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Review on Natural Ph Indicators

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ABSTRACT

Materials from fruits, plants, or other natural sources that change color in response to pH differences are known as natural pH indicators. These indicators are non-toxic, economical, and environmentally beneficial substitutes for artificial pH indicators. Natural sources that include anthocyanins, curcumin, and other pigments that change color based on the acidity or alkalinity of the solution include hibiscus, butterfly pea flowers, pomegranates, red onions, dragon fruit, grapes, red cabbage, turmeric, and beetroot. Because of their ease of use and accessibility, natural pH indicators are frequently utilized in environmental monitoring, educational settings, and the food industry. The potential of natural pH indicators as environmentally friendly instruments for measuring pH is examined in this study as it examines their extraction, processing, and use. The findings show that natural pH markers are efficient, trustworthy, andenvironmentally friendly, making them a valuable resource for both scientific and practical applications.

I. INTRODUCTION

1.1. INTRODUCTION TO NATURAL pH INDICATORS

A natural indicator is a type of indicator found in nature that may determine whether a chemical is acidic or basic. Plant dyes and pigments are brilliantly colored chemicals that change color when the pH changes. Flavonoids, Flavonols, Acylated flavonoids, Anthocyanins, Glucosylated acylated anthocyanin, Quinines, Imines, Polymethines, Napthaquinones, Anthraquinonoids, Indigoids, Dihydropyrans, Diarylmethanes, and Carotene are examples of organic and inorganic compounds that contribute to the color of plant tissues Ill. Some of these compounds change color with pH, which can be used as a natural indicator. The hue and stability of these pigments are influenced by pH, light, temperature, and structural features. Anthocyanins are strong, water-soluble pigments that give many fruits, vegetables, and flowers their red, purple, and blue hues.

The majority of commercially available standard synthetic indicators are expensive. Additionally, they are both poisonous and combustible. They also demonstrate downsides such as availability, environmental pollution, and chemical pollution. Furthermore, the use of synthetic markers in food applications is being avoided or reduced to a greater extent due to their possibly harmful effects on humans. To solve the shortcomings of synthetic indicators, scientists are conducting substantial research in the field of natural materials, which are less dangerous to humans, cost-effective, readily available, and environmentally acceptable.121 Natural pigments or dyes found in plants are rarely harmful, pollution-free, and simple to make or extract.

Examples of Anthocyanin Containing species: Flowers: Hibiscus, Butterfly pea,Rose. Fruits: Grapes, Pomegranates, dragon fruit, Apple,

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Strawberries. Vegetables: Red Cabbage, Red Onion, Beetroot.131

1.2 INTRODUCTION TO PLANTS

➢ HIBISCUS

Hibiscus is a blooming plant in the mallow family (malvaceae). The flowers are hermaphrodite and pollinate with insects. The leaves are alternating, oblong to lanceolate, with a toothed or lobed border. The flowers are huge, conspicuous, trumpet-shaped, with five or more petals, ranging in hue from white to pink, red, orange, purple, or yellow, and measuring 4-18cm in width.r41

There are over 200 species of Hibiscus, but Hibiscus sabdariffa is the most commonly cultivated and used for medicinal, culinary, and cultural purposes.

Scientific Name: Hibiscus sabdariffa L
Common Names: Roselle, Hibiscus, Sorrel, Jamaican tea, Red sorrel.
Family: Malvaceae
Plant Type: Annual herb, Shrub-like plant, Tropical plant.
Origin: Native to Africa (tropical regions), Naturalized in Asia, Americas, and Pacific Islands, Cultivated in many tropical and subtropical regions.

Fig no :1 Hibiscus

➢ BUTTERFLY PEA

The plant species used in this study is Clitoria ternatea, which belongs to the fabaceae family. It grows as a vine or creeper, and thrives in damp soil. One of this plant's most notable qualities is its vibrant deep blue blossoms. They are solitary, with a bright yellow marking and dimensions of around 4 cm long and 3 cm wide. Some cultivars of this plant produce white flowers. The fruits are 5-7 cm long flat pods containing 6 to 10 seeds apiece. When tender they are edible. [51

Scientific Name: Clitoria ternatea L.
Common Names: Butterfly Pea, Blue Pea, Asian Pigeonwings, Bluebell Vine, Darwinia
Family: Fabaceae (Legume family)
Plant Type: Perennial vine, Climbing plant, Tropical plan
Origin: Native to tropical Asia (India, Southeast Asia, China), Naturalized in Africa, Australia, and Pacific Islands, Cultivated in many tropical and subtropical regions.

