These organelles contain and transport digestive enzymes namely β-glucuronidase, deoxyribonuclease, ribonuclease, lipases, protease, peptidase, phosphatases and sulfatases. These enzymes have the ability to hydrolyze large biological polymers like carbohydrates, proteins, lipids and nucleic acids.

Functions

Lysosomes play a very limited role in plant cell. Most of the functions are related to the animal cell.

1. Lysosomes take part in heterophagy i.e., digestion of foreign food particles.
2. Lysosomes also bring about autolysis i.e., digestion of the cell in which it is contained. This autolysis take place after the death of the cell due to which the lysosomal enzymes get released. Therefore, these cell organelles are also termed as the suicidal bags of the cells.

Peroxisomes (Microbodies)

These are simple, spherical, membrane bound vesicles in the cytoplasm, without DNA or ribosomes, containing more than 50 oxidative enzymes.

Functions

1. Peroxisomes protect the cells and the surrounding area from the harmful effects of H_2O_2.
2. They take part in the catabolism of very long chain fatty acids.
3. They also help in the synthesis of phospholipids.

Glyoxysomes

Glyoxysomes are specialized cytoplasmic organelles that develop especially in lipid rich seeds during germination. They contain enzymes for glyoxylate cycle which catalyze the conversion of fats to carbohydrates.

Cytoskeleton

Cytoskeleton is an expanded network of filamentous, proteinaceous structure that occur abundantly in cytoplasm. Only eukaryotic cells contain cytoskeleton. It consists of three major components,

1. Microfilaments
2. Intermediate filaments
3. Microtubules.

Functions

Main functions of cytoskeleton are as follows,

1. Provide mechanical support to the cell
2. Maintains the shape of the cell
3. Helps in motility of the cell
4. Facilitates intracellular transport
5. Facilitates signaling across the cell
6. Karyokinesis (helps in chromosomal movement during the process of cell division).

2. CELL INCLUSIONS

Cell-inclusions refer to the non-living components found in the cytoplasm. These include vacuoles, ergastic substances and calcium oxalate crystals.

1. Vacuoles

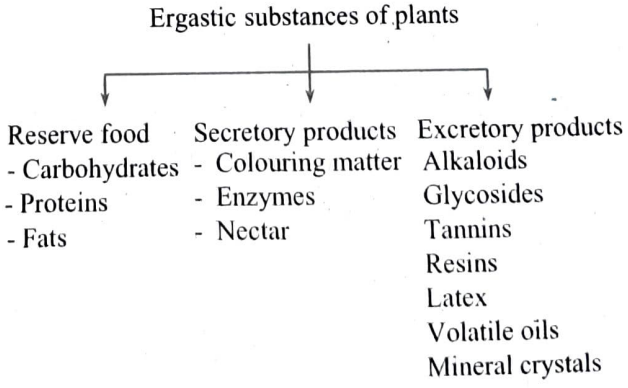
Vacuoles are single membrane, fluid-filled, sac-like structures that occupy a large percent of the total volume of a plant cell. The vacuolar membrane is called *tonoplast* and fluid within the vacuole is called *cell sap*. The various components of the cell sap are mineral salts, sugars, organic acids, oxygen, carbon dioxide, blue and pink coloured pigments (anthocyanins), toxic wastes and secondary products of metabolism.

Functions

1. Tonoplast allows the entry of water, ions and other materials into the vacuole by osmosis.
2. The dissolved anthocyanin pigments in the vacuole are responsible for the colour of flowers, fruits, buds and leaves.
3. Some secondary products and other waste by-products such as calcium oxalate crystals, alkaloids and tannins stored in the vacuoles provide protection from herbivores.
4. Reserve food (like sucrose and mineral salts) stored in the vacuole can be used by the cytoplasm when required.

2. Ergastic Substances

Ergastic substances of plants include all those non-living cytoplasmic inclusions which are basically products of plant metabolism. There are of 3 types.



(a) ***Reserve Food***

Reserve food refers to the excess food that is stored in an insoluble form for further use. When the need arises, these insoluble food reserves are subjected to enzymatic hydrolysis.

Carbohydrates

Both water soluble and water insoluble carbohydrates are utilized as reserve food. Example of water soluble simple sugars (carbohydrates) include glucose, fructose and sucrose. Water insoluble carbohydrates i.e., polysaccharides also function as reserve food. Some examples include starch, inulin, cellulose, mucilage etc.

Proteins

These are basically nitrogenous compounds which may or may not exhibit water solubility. When acted upon by proteolytic enzymes, they degrade to yield amino acids. They are found as an aleurone layer when they exist in an amorphous form (E.g: Maize). On the contrary, when they exist in a crystalline form, they are found as aleurone grains (E.g: Castor seeds).

Fats and Oils

Both fats and oils are composed of fatty acids and glycerol, but differ in their state. Fats are solid while oils exist as liquids at room temperature. Endosperm of certain seeds like sesame, castor, peanut etc., are rich in fats.

(b) *Secretory Products*

Secretory products are specially secreted by the plants and they serve a specific function.

Colouring Substances

These include photosynthetic pigment chlorophyll, anthocyanins, xanthophylls, flavonoids etc. These substances function to impart colour to the plants and leaves which helps to attract insects which in turn help in pollination and seed dispersal.

Enzymes

Enzymes are water-soluble, nitrogen containing compounds that catalyze the hydrolysis of reserve foods such as carbohydrates and proteins.

Nectar

Nectar is a sweet solution secreted by certain specialized glands in numerous flowers. It helps to attract insects which help in pollination.

(c) *Excretory Products*

Alkaloids

Alkaloids are basic, organic, heterocyclic, nitrogenous compounds of plant origin. They occur in plants both in free form and also as salts of organic acids (like quinic acid, citric acid and meconic acid). They are usually colourless, crystalline solids with some exceptions. Alkaloidal salts are soluble in aqueous and organic media. They are basically secreted to protect the plant from herbivores and insects.

E.gs: Quinine, physostigmine, morphine, caffeine etc.

Glycosides

Glycosides are organic compounds which yield glycone (sugar moiety) and aglycone (nonsugar moiety) on acidic or enzymatic hydrolysis. Glycone and aglycone are joined together by a glycosidal linkage. These are colourless, crystalline compounds soluble in water and alcohol, but insoluble in organic solvents. Glycosides are known to exert significant therapeutic effects on mammals.

E.gs: Sennosides (senna), digitoxin (digitalis), glycyrrhizin (liquorice) etc.

Tannins

These are secondary metabolites, which are deposited in the dead tissues of mature plants (like outer cortex, galls, heart-wood). These are non-crystalline, non-nitrogenous organic compounds. Commercially they find extensive application in leather industry. Due to the presence of astringent property, they are used as healing agents in inflammation, burns, piles, leucorrhoea and also as an antidote in alkaloidal poisoning. Tannins are found in arjuna, myrobalan etc.

