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القسم	التقانات الاحيائية
المادة باللغة الانجليزية	Medicinal plants biotechnology
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محتوى المحاضرة

Introduction

Phytochemistry is the branch of science concerned with the chemical substances produced by plants, especially secondary metabolites with medicinal value. These compounds are responsible for the therapeutic properties of medicinal plants, including antimicrobial, anti-inflammatory, antioxidant, anticancer, and cardioprotective effects.

Understanding the phytochemistry of medicinal plants is crucial for:

- Identifying bioactive compounds.
- Standardizing herbal medicines.
- Discovering lead compounds for drug development.
- Enhancing pharmacological and nutraceutical applications.

4.2 Primary vs. Secondary Metabolites

4.2.1 Primary Metabolites

- Involved in essential plant functions.
- Examples: carbohydrates, proteins, lipids, nucleic acids.
- Indirect medicinal value: energy, nutrition.

4.2.2 Secondary Metabolites

- Not directly involved in growth or development.
- Specialized compounds with ecological and medicinal functions.
- Derived from primary metabolic pathways.

4.3 Classification of Plant Secondary Metabolites

Class	Key Examples	Properties & Uses
Alkaloids	Morphine, atropine, quinine	Analgesic, antimalarial, CNS activity
Flavonoids	Quercetin, kaempferol	Antioxidant, anti-inflammatory
Terpenoids	Menthol, artemisinin	Antimicrobial, antimalarial
Glycosides	Digoxin, sennosides	Cardiotonic, laxative
Phenolics	Tannins, gallic acid	Astringent, antioxidant
Saponins	Dioscin, ginsenosides	Immunomodulatory, expectorant
Lignans and Coumarins	Podophyllotoxin, esculetin	Anticancer, anticoagulant

4.4 Biosynthesis of Secondary Metabolites

4.4.1 Shikimic Acid Pathway

- Produces aromatic amino acids (phenylalanine, tryptophan).
- Leads to phenolics, flavonoids, alkaloids.

4.4.2 Mevalonate (MVA) and MEP/DOXP Pathways

- Produce isoprenoid units.
- Synthesize terpenoids, sterols, carotenoids.

4.4.3 Acetate-Malonate Pathway

- Responsible for the synthesis of fatty acids and polyketides.
- Leads to anthraquinones and certain antibiotics.

Key Enzymes

- Phenylalanine ammonia-lyase (PAL)
- Chalcone synthase (CHS)
- Terpene synthases (TPS)

4.5 Methods of Phytochemical Screening

4.5.1 Qualitative Phytochemical Tests

Used for rapid detection of chemical groups:

- **Alkaloids**: Mayer's, Wagner's, Dragendorff's tests.
- **Flavonoids**: Shinoda test (pink/red with Mg/HCl).
- **Saponins**: Frothing test (persistent foam).
- **Tannins**: Ferric chloride test (blue-black or green).

4.5.2 Quantitative Estimation

- **Total phenolics**: Folin–Ciocalteu method.
- **Total flavonoids**: Aluminum chloride colorimetric assay.
- **Alkaloids and saponins**: Gravimetric or spectrophotometric methods.

4.6 Techniques for Phytochemical Analysis

4.6.1 Chromatographic Methods

Technique	Application
TLC (Thin-Layer Chromatography)	Fingerprinting, purity check
HPTLC	Quantitative multi-compound analysis
GC-MS (Gas Chromatography–Mass Spectrometry)	Volatile and thermally stable compounds
HPLC (High-Performance Liquid Chromatography)	Non-volatile, thermolabile compounds
LC-MS	Metabolite profiling, drug discovery

4.6.2 Spectroscopic Techniques

Technique	Purpose
UV-Vis	Quantification of phenolics, flavonoids
FTIR	Functional group identification
NMR (1H and 13C)	Structure elucidation
MS	Molecular mass and fragmentation patterns

4.7 Factors Affecting Phytochemical Production

Factor	Impact
Genetic factors	Species and chemotypes influence compound profile.
Environmental factors	Light, temperature, water, and soil nutrients affect biosynthesis.
Plant part used	Leaves, roots, bark, or flowers may differ in composition.
Growth stage	Immature vs. mature tissues may vary in metabolite content.
Post-harvest handling	Drying, storage, and extraction method can degrade or preserve actives.

4.8 Role of Phytochemicals in Plant Defense and Human Health

4.8.1 In Plants

- Defense against herbivores and pathogens.
- Attraction of pollinators.
- Allelopathy (inhibiting competing plants).

4.8.2 In Human Health

- Antioxidant and free radical scavenging.
- Antimicrobial and antiviral properties.
- Cancer prevention and treatment.
- Cardiovascular protection.
- Hepatoprotective and neuroprotective roles.

4.9 Applications of Phytochemistry in Biotechnology

Area	Application
Drug development	Screening for lead compounds.
Plant tissue culture	Elicitor-based enhancement of secondary metabolite yield.
Metabolic engineering	Manipulation of biosynthetic genes in plants or microbes.
Quality control	Standardization and authentication of herbal drugs.
Nutraceuticals	Development of health-promoting products.

4.10 Summary

Phytochemistry bridges botany, chemistry, and pharmacology by identifying and analyzing bioactive compounds in medicinal plants. Techniques like chromatography, spectroscopy, and molecular tools are critical in discovering and standardizing phytochemicals for therapeutic use. Understanding biosynthetic pathways and environmental influences allows for biotechnological enhancement of phytochemical production.

Key Terms

- **Secondary Metabolite**: Specialized plant compound with ecological or medicinal function.
- **Phytochemical Screening**: Testing plant extracts for bioactive groups.
- **Chromatography**: Separation technique based on compound properties.
- **Terpenoids**: Largest class of secondary metabolites from isoprene units.
- **Alkaloids**: Nitrogen-containing compounds with pharmacological activity.

Review Questions

1. Differentiate between primary and secondary metabolites with examples.
2. Describe the major classes of plant secondary metabolites and their uses.
3. Explain the role of GC-MS and HPLC in phytochemical analysis.
4. What factors influence the production of phytochemicals in medicinal plants?
5. How are phytochemicals important in drug discovery and biotechnology?

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