Fig no:2 Butterfly pea flower

➢ GRAPES

The Common or European grapevine (Vitis vinifera) is a long-stemmed, woody vine that yields high-quality berries or grapes. With careful management, the vines can grow to be more than 30 meters long and live for many years. The grape vine's leaves are alternately arranged on the stem, long and broad with 5-7 lobes, and normally reach sizes of 5-20 cm (2.0-7.9 in). Flowers are produced in clusters, as is fruit. The fruit is a berry called a grape that grows in clusters on the vine. In wild species, the fruit is 6 mm (1/5 in) in diameter and ripens from dark purple to black, with a pale wax bloom. The berries are usually much larger, up to 3 cm (1.2 in) long and can be green, red or purple. [6]

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Fig no:3 Grapes

Scientific Name: Vitis vinifera L.
Common Names: Grape, Common Grapevine, Wine Grape, Table Grape.
Family: Vitaceae
Plant Type: Perennial vine, Woody vine, Fruit-bearing plant.
Origin: Native to Mediterranean region (Southern Europe, North Africa, Western Asia).

➢ POMEGRANATE

The Lythraceae family includes the fruit-bearing deciduous shrub known as the pomegranate (Punica granatum). Pomegranates are small trees or shrubs with several thorny branches that reach heights of 5 to 10 meters (16 to 33 feet). It has a lengthy lifespan; some examples have been around for 200 years in France. The glossy, slender, oblong, whole leaves of P. granatum are opposite or subopposite, measuring 3-7 cm in length and 2 cm (3/4 in) in width. The brilliant red flowers have three to seven petals with a diameter of 3 cm [71. Some kinds that bear no fruit are cultivated only for their blooms. Pomegranates have thick, red skins and are sweet, tart fruits. Although the skin is inedible, it is packed with hundreds of juicy seeds that can be eaten on their own or added to oatmeal, salads, and other foods. The pigmentation of pomegranate juice primarily results from the presence of anthocyanins and ellagitannins.

Fig no:4 Pomegranate

Scientific Name: Punica granatum
Common Name: Pomegranate
Family: Lythraceae (Loosestrife family)
Plant Type: Deciduous shrub or small tree
Origin: Native to the Middle East and South Asia (Iran, Afghanistan, Pakistan, India), Cultivated in Mediterranean regions (Greece, Turkey, Italy) for thousands of years, Introduced to California, USA, by Spanish settlers in the 18th century.

➢ RED ONIONS

Red onions are characterized by their purplish-red exterior and red-tinged white flesh. Although the skin has been used as a dye, they are most frequently utilized in cooking. Because red onions contain fewer pyruvic acid and sulfur compounds than white or yellow onions, they are typically medium to large in size and have a sweeter flavor. They are frequently eaten raw, grilled, or mildly cooked with other dishes. They can also be added to salads for color and bite. Unlike white and yellow onions, red onions are accessible all year round and are rich in fiber and flavonoid.r81

Fig no:5 Red onion

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Scientific Name: Allium cepa var. aggregatum
Common Name: Red Onion
Family: Amaryllidaceae (formerly Alliaceae)
Plant Type: Bulbous perennial vegetable
Origin: Native to Central Asia (Afghanistan, Pakistan, India), Cultivated in Middle East, Mediterranean, and Europe for thousands of years, Introduced to Americas by European colonizers.

➢ DRAGON FRUIT

The pitaya fruit, often called the dragon fruit, is a fruit native to Asia, South America, and Central America. It is intensely shaped and colored, tastes mildly sweet, and has a texture similar to that of a kiwi. It has a variety of nutritious components, is pleasant and refreshing, and is high in water and other vital minerals. The term "dragon fruit" describes fruits from the Cactaceae family's genus Selenicereus (previously Hylocereus) [9]. The fruit's leather-like skin and scaly spikes on the outside give it its common English moniker, dragon fruit. The flesh of pitaya fruits can be red, white, or yellow, and it can taste sweet or sour, depending on the type.

Scientific Name: Hylocereus spp. (commonly H. undatus,H. polyrhizus, or H. costaricensis)
Common Name: Dragon Fruit, Pitaya, Pitahaya
Family: Cactaceae
Plant Type: Climbing epiphytic cactus
Origin: Native to Central and South America (Mexico, Costa Rica, Ecuador), Cultivated in Southeast Asia (Vietnam, Thailand, Indonesia) for centuries, Introduced to China, Australia, and United States as an ornamental and fruit crop.