Resins

Resins are excretory products released from resin ducts. They may be present in solid or semi-solid form and are always insoluble in water.

Gums and Mucilages

Mucilages are generally normal products of metabolism formed within the cell. Gums are pathological products formed upon injury of the plant or due to unfavourable conditions. They are soluble in water but insoluble in most of the organic solvents. Chemically, gums are mixtures of calcium, sodium or potassium salts.

Volatile Oils

These are odourous, volatile, vapourizable principles of plant and animal origin. They are optically active and have high refractive index. They are insoluble in water but soluble in most of the organic solvents. These are used as carminatives, antiseptics, stimulants etc.

E.gs: Ginger, eucalyptus, cinnamon, lemon, coriander etc.

3. **Calcium Oxalate Crystals**

Calcium oxalate crystals are found in certain cells. These water insoluble substances can be seen in various parts of the plant like root, stem, fruits, leaves etc. Different types of calcium oxalate crystals assist in the identification of crude drugs and in the detection of adulterants especially in powdered drugs.

The various types of calcium oxalate crystals are,

(a) *Prisms*: These are simple and regular prism-shaped crystals.

E.gs: Quassia, senna, hyoscyamus, rauwolfia, cascara etc.

(b) *Single Acicular Crystals*: These are long and pointed crystals of calcium oxalate which occur either singly or in bundles.

E.gs: Gentian, cinnamon, squill etc.

(c) *Rhombic Crystals*: These are diamond shaped crystals of unequal length which consists of three axes that are perpendicular to each other.

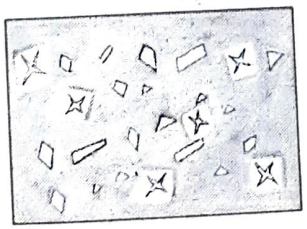
E.gs: Kurchi, mimosa etc.

(d) *Rosettes*: These are aggregates of calcium oxalate crystals arranged in a spherical manner.

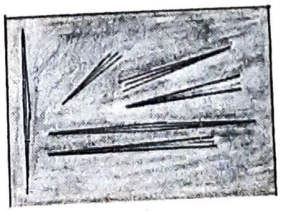
E.gs: Senna, cascara, stramonium, rhubarb etc.

(e) *Sandy Crystals (Microsphenoidal Crystals)*: These are small tetrahedral crystals of calcium oxalate found in clusters.

E.gs: Cinchona, belladonna etc.

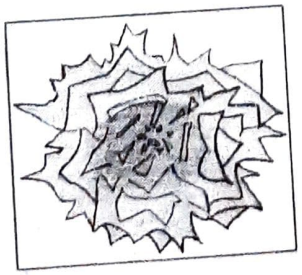


Prisms



Single acicular crystals

Groups of acicular crystals



Rosettes (Druses)

Sandy crystals

Figure: Calcium Oxalate Crystals

CHAPTER

7

NATURAL PESTICIDES

CHAPTER

7

NATURAL PESTICIDES

LEARNING OBJECTIVES

After the completion of this chapter, you should be able to,

- *Define a pesticide and outline its ideal characteristics*
- *Enlist some examples of natural pesticides*
- *Explain the systematic pharmacognostic study of some natural pesticides such as neem, acorus, pyrethrum, nicotine etc.*

1. INTRODUCTION

Certain plants contain components that are toxic to insects. Insecticidal components that are extracted from the plants and applied over infected crops are termed as natural pesticides. Use of natural pesticides for the control of pests is not a new concept. Pyrethrins, nicotine, rotenone, rotinone, acorus etc., have been used since times immemorial on small as well as large scale farming.

Natural pesticides are usually classified according to the type of organism against which they are effective. For instance, insecticides, rodenticides, herbicides, fungicides, molluscicides etc. Among these, the use of herbicides accounts for the largest share in agrochemical market, followed by insecticides, fungicides and other products.

Although the use of naturally derived pesticides continue to increase for their beneficial effects, they are associated with certain harmful effects on human beings and warm blooded animals. Major manifestations include respiratory arrest and stomach poisoning. However, toxicity of these products can be significantly reduced by their selective application. Additionally, these agents are generally highly degradable, hence they become inactive within a few hours or a few days. This property also reduces their negative impact on beneficial organisms.

Ideal Characteristics

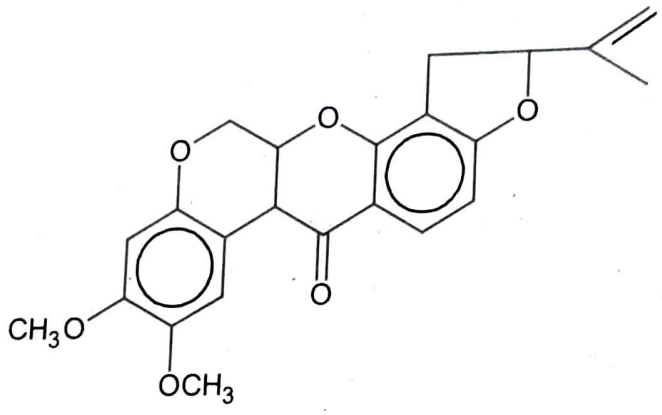
An ideal pesticide should possess the following properties,

1. It should be easily available at an affordable cost.
2. It should be non-toxic towards warm-blooded animals.
3. It should be easy as well as safer to use.
4. It should be non-inflammable.
5. It should not show the residual effects of pesticides.
6. It should cause very little or no harm to the foliage or livestock.

Examples of Natural Pesticides

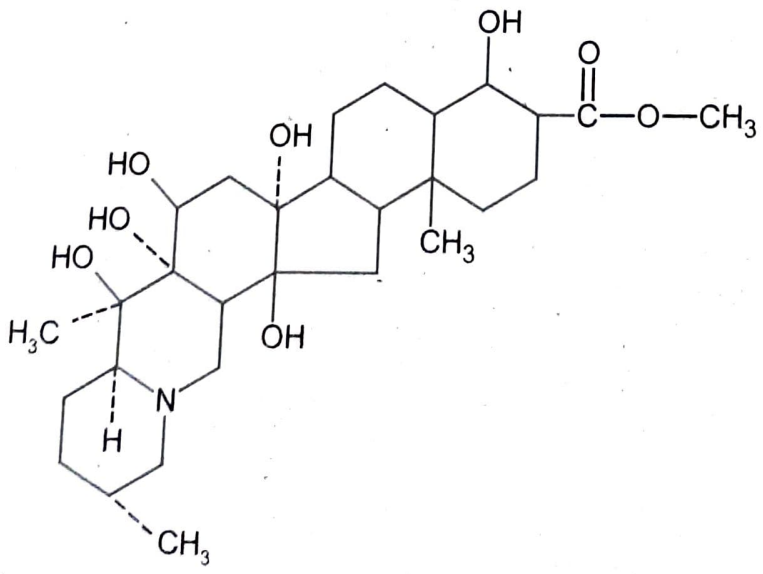
Some commonly used natural pesticides are listed below.

