



Floral Pigments: Classification, Function and Importance in Floriculture

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Flower pigments are essential components in floriculture, determining the aesthetic, ecological, and commercial significance of ornamental crops. The vivid colors in flowers are due to natural pigments such as anthocyanins, carotenoids, and betalains. These pigments not only influence consumer preferences but also serve ecological roles by attracting pollinators and protecting plants against environmental stresses. The manipulation of pigment pathways through conventional breeding, mutation, and genetic engineering offers enormous potential for developing novel flower colors. This article explores the types, functions, and mechanisms of flower pigments, along with their impact on floriculture industry.

Keywords: Floriculture, Flower pigments, Anthocyanins, Carotenoids, Betalains,

Introduction

Color is one of the most important quality parameters in ornamental flowers. Whether used for aesthetic decoration, gifting, or symbolic representation, the color of flowers strongly influences consumer choice. The color is primarily due to pigments that accumulate in the epidermal cells of petals. These pigments are secondary metabolites synthesized through complex biochemical pathways and regulated by genetic and environmental factors. In floriculture, the ability to modify or enhance flower color is a powerful tool in breeding. Understanding the chemistry and function of these pigments enables the development of flower varieties that are not only visually appealing but also better suited for market demands and environmental adaptability.

Major Classes of Flower Pigments

1. Anthocyanins

Category: Flavonoids (Phenolic compounds)

Solubility: Water-soluble (stored in vacuoles)

Color Range: Red, pink, purple, violet, blue

1.1 Structure and Properties

- Derived from **flavylium ion (2-phenylbenzopyrylium)** backbone.
- Exist as glycosides (sugar-bound forms) – e.g., **cyanidin-3-glucoside**.
- The color depends on:
 - ✓ **pH** of the vacuole
 - ✓ **Presence of metal ions** (e.g., Al^{3+} , Fe^{2+})
 - ✓ **Co-pigmentation** (interaction with other molecules)

1.2 Types of Anthocyanins

Pigment	Color	Common in
Cyanidin	Red to purple	Roses, chrysanthemum
Delphinidin	Blue to violet	Petunia, lobelia
Pelargonidin	Orange to red	Geranium, carnation
Peonidin	Magenta	Orchids, roses

Malvidin	Violet	Petunia, periwinkle
Petunidin	Deep purple	Petunia

1.3 Biosynthesis Pathway

Starts from **phenylalanine** → **cinnamic acid** → flavonoid intermediates → **anthocyanidins**, then glycosylation.

Key Enzymes:

- Chalcone synthase (CHS)
- Flavanone 3-hydroxylase (F3H)
- Dihydroflavonol reductase (DFR)
- Anthocyanidin synthase (ANS)
- UDP-glucose:flavonoid glucosyltransferase (UFGT)

2. Carotenoids

Category: Isoprenoids / Tetraterpenoids

Solubility: Lipid-soluble (stored in plastids)

Color Range: Yellow, orange, red

2.1 Structure and Properties

- Composed of **8 isoprene units (C40)**.
- Consist of:
 - ✓ **Carotenes** (pure hydrocarbons) – e.g., β -carotene, lycopene
 - ✓ **Xanthophylls** (contain oxygen) – e.g., lutein, zeaxanthin

2.2 Types of Carotenoids

Pigment	Color	Common in
β-Carotene	Orange	Marigold, calendula
Lutein	Yellow	Sunflower, zinnia
Zeaxanthin	Yellow	Daffodils, marigold
Lycopene	Red	Rose hips, rare cases
Violaxanthin	Yellow	Gladiolus

2.3 Biosynthesis Pathway

Starts from **geranylgeranyl pyrophosphate (GGPP)** → phytoene → lycopene → β -carotene and others

Key Enzymes:

- Phytoene synthase (PSY)
- Phytoene desaturase (PDS)
- Lycopene β -cyclase
- β -carotene hydroxylase

3. Betalains

Category: Nitrogen-containing pigments (tyrosine-derived)

Solubility: Water-soluble (in vacuoles)

Color Range: Red-violet (betacyanins), Yellow-orange (betaxanthins)

3.1 Structure and Properties

- Occur **only in Caryophyllales** (e.g., Bougainvillea, Amaranthus).
- Mutually exclusive with anthocyanins (a plant never has both).
- Derived from **L-tyrosine** → **betalamic acid**.

3.2 Types of Betalains

Group	Pigment Example	Color	Common in
Betacyanins	Betanin	Red-violet	Bougainvillea, beetroot
Betaxanthins	Indicaxanthin	Yellow-orange	Portulaca, amaranth

3.3 Biosynthesis Pathway

- Tyrosine → L-DOPA → betalamic acid
- Betalamic acid + amines → betaxanthins
- Betalamic acid + cyclo-DOPA → betacyanins

Other Pigments (Minor Roles in Flower Color)

4.1 Flavanols and Flavones

- Colorless or pale-yellow compounds.
- Often act as **co-pigments** to stabilize anthocyanin color.
- Found in roses, petunia, and cosmos.

4.2 Chlorophyll

- Normally degraded in flower petals.
- Sometimes persists in **green flowers** (e.g., green zinnia).

4.3 Alkaloids and Tannins

- Rare in flower color development.
- May contribute to browning or dark hues in some petals.

Comparison Summary of Major Pigments

Feature	Anthocyanins	Carotenoids	Betalains
Solubility	Water-soluble	Lipid-soluble	Water-soluble
Location	Vacuoles	Plastids	Vacuoles
Color range	Red to blue	Yellow to red	Yellow to violet
Chemical class	Flavonoids	Terpenoids	Tyrosine-derived
Common plants	Roses, petunia	Marigold, zinnia	Bougainvillea
Shared in plants?	Yes	Yes	Mutually exclusive with anthocyanins

Importance of Flower Pigments in Floriculture

- ✓ **Enhance flower beauty and ornamental appeal** – Pigments create the vibrant colors that make flowers visually attractive for landscaping, décor, and gifting.
- ✓ **Increase market value of flower crops** – Bright and rare-colored flowers are more desirable, boosting their commercial demand and profitability.
- ✓ **Attract pollinators like bees and butterflies** – Different pigments help draw in specific pollinators, ensuring better pollination and seed production.
- ✓ **Aid in developing new flower color varieties** – Pigment knowledge supports breeding and biotechnology for producing novel flower colors.
- ✓ **Improve shelf life and postharvest quality** – Some pigments, especially anthocyanins, act as antioxidants and protect flowers during storage and transport.
- ✓ **Serve as sources of natural dyes and colorants** – Pigments are used in eco-friendly products like herbal cosmetics, textile dyes, and food coloring.
- ✓ **Help plants adapt to environmental stress** – Pigments provide defense against UV rays, heat, and oxidative damage, enhancing plant survival.

Conclusion

Flower pigments are indispensable to the identity and commercial appeal of ornamental plants in floriculture. Beyond beauty, these pigments serve vital ecological and physiological roles. The interplay of genetics, environment, and human innovation continues to expand the spectrum of floral colors available to consumers. With emerging technologies in biotechnology and genomics, the future of pigment manipulation in floriculture promises even more spectacular and diverse blooms.

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