CHAPTER 1

INTRODUCTION

1.1. Background of the study

Colour is one of the most noticeable characteristics of plants and plays an important role in the natural environment. The attractive colours of flowers, fruits, leaves, seeds, roots, and other plant parts are mainly due to the presence of naturally occurring pigments. These pigments are chemical substances that absorb certain wavelengths of visible light and reflect others, producing the colours perceived by the human eye. Plant pigments are not merely responsible for the visual appearance of plants; they also perform several important biological functions.Plants contain a wide variety of pigments that participate in processes such as photosynthesis, protection against excessive light, defence against environmental stresses, and attraction of pollinators and seed-dispersing organisms. The diversity of plant pigments results in the wide range of colours observed in nature, from the green of leaves to the yellow, orange, red, purple, and blue colours of flowers and fruits.

Natural pigments have been used by humans since ancient times. Plant materials were traditionally used to obtain colours for food, clothing, artwork, cosmetics, and other purposes. With the development of modern industries, synthetic dyes and colourants became widely used because they could be produced on a large scale and often provided intense and stable colours. However, growing interest in naturally derived materials has renewed scientific attention towards pigments obtained from plants.Natural plant pigments are now being investigated as potential sources of colouring agents because plants are renewable sources of raw materials and many pigments possess additional biological properties. Their properties, however, depend on their chemical structure and can be influenced by factors such as pH, temperature, light, oxygen, solvents, and storage conditions. Therefore, understanding the nature and behaviour of plant pigments is important for their appropriate utilization.

Among the various natural pigments, anthocyanins and curcumin are particularly important because they represent two different types of plant-derived colour compounds. Anthocyanins are responsible for many red, purple, violet, and blue colours found in plants, whereas curcumin produces the characteristic yellow-orange colour of turmeric. Both have attracted considerable scientific interest because of their distinctive colour properties and potential applications.

1.2 Natural Pigments

Natural pigments are coloured compounds obtained from natural sources such as plants, microorganisms, and some animals. Plant pigments are particularly important because plants contain a diverse range of compounds capable of producing different colours.The major groups of plant pigments include chlorophylls, carotenoids, anthocyanins, betalains, and several other phenolic compounds. Chlorophyll is mainly responsible for the green colour of leaves and is essential for photosynthesis. Carotenoids produce yellow, orange, and some red colours and are found in many fruits, vegetables, flowers, and leaves. Anthocyanins are responsible for a wide range of red, purple, violet, and blue colours, while betalains produce red-violet and yellow colours in certain plants.Natural pigments differ in their chemical structures and therefore show different physical and chemical properties. Some pigments are soluble in water, whereas others show greater solubility in organic solvents. Similarly, some pigments are relatively stable under particular environmental conditions, while others are highly sensitive to pH, temperature, light, or oxygen.

The study of natural pigments is therefore important not only for understanding plant chemistry but also for exploring their possible applications. The recovery of pigments from plant materials can provide an approach for utilizing naturally occurring compounds that may otherwise remain underused.

1.3 Anthocyanin

Anthocyanins are an important group of naturally occurring plant pigments belonging to the flavonoid family of polyphenolic compounds. They are widely distributed in flowers, fruits, vegetables, and other plant tissues. Anthocyanins are primarily responsible for many of the red, pink, purple, violet, and blue colours observed in plants.

The word anthocyanin is derived from Greek words associated with flowers and blue colour. Chemically, anthocyanins are generally present in plants as glycosides of anthocyanidins. The sugar components attached to the anthocyanidin structure influence their solubility, stability, and colour properties. Common anthocyanidins include cyanidin, delphinidin, pelargonidin, peonidin, petunidin, and malvidin.