1. ***Margosa (Neem) :*** It is obtained from the dried aerial parts of neem tree, *Azadirachta indica*, belonging to Meliaceae family. Its dried leaves are used against pests generally thriving in stored grain.
2. ***Acorus :*** It is obtained from the plant, *Acorus calmus*. It is effective against aphids and caterpillars.
3. ***Pyrethrum :*** It is obtained from white flowers of the plant, *Chrysanthemum cinerariaefolium*, belonging to Compositae. It is effective against aphids, ectoparasites etc. Pyrethrum contains pyrethrin I and II, which are responsible for its insecticidal action.
4. ***Nicotine :*** It is obtained from tobacco plant, *Nicotiana tabaccum* and *Nicotiana rustica*, belonging to the family Solanaceae. It is a pyridine-piperidine type of alkaloid and possesses contact insecticide action against aphids, thrips, ectoparasites etc.
5. ***Rotenone :*** It is derived from the roots and rhizomes of plants *Derris elliptica*, *Derris malaccensis*, belonging to Leguminosae family. It is used to kill aphids, cattle grubs, vegetable pests etc.



Rotenone

6. ***Sabadilla :*** It is obtained from the dried ripe seeds of *Schoenocaulon officinale*, belonging to Liliaceae. It consists of veratrine alkaloids, cevadine and sabadine which are toxic to insects like bugs, thrips, human lice etc.



Sabadine

7. ***Ryania :*** It is obtained from roots and stems of *Ryania speciosa* (Family-Flacourtriaceae). It is used against borers and other pests.
8. ***Quassia:*** It is obtained from the tree *Quassia amara*. It is effective against saw flies and aphids.

2. NEEM

Synonym

Margosa

Biological Source

Neem consists of all aerial parts of the plant, *Azadirachta indica* that belongs to Meliaceae family.

Location

It mostly grows in South-eastern Asian countries, India, Pakistan, Sri Lanka, Bangladesh, Malaysia, Indonesia, Thailand, Mauritius, Fiji, Japan, South Africa, Australia and East Africa.

Characteristics

1. ***Leaves***

Colour - Dark green

Odour - Characteristic smell of neem

Taste - Bitter

Length - 20-25 cm

Shape - Ovate-lanceolate

Description - Leaves are imparipinnate consisting of a short stalk and are alternately or oppositely arranged on a long slender petiole. They are closely arranged in the form of clusters that are found at the end of the branches.

2. ***Fruits***

Colour - Young and unripe fruits are green in colour whereas ripe and mature fruits are yellow in colour and contain very less quantity of pulp.

Shape - Ovoid and bluntly, pointed

Taste - Bitter

3. ***Seeds***

They contain about 23-31% of fixed oil which has following characteristics,

Colour - Deep greenish yellow to brown

Odour - Garlic-like

Taste - Bitter and acrid

Solubility - It is soluble in chloroform and ether but insoluble in water and alcohol.

4. ***Bark***

Colour - Externally it appears brown in colour whereas internally it occurs as starchy white

Odour - Characteristic smell of neem

Taste - Bitter

Appearance - It is rough and moderately thick with longitudinal and oblique furrows.

Chemical Constituents

Numerous medicinally active chemical compounds have been isolated from various parts of the neem tree. Seed kernels of neem tree consists of nimbolide, 6-deacetylnimbin, salanin, olichinolide B, azadiradione and azadirachtin-k (a recently developed tetraterpenoid).

Table: Active Constituents of Neem

Part of the plant	Active constituent	Uses
1. Leaves	- Azadirachtin - Meliantriol, Salanin, Rutin (NLT 1%w/w)	Insect repellent Antifeedants
2. Seeds	- Nimbin, Nimbidin, - Azadirachtin.	Antiviral agents Insect repellent
3. Flowers	Nimbosterol, Myricitin, Kaempferol.	Insecticides
4. Fruit	Deacetyl, azadirachtinol	It paralyzes the swallowing mechanisms of insects.
5. Bark	- Nimbin, Nimbidin, Nimbinin, - Margolone, Margolonone.	Antiviral agents Antibacterial agents
6. Roots	- Nimbidiol, Nimbolicin, Nimbocidin. - Margocinin, Margocilin.	Antiviral agents Antibacterial agents
7. Neem oil (2% of bitter active constituents)	Nimbin, Nimbidin, Nimbinin, Nimbidiol, Sugiol, Melantriol, Azadiradione.	Spermicidal and contraceptive agents
8. Neem cake (Remnants of oil extraction)	Sulphur content (1.07-1.36%) Nitrogen content (2-3%)	Antinematode agent Coating of fertilizers (urea) with extract of neem cake increases protein content in crops.

Uses

1. Neem oil can be used for its antiseptic, stimulant, anti-inflammatory, antipyretic, antibacterial and hypoglycaemic activities.
2. It is also used to treat rheumatism and skin diseases.
3. It can also induce infertility in males and can be used as an oral or vaginal contraceptive in females.
4. Leaf decoction is used to treat jaundice, worm infestations and numerous skin diseases.
5. Paste of leaves can be applied topically to heal small-pox rashes.

3. ACORUS

Synonyms

Sweet flag, Calamus rhizomes, Vaj, Ghoda vaj.

Biological Source

It consists of dried rhizomes of the medicinal plant *Acorus calamus* belonging to the family Araceae. The drug contains not less than 1.5% of volatile oil.

Location

Acorus is indigenous to Europe and is widely found in England. It is cultivated for its medicinal properties in N. America, Central Asia, Japan, Holland and a vast number of European countries. The herb grows well throughout India. In Himalayas, it grows up to an altitude of 2000 m.

