, the colour shifted to bluish or greenish tones. These visible changes confirmed that the anthocyanin pigment reacts to changes in chemical conditions.

The indicator strips also showed a quick response time, with colour changes appearing within few seconds after contact with the test solution. This makes the strips convenient for quick and simple detection without requiring expensive laboratory instruments. However, it also observed that the stability of the strips can be affected by light, temperature, and long storage periods, which may cause the colour to fade gradually.

Overall, the experiment demonstrates that natural pigments like anthocyanins can effectively be used to create simple sensing tools for food quality testing.

CONCLUSION

In conclusion, the cherry anthocyanin adulteration indicator strip proved to be a simple, low-cost, and environmentally friendly method for detecting food adulteration. The natural pigment extracted from cherries showed clear and reliable colour changes in response to different chemical conditions, particularly alkaline adulterants. The strips were easy to prepare and provided rapid visual results, making them suitable for educational experiments and basic food safety testing. Although the stability of the strips can be improved with better storage conditions, the study highlights the potential of plant-based pigments as safe and sustainable alternatives to synthetic chemical indicators.

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