Fig no:6 Dragon fruit

1.3 CHEMISTRY

The fundamental C skeleton that makes up anthocyanin structure is C6-C3-C6. The primary distinctions between the more than 600 different forms of anthocyanins are the number and location of hydroxyl groups, the degree of methylation of the hydroxyl groups, the type and quantity of sugar molecules, and the acids that are attached to the sugars.

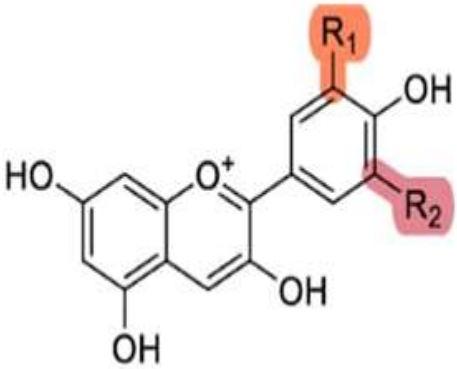

Fig no: 7 Structure of Anthocyanin

The red, purple, and blue hues of fruits, vegetables, flowers, and red wine are caused by a class of water-soluble pigments called anthocyanins. They belong to a broader class of plant-based compounds known as flavonoids, which also aid in plant reproduction and provide defense against environmental stressors. Anthocyanins have several possible health advantages and are generally regarded as safe and harmless. They are as follows:

- Antioxidant properties: Anthocyanins can aid in the destruction of free radicals, which are unstable chemicals that can harm cells.
- Anti-inflammatory and antimicrobial properties: Anthocyanins may have both anti-inflammatory and antimicrobial properties.
- Chemoprevention: Anthocyanins may aid in prevention of various diseases, such as diabetes, obesity, and cancer.

Anthocyanins are sensitive to pH, light, temperature, oxygen, metal ions, and other factors. The color of anthocyanins depends on the pH of the cell sap in which they are dissolved:

- Acidic sap: Anthocyanins produce a bright red color.
- Less acidic sap: Anthocyanins produce a more purple color.

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Anthocyanins are also used as natural pigments in various industries. However, their low stability can be a disadvantage.

Chemical Properties:

- Molecular formula: $C_{15}H1_{10}+$
- Molecular weight: 207.2474 g/mol
- Solubility: Water-soluble
- Stability: Unstable to heat, light, and oxygen

Physical Properties:

- Color: Red, purple, blue, violet
- Absorption spectrum: 520-560 nm (visible light)
- Melting point: 150-200°C
- Density: 1.5-2.0 g/cm3
- Refractive index: 1.5-1.7

Spectroscopic Properties:

- UV-Visible spectroscopy: Maximum absorption at 520-560 nm
- Infrared spectroscopy: Characteristic peaks at 1600-1700 cm^{-1}
- Nuclear Magnetic Resonance (NMR) spectroscopy: Characteristic signals at 6-8 ppm

Thermal Properties:

- Thermal stability: Unstable above 80°C
- Decomposition temperature: 150-200°C
- Glass transition temperature: 50-70°C

Optical Properties:

- Absorbance: High absorbance at 520-560 nm
- Fluorescence: Weak fluorescence emission at 600-700 nm
- Opacity: Variable, depending on concentration

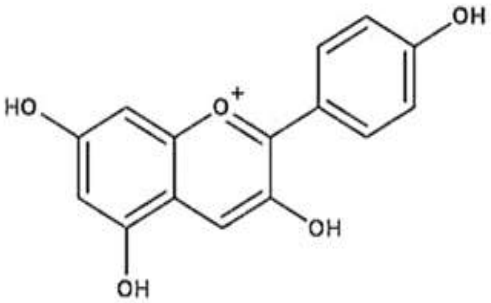
Other Properties:

- Hydrophobicity: Moderate hydrophobicity Isoelectric point: pH 3-5
- Partition coefficient: Log P = 1-3

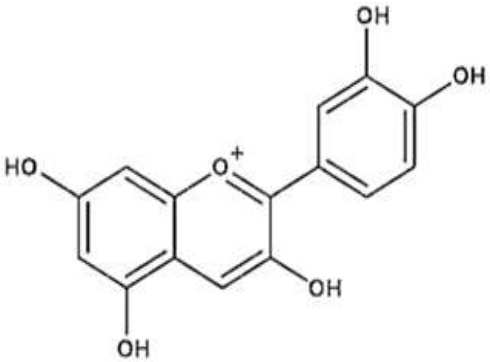
Types:

Only six anthocyanin types-pelargonidin, cyanidin, peonidin, delphinidin, petunidin, and malvidin—are thoroughly studied, despite the large number of anthocyanin molecules already listed in the food matrix. Anthocyanins, the largest class of phenolic pigments, are mostly linked to the fruit or flower's colorant and antioxidant qualities. The blue, purple, pink, red, and orange hues that plants exhibit are directly caused by these same chemicals.