Characteristics

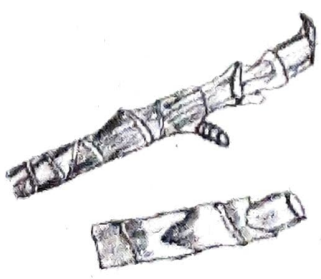
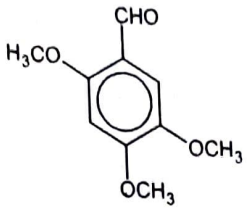


Figure: Acorus Rhizome

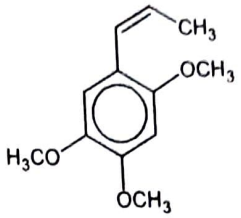
Colour - Brown
Odour - Characteristic and aromatic
Taste - Pungent, bitter and disagreeable
Size - Length : 5-15 cm
Thickness : 1-2 cm
Shape - Cylindrical and surface bears wrinkles
Fracture - Short

Chemical Constituents

1. 1.5-3.5% of volatile oils which contain asaraldehyde along with eugenol and asarone. European acorus contains 10% asarone while N. American acorus is devoid of it.



Asaraldehyde



Asarone

2. Acorine (10%), a bitter glycoside serves as the active constituent.
3. The drug also contains tannins (1.5%), resins (2.5%) and starch.

Uses

1. Acorus is used as an insect repellent.
2. It is useful in convulsions, depression and flatulence.
3. Acorus stimulates the power of self expression and intelligence. It serves as an excellent nervine for children.
4. Nasal administration of the drug is helpful in hysteria, epilepsy and insomnia.
5. It is used as a rejuvenative for brain and nervous system.
6. It is used as a vermifuge, bitter and stimulant.
7. Due to its aromatic and characteristic odour, it is used in the preparation of perfumes and beers.

4. PYRETHRUM

Synonyms

Insect flowers, Pyrethrum flowers, Dalmatian insect flowers.

Biological Source

It consists of dried flower heads of *Chrysanthemum cinerariaefolium*, *C.coccineum* and *c.marshallii* belonging to the family Compositae.

Location

The plant is indigenous to Dalmata and is cultivated in places like Yugoslavia, Kenya, Japan, Switzerland, Spain, Belgium and also in India.

Method of Preparation

Pyrethrum is propagated by means of seeds and splits which are small stems bearing roots. Seeds are sown in nurseries and about 4 month old seedlings are transplanted in the open field in rows about 1m apart. An altitude of 1900-2700 m, annual rainfall of 76-180 cm and night temperature of about 5-15°C favours good yield. Flower heads are plucked by hand from about 4 months old plants or when about 2/3^{rds} of the disc florets are open. These are then dried in sun or in drying chambers at a temperature below 50°C. Finally the flower heads are powdered or made into standard liquid extract and stored. Fresh flowers are non-toxic whereas dried flowers possess insecticidal properties.

Characteristics

Color - Cream or straw coloured

Odour - Aromatic

Taste - Bitter

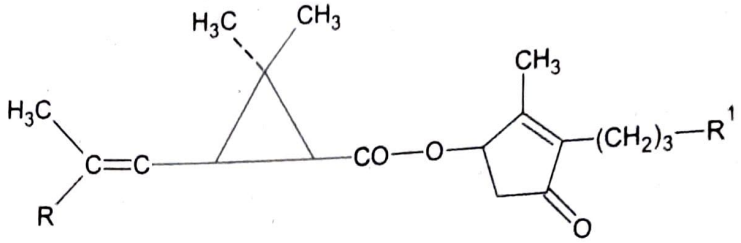
Size - Closed flower heads: 6-9 mm in diameter

Open flower heads: 10-15 mm in diameter

Shape - Flower head is flat with convex receptacle.

Chemical Constituents

1. Esters of chrysanthemic acid (pyrethrin I, jasmolin I and cinerin I).
2. Esters of pyrethric acid (pyrethrin II, jasmolin II and cinerin II) pyrethrin I is lethal to insects whereas pyrethrin II is responsible for knock-down effect.
3. Alcoholic components are present in the form of pyrethrolone and cinerolone.
4. Other constituents include sesquiterpene lactones and triterpenoid pyrethrol.



Component	R	R'
Pyrethrin I	CH_3	$HC{=}CH_2$
Pyrethrin II	$COOCH_3$	$HC{=}CH_2$
Jasmolin I	CH_3	C_2H_5
Jasmolin II	$COOCH_3$	C_2H_5
Cinerin I	CH_3	CH_3
Cinerin II	$COOCH_3$	CH_3

Uses

1. Used as an insecticide and pesticide.
2. Used as contact poison.
3. Used as an aerosol preparation (powder dissolved in kerosene or suitable organic solvents) for controlling pes fleas, lice and ticks on pets.
4. Used as a spray in aircraft to destroy the insect vectors and also to prevent insect-borne diseases.

5. TOBACCO

Nicotine present in tobacco plants possesses insecticidal properties. For detailed pharmacognostic study of tobacc refer Chapter-6.

CHAPTER

4

STUDY OF PLANT CELL

CHAPTER

4

STUDY OF PLANT CELL

LEARNING OBJECTIVES

After the completion of this chapter, you should be able to,

- *List out the various components of a typical plant cell*
- *Explain in detail about constituents of cell wall*
- *Give the composition, structure and functions of various cellular organelles*
- *Describe the various plant inclusions.*

1. PLANT CELL

Introduction

Cell is defined as the smallest, fundamental, structural and functional unit of living organism. Living organisms are made up of cells. Organisms composed of only one cell are called unicellular organisms. Such organisms exist as independent units and perform all the activities independently. On the other hand, multicellular organisms are composed of several cells which coordinate with each other.

When viewed under a microscope, a typical plant cell exhibits the following:

1. Cell wall
2. Plasma membrane/cell membrane
3. Cytoplasm
   (a) Cell Organelles

   Nucleus, Ribosomes, Mitochondria, Plastids, Endoplasmic reticulum, Golgi complex, Peroxisomes, Glyoxysomes, Vacuole and Cytoskeleton