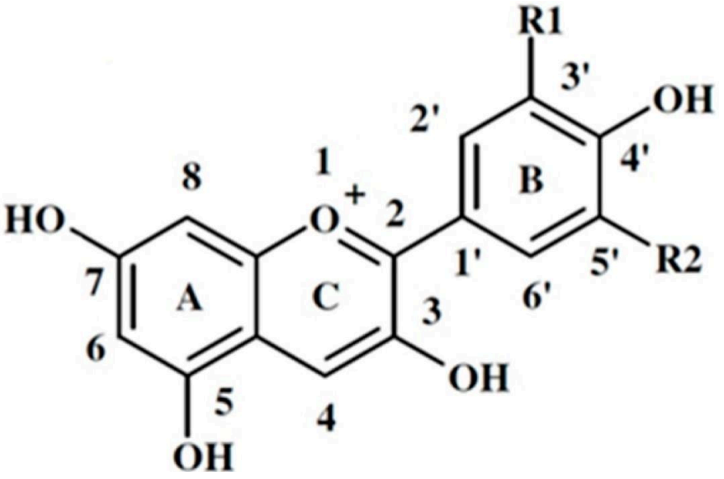


Fig: Structure of Anthocyanin

One of the most interesting characteristics of anthocyanins is their ability to exhibit different colours under different pH conditions. Changes in acidity can alter the chemical form of the pigment, resulting in visible colour changes. In general, anthocyanin-rich extracts tend to show red or pink colours under acidic conditions, while their colour may shift towards purple, blue, or other shades as the pH increases.This pH-dependent behaviour makes anthocyanins particularly interesting for scientific studies and potential applications. Their colour can also be affected by temperature, light, oxygen, metal ions, and interactions with other compounds. As a result, the stability of anthocyanins is an important consideration when investigating their potential use as natural colourants.

1.4 Sources of Anthocyanin

Anthocyanins occur naturally in a large number of plant species. They are particularly abundant in plant tissues that display red, purple, violet, or blue colours. Important sources include berries, grapes, cherries, black rice, red cabbage, purple sweet potato, purple corn, and several coloured flowers.



Fig: Red Rose Flowers



Fig: Red Cabbage

Flowers are also important sources of anthocyanins because these pigments contribute significantly to their attractive colours. Red and purple flowers can contain considerable amounts of anthocyanin pigments. The type and concentration of anthocyanins vary according to plant species, variety, maturity, environmental conditions, and the particular plant tissue.The widespread occurrence of anthocyanins makes them an interesting group of natural pigments for extraction and study. Plant materials containing visible red, purple, or blue colour can therefore serve as potential sources of these pigments.

1.5 Importance and Applications of Anthocyanin

Anthocyanins have attracted considerable interest because of both their colouring properties and their reported biological activities. They are associated with antioxidant properties and have been investigated in relation to various biological effects. However, the activity and stability of anthocyanins depend on their chemical structure and surrounding conditions.

As natural colourants, anthocyanins have potential applications in food and beverage products, cosmetics, pharmaceutical preparations, and other areas where naturally derived colours are desirable. Their ability to respond to changes in pH has also generated interest in their use as natural colour indicators.

The study of anthocyanins is therefore relevant from both scientific and practical perspectives. Understanding their extraction and properties can contribute to the development of improved methods for utilizing plant sources of natural colour.

1.6.Curcumin

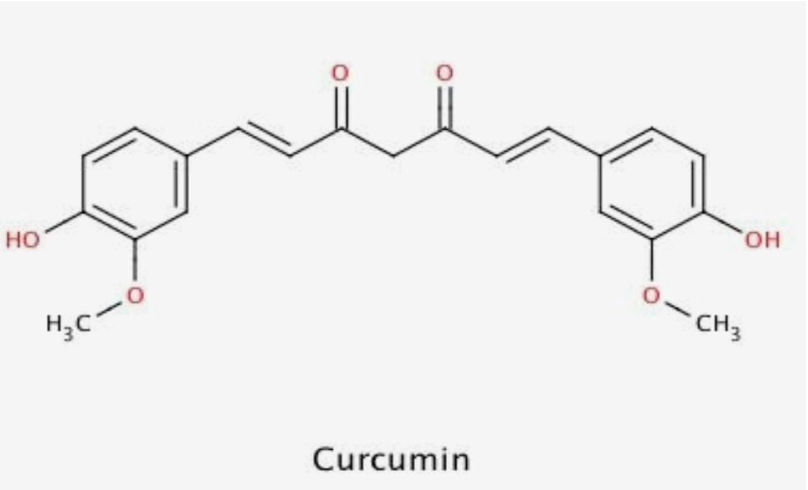


Fig:Structure of Curcumin

Curcumin is another important naturally occurring plant pigment. It is a yellow-orange polyphenolic compound obtained primarily from the rhizomes of Curcuma longa, commonly known as turmeric. Turmeric belongs to the family Zingiberaceae and has been used traditionally for centuries as a spice, colouring material, and component of various preparations.Curcumin is the major colouring compound among the curcuminoids present in turmeric. The principal curcuminoids include curcumin, demethoxycurcumin, and bisdemethoxycurcumin. Together, these compounds contribute to the characteristic yellow colour of turmeric, with curcumin being the principal pigment.