The most prevalent anthocyanins found in plants are cyanidin, delphinidin, pelargonidin, peonidin, malvidin, and petunidin. These anthocyanins are distributed as follows in fruits and vegetables: 50%, 12%, 12%, 7%, and 7%, respectively.[11]



Pelargonidin



Cyanidin

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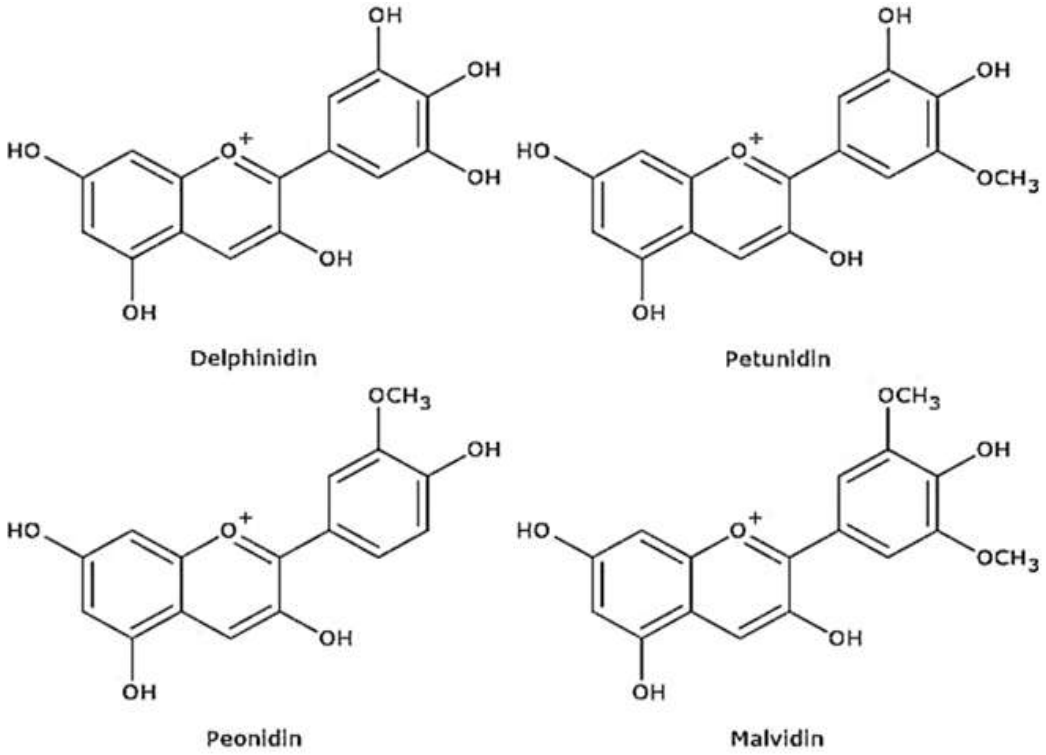

Fig no:8 Types of Anthocyanin

Types of Anthocyanins; structure,colour & its source

Anthocyanins	R_1	R_2	colour	source
Cyanidin	OH	H	Reddish purple	Grapes, sweet potato, red onion, red cabbage, hibiscus, dragon fruit
Pelargonidin	H	H	Orange hue to flowers and red to some fruits and berries	Dragon fruit, rose, grapes, strawberry, pomegranates, plum
Delphinidin	OH	OH	Purple	Dragon fruit, tomato, carrot, red onion, viola, butterfly pea
Peonidin	OCH_3	H	Purplish red	Rose, grapes, red onion, berries
Petunidin	OCH_3	OH	Dark red or purple	Grapes, tomato, black currants
Malvidin	OCH_3	OCH_3	Purple	Berries, grapes, blue pimpernel

Table 1: Types of Anthocyanin, structure & its sources

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