   (b) Cell Inclusions

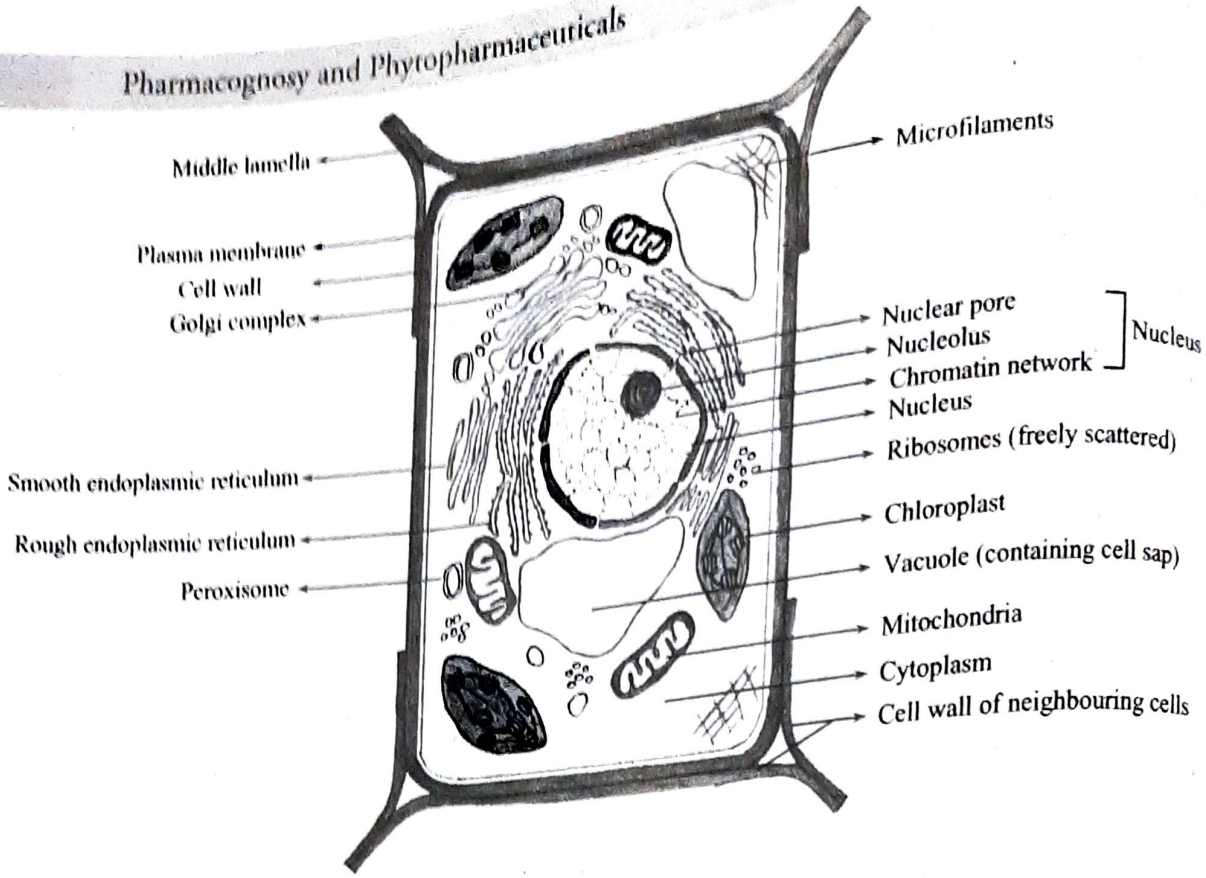


Figure: Ultrastructure of Plant Cell

Cell Wall

External covering of plant cells is known as cell wall. It is a rigid non-living secretion of the cell membrane which is composed of cellulose, pectin, hemicellulose, glycoprotein and lignin. Scientist Robert Hooke was the first to observe cell wall in cork of the oak tree in the year 1665. It is characteristic to only plant cells as it is absent in animal cells. The basic function of cell wall is to protect the constituents present within the cell and also to provide shape to the cell.

Layers of the Cell Wall

Cell wall is further divided into four layers.

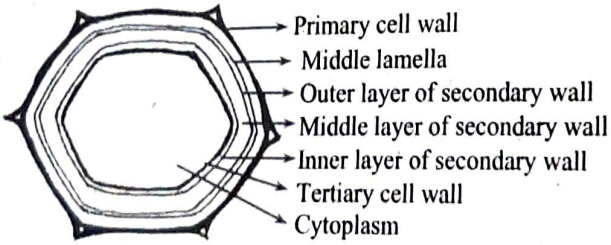


Figure: Cell Wall and Its Layers

1. *Middle Lamella*

Middle lamella is the first layer formed during cell division. It forms the outer wall of the cell and holds the adjacent cells together. It is composed of cellulose, calcium and magnesium crystals.

2. *Primary Cell Wall*

Primary cell wall is formed by the secretion of cellulose and other polysaccharides after the formation of middle lamella. It is found inner to the middle lamellum. It is made up of a rigid skeleton of cellulose microfibrils embedded in a gel-like matrix which is made up of cellulose, hemicellulose, glycoproteins and pectic compounds. The basic function of primary cell wall is to increase the volume of the cell. Certain areas of the primary cell walls are relatively thinner which are referred as primary pit fields. In higher plants, cytoplasm occurs as bridges (called plasmodesmata) which pass through these pit fields and help to connect the neighbouring cells.

3. *Secondary Cell Wall*

Secondary cell wall is located on the inner side of the primary cell wall. It is formed once the cell enlargement stops and the plant cell begins the deposition of more polysaccharides (cellulose, hemicellulose) and other materials such as lignin or suberin. Presence of inelastic materials such as lignin makes it hard and tough. It also bears pits, which are the areas where the cell wall material has not been deposited.

4. *Tertiary Cell Wall*

Tertiary cell wall is a very thin layer, formed on the inner side of the secondary cell wall and composed of cellulose, hemicellulose and xylan. Tertiary cell wall is commonly found in the xylem tracheids of gymnosperms.

Functions

1. Cell wall provides mechanical protection from physical injury, insects and pathogens.
2. It provides tensile strength to the cell by preventing it from rupturing due to turgor pressure.
3. Provides mechanical support and imparts shape to the cell.

Plasma Membrane/Cell Membrane

Plasma membrane is a bilayered membrane present below the cell wall and covers the cytoplasm. It consists of carbohydrates, lipids, phospholipids, sterols (mainly cholesterol) and proteins. The phospholipids, lipids and proteins are arranged in two layers. Each phospholipid molecule possesses two hydrophobic tails and a hydrophilic head hence it is known as amphipathic molecule. Phospholipid molecules are arranged such that the tail of each molecule faces inward while the hydrophilic head of each molecule faces outwards. Hence, the lipid bilayer formed is the basic structural unit of all the membranes. It act as a permeability barrier for many water soluble substances to enter and exit the cell.

Membrane Proteins

S. Jonathan Singer and Garth Nicolson (1972) proposed the widely accepted fluid mosaic model which explains the structure of the plasma membrane.