The intense yellow-orange colour of curcumin makes it an important natural colouring compound. Unlike anthocyanins, curcumin has very limited solubility in water and shows greater solubility in several organic solvents. This difference demonstrates how the chemical structure of a pigment influences its physical properties.Curcumin is also sensitive to environmental conditions. Its colour and stability can be affected by factors such as pH, light, temperature, and oxygen. Under different pH conditions, curcumin may exhibit changes from yellow towards orange or reddish shades. These properties make curcumin an interesting pigment for studying the relationship between chemical structure and colour behaviour.

1.7 Source of Curcumin

The primary natural source of curcumin is the rhizome of Curcuma longa. Turmeric rhizomes contain curcuminoids along with essential oils, carbohydrates, proteins, minerals, and other

naturally occurring substances. After harvesting, turmeric rhizomes are commonly cleaned, dried, and processed into a yellow-coloured powder.



Fig:Fresh Turmeric roots.



Fig: Turmeric powder

Turmeric is widely available and has a long history of use in traditional practices and food preparation. Its intense colour and relatively easy availability make it a suitable plant source for studying natural pigments.The extraction of curcumin from turmeric provides an example of obtaining a valuable coloured compound from a commonly available plant material. It also demonstrates the importance of selecting suitable extraction conditions based on the chemical characteristics of the pigment.

1.8 Importance and Applications of Curcumin

Curcumin has attracted considerable attention because of its characteristic colour as well as its reported biological properties. It has been investigated for antioxidant, anti-inflammatory, and other biological activities. These properties have made curcumin a subject of research in areas including pharmaceutical science, food science, and natural product chemistry.

From the perspective of natural colouring, curcumin has been used traditionally to impart a yellow colour to food and other materials. Its intense colour has also led to investigations into its potential applications in cosmetics, textiles, food products, and other areas.

However, the practical use of curcumin as a natural pigment is influenced by factors such as its poor water solubility and sensitivity to environmental conditions. Therefore, understanding its physical and chemical behaviour is important when considering potential applications.

1.9 Significance of Studying Anthocyanin and Curcumin Together

Anthocyanin and curcumin provide two interesting examples of natural pigments obtained from plant materials. Although both are responsible for producing colour and have potential applications as natural colourants, they differ significantly in their chemical nature and properties.Anthocyanins are flavonoid pigments commonly associated with red, purple, and blue colours, while curcumin is a polyphenolic pigment responsible for the yellow-orange colour of turmeric. Anthocyanins are generally water-soluble, whereas curcumin has poor water solubility. Anthocyanins show particularly pronounced pH-dependent colour changes, while curcumin also exhibits changes in colour under different chemical conditions.

Studying both pigments in a single research project provides an opportunity to understand the diversity of plant pigments and to compare pigments obtained from different plant sources. It also demonstrates that different chemical structures can result in different colour characteristics, solubility patterns, and stability behaviour.

1.10 Importance of Natural Pigments in the Present Context

The increasing interest in natural products has encouraged researchers to investigate plant-derived compounds that can serve as alternatives or supplements to synthetic materials. Natural pigments are particularly significant because colour is required in many products and processes, while consumers and industries have shown increasing interest in materials derived from natural sources.Plant materials are widely available and contain numerous valuable compounds. The recovery of pigments from such materials can therefore contribute to the utilization of natural resources and encourage further investigation of plant-based colouring agents.Anthocyanin and curcumin are especially useful for such studies because they exhibit strong and distinctive colours and can be obtained from commonly available plant materials. Their different properties make them suitable for comparative investigation.

Thus, the study of these pigments is relevant not only to natural product chemistry but also to food science,pharmaceutical chemistry, cosmetics, and other areas where natural colouring compounds may have potential value.