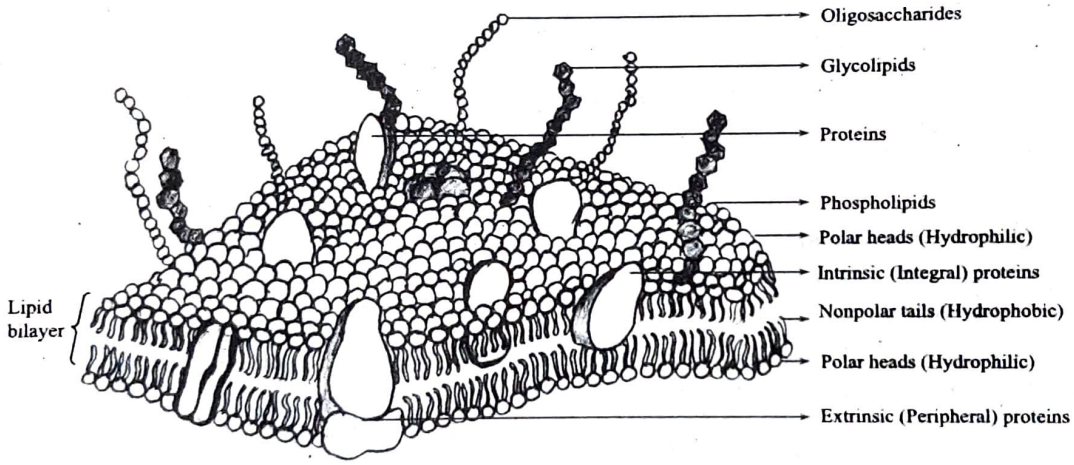


Figure: Fluid Mosaic Model of Plasma Membrane

According to this model, plasma membrane is a basic lipid bilayer structure with a mosaic of proteins embedded in it. These proteins may be categorized into extrinsic and intrinsic.

Extrinsic proteins are bound to the polar surface of lipids and to the hydrophilic ends of other proteins on the surface of plasma membrane. Intrinsic proteins are firmly embedded within the lipid bilayer. Some proteins which completely penetrate the membrane and pass through the width of the membrane are often referred as transmembrane proteins. Integral proteins are amphipathic i.e., they contain both hydrophilic and hydrophobic ends. Hydrophilic ends extend into the aqueous environment (either cytosol or extracellular fluid) while hydrophobic ends fit with the fatty acid tails.

Functions of Membrane Proteins

1. These proteins have an important role in the selective transport of certain substances across the phospholipid bilayer, either serving as channels or active transport molecules.
2. Some intrinsic proteins may function as receptors that bind to hormones and transmit corresponding signals to the interior of the cell.
3. Other intrinsic proteins may exhibit enzymatic activity, wherein they serve to catalyze various chemical reactions related to the plasma membrane.

4. Both extrinsic and intrinsic proteins may also act as linkers that provide structural stability and shape to the cell by anchoring the proteins located in the plasma membranes of the neighbouring cells to one another.
5. Glycoproteins and glycolipids may function as cell-identity markers i.e., they help the cell to recognize other cells of the same origin during tissue formation or may help to initiate an immune response against the antigens.
6. Membrane proteins also take part in activities like attaching cells to one another, changing the shape of the cells during cell division and moving cell organelles within the cell.

Functions of Plasma Membrane

1. Plasma membrane serves as a permeability barrier, regulating the passage of nutrients into the cell and keeping out many harmful substances.
2. Plasma membrane help in regulating the transport of substances. It is permeable to small molecules such as O_2, CO_2, water, nutrients and other essential elements which cross the membrane to enter the cell and waste materials to leave the cell. However, passage of larger molecules such as amino acids and sugars is carefully regulated.
3. Plasma membrane also aids in osmoregulation.

Cytoplasm

The amorphous, translucent and homogenous ground substance that is found in between the plasma membrane and the nucleus is termed as cytoplasm. It is made up of 85-90% water, proteins, fats and inorganic substances. The two basic components of cytoplasm are cell organelles and cell inclusions.

Cytoplasm without any cellular organelles and other substances is termed as *cytosol*. Cytoplasm is a site where all the chemical reactions, essential for the survival of the cell, take place.

Functions

1. It facilitates the exchange of materials between the cell organelles as well as with the extracellular fluid.
2. It functions as a source of raw materials which are essential for the functioning of various cell organelles.
3. It helps to synthesize fats, nucleotides, proteins etc.

Nucleus

In 1831, Robert Brown coined the term nucleus (Latin: Little nut) to describe the globular structure in cells. Nucleus is regarded as the 'headquarter' of the cell as it contains genetic material or DNA that in turn contains instructions required for reproduction and growth of the organism.

Generally, each cell has one nucleus but sometimes the number of nucleus per cell varies. Some of the cells such as human RBCs and sieve tubes of plants lack nucleus.

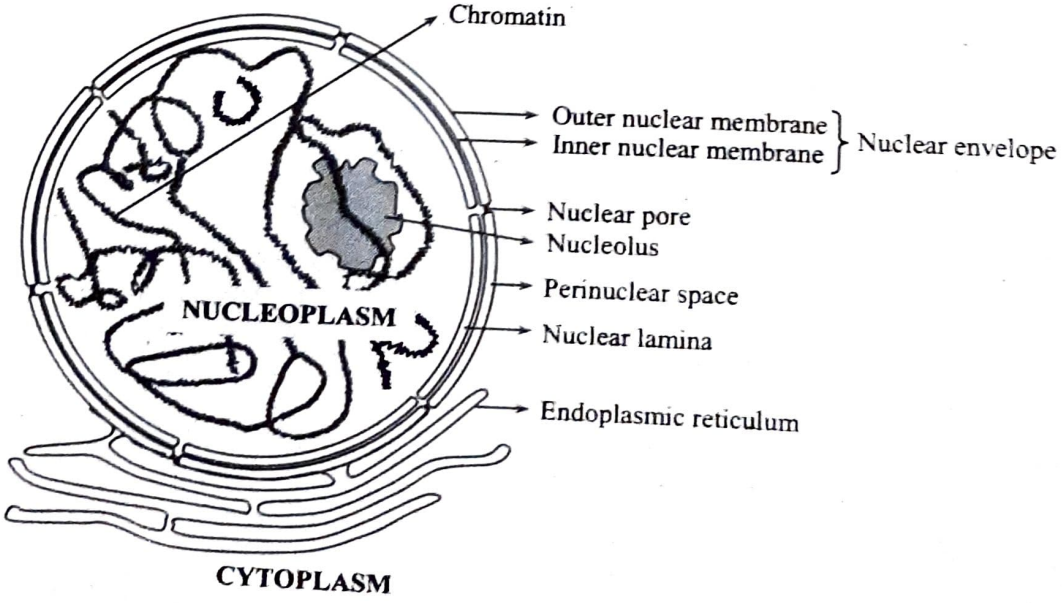


Figure: Nucleus

Following are the components of a cell's nucleus.

1. ***Nuclear Envelope (Nuclear Membrane)***

Nuclear envelope is a double layered membrane composed of proteins and lipids (a phospholipid bilayer) that separates the nucleus from the cytoplasm. Space between the two membranes is referred as perinuclear space. Outer membrane of the nuclear envelope is continuous with the endoplasmic reticulum.

Nuclear membrane has specialized openings called nuclear pores which serve to regulate the passage of RNA and protein molecules between the nucleus and the surrounding cytoplasm.

Functions

1. It functions to maintain the shape of the nucleus.
2. It helps in interaction between the nucleus and the cytoplasm.
3. It acts as a passage for the entry and exit of inorganic ions and other small organic molecules.
4. Large molecules can be phagocytosed or pinocytosed by the nuclear envelope.
5. Nuclear pores in the nuclear envelope function as passages for RNA, proteins and ribosomal subunits.

2. ***Nucleoplasm***

The ground substance of the nucleus which is transparent, homogenous with a gel-like consistency is termed as nucleoplasm. It is lined by nuclear envelope and contains nucleoli and nuclear chromatin.

Functions

1. It maintains the shape of the nucleus.
2. Various enzyme activities take place in the nucleoplasm.
3. It also helps to support the nucleoli and nuclear chromatin.
4. Numerous essential components like nucleic acids (RNA, DNA), nucleotides (ATP, NAD) etc., are synthesized in the nucleoplasm.

3. ***Nucleolus***

Nucleolus (Plural: Nucleoli) is a spherical, membraneless organelle located within the nucleus. It is involved in the synthesis of ribosomes.

Functions

1. It is primarily involved in the biosynthesis and storage of rRNA (ribosomal RNA).
2. It helps in the formation of spindles during cell division.
3. It is responsible for forming ribosomal subunits, by combining rRNAs with ribosomal proteins (received from the cytoplasm).

4. ***Nuclear Chromatin***

When a cell is not involved in active division, its nucleus contains chromatin, a fibrous structure comprising of proteins and DNA. When the cell undergoes division to form new cells, the DNA is duplicated via mitosis so that each of the two daughter cells formed receive a complete copy of the genetic material as that of the parent cell. The chromatin material is associated with DNA and histone proteins.

In eukaryotes, DNA is in the form of linear chromosomes enclosed in the cell nucleus. During the process of cell division, the chromatin organizes itself into chromosomes. Each chromosome contains a molecule of DNA and each DNA molecule consists of many genes that in turn contain instructions to direct the synthesis of proteins with specific functions.

Functions

1. Chromatin fibres contain DNA, a nucleic acid which contains all the necessary genetic information.
2. Synthesis of both structural and enzymatic proteins is controlled by the nuclear chromatin.

Ribosomes

Ribosomes are non-membranous, tiny spherical bodies composed of RNA and proteins. These are smallest among all the organelles and hence can be observed only with the help of an electron microscope. These are present in both prokaryotes and eukaryotes.

The units of ribosomes are described by Svedberg (S) values, based upon their rate of sedimentation in a centrifuge. The spherical granule is composed of two subunits, a large subunit and a small subunit. The two units join together when the ribosome attaches to a messenger RNA in the cytoplasm to produce a protein.

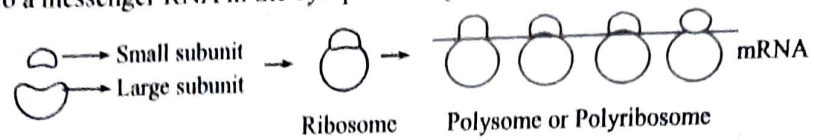


Figure: Subunits and Organization of Ribosomes

In eukaryotes, the ribosome is of 80S type, which is divided into 60S large subunit and 40S small subunit. In prokaryotes, the ribosome is of 70S type; 50S as large subunit and 30 S as small subunit.

Protein synthesis requires the binding of ribosomes to the mRNA strand. When the number of ribosomes bound to the mRNA strand ranges in between 6-8, it is called polyribosome or polysome.

Function

Ribosomes have a very important role in protein synthesis, a process by which proteins are made from individual amino acids. The proteins so produced may function as enzymes, control cellular structures or their functioning.

Mitochondria

Mitochondria (Singular: Mitochondrion) are membrane-bound organelles present in eukaryotic cells. They are the power house of the cell, because the process of ATP generation by oxidative phosphorylation takes place in them. Mitochondria is bound by two membranes.

1. ***Outer Membrane***

   Outer mitochondrial membrane is 6 to 7 nm in thickness, smooth and unfolded. Main components of the outer membrane are phospholipids and cholesterol. It is impregnated with numerous proteins called porins which permit substances with molecular weight less than 10,000 to enter through them. It also serves to maintain the shape of the mitochondria.

2. ***Inner Membrane***

   Inner membrane is 6 to 8 nm in thickness with numerous inward folds called as mitochondrial crests or cristae. These cristae are meant to increase the surface area of the inner mitochondrial membrane. Protein complexes of the respiratory electron transport chain, ATP synthase and ATP/ADP translocators are situated in the inner membrane.

Space between the outer and inner membrane is referred as *intermembrane space* or *perimitochondrial space* which is about 5 to 10 nm in thickness. Mitochondrial matrix contains 70S ribosomes, DNA molecule, some RNA molecules and other components essential for protein synthesis.

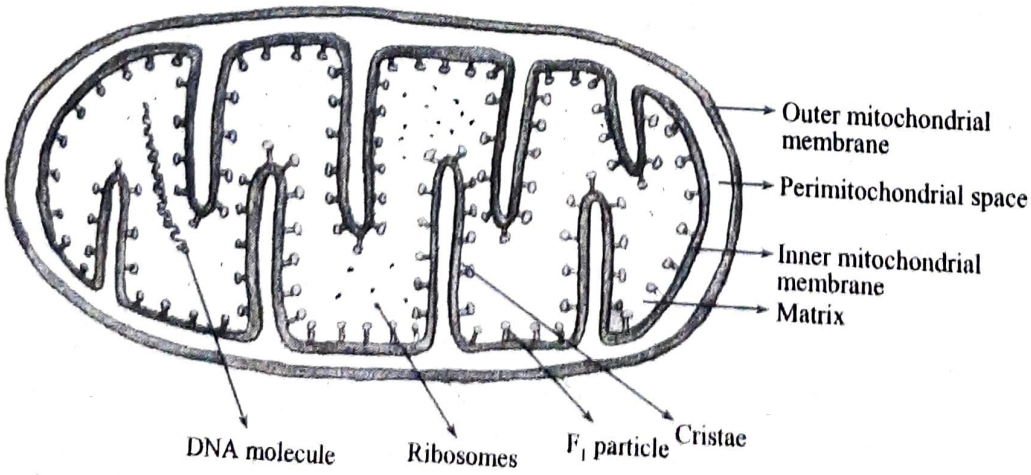


Figure: Structure of Mitochondria

Functions

1. Mitochondria is termed as the power house of the cell, since they are involved in the production of ATP via oxidative phosphorylation and electron transport processes.
2. These are also involved in thermogenesis (production of heat).

Plastids

The term plastid was first coined by Haeckel. These are found in all the plant cells except fungi and cyanobacteria. Plastids contain specific pigments which are responsible for providing colour to the plant part that possesses them. There are 3 types of plastids, classified based on their function and the type of pigmentation.

1. ***Leucoplasts***

These are colourless plastids which function to store organic food material. These are further subdivided as follows,

(a) Amyloplasts store starch

(b) Aleuroplasts store proteins

(c) Elaioplasts store fats.

2. ***Chromoplasts***

Chromoplasts are coloured as they contain pigments which impart red, yellow or orange colour to the plant part that possesses them.

Examples: β-carotene (in carrot), lycopene (in ripe tomatoes) and capsanthin (in capsicum).

3. ***Chloroplasts***

These are small, disc-like structures that contain the green pigment chlorophyll, thus giving the characteristic green colour to the plants. Chloroplasts are double layered, membrane bound, specialized intracellular organelles. Each chloroplast has an outer and an inner membrane with an intermembrane space between them called as *periplastidial space*. The inner space of chloroplast is filled with aqueous solution called as *stroma*. Stroma contains enzymes which are required for synthesizing carbohydrates and proteins.

Stroma also contains flattened discs which are termed as *thylakoid*. Many thylakoids are stacked one above the other, which is termed as *grana* (Singular: Granum).

The number of thylakoids vary from 2 to 100 in one granum. The grana are interconnected by tube-like strands of thylakoid membrane called as stromal lamellae. Thylakoid membrane is considered as the site for photosynthesis and consists of photosynthetic pigments and enzyme complexes for light-dependent reactions and ATP synthesis.

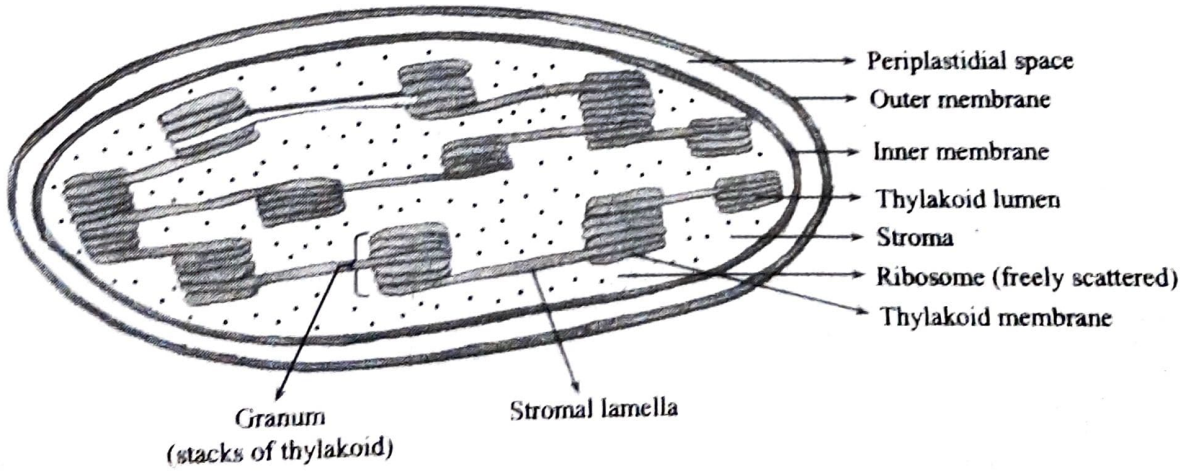


Figure: Chloroplast

Functions

1. Chloroplasts are involved in photosynthesis i.e., the process of synthesis of carbohydrates by using raw materials like water, CO_2 and sunlight.
2. Chloroplasts during the photosynthetic process evolve oxygen which is essential for the respiration of aerobic organisms.

Endoplasmic Reticulum (ER)

Endoplasmic reticulum is an elaborated network of flattened interweaving tubules and sacs interconnected to one another. It is continuous with the outer membrane of the nuclear envelope and extends throughout the cytoplasm of an eukaryotic cell. It is considered to be the largest organelle in majority of the eukaryotic cells.

Endoplasmic reticulum is of two types,

1. *Rough Endoplasmic Reticulum (RER)*

   It is characterized by the presence of 80S ribosomes on the outer surface of the membrane. RER, also termed as the granular ER, is involved in the synthesis and packaging of proteins.

2. *Smooth Endoplasmic Reticulum (SER)*

   SER is characterized by the absence of ribosomes on their membrane surface. It is involved in lipid and carbohydrate metabolism.

Functions

1. It helps in the transport of materials within and outside the cell. The materials are first transferred from RER to SER, then to Golgi complex from here, the lysosomes take up the material and transfer them out of the cell via exocytosis.
2. It provides mechanical support and maintains the shape of the cell.
3. ER contains biosynthetic enzymes such as dehydrogenases, phosphatases, reductases, ATPases etc.
4. It helps to transfer the genetic information from nucleus to other organelles.
5. RER is very important in the synthesis and packaging of proteins.
6. RER is also involved in the formation of vesicles, which help to transfer proteins to the Golgi complex where they undergo further processing.

Golgi Complex (Golgi Body)

Golgi complex is also termed as the *Golgi body* and was first observed by Camilo Golgi. It is an important cell organelle of eukaryotes.

Ultrastructure of Golgi Complex

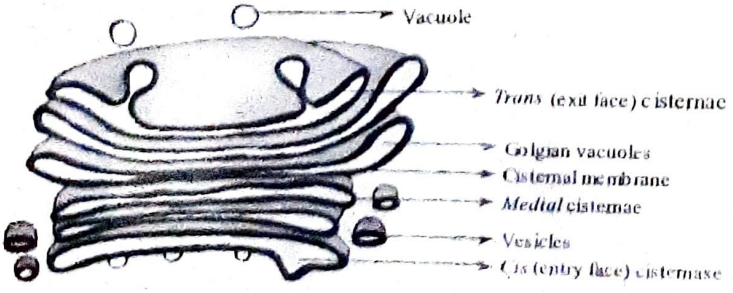


Figure: Ultrastructure of Golgi Complex

Golgi complex is composed of three types of elements; cisternae, vacuoles and vesicles.

1. *Cisternae*

   These are also known as *flattened sacs or saccules*. Cisternae are minute, double-membrane structures which bear swollen ends. These cisternae are curved and stacked one above the other. The swollen ends of the cisternae are termed as *Golgian vacuoles*. Based upon the shape, size and functional activity, cisternae are further subdivided as follows:

   (a) Entry Face Cisternae: These are convex in shape, face towards the rough endoplasmic reticulum (RER) and are also termed as *cis* face. They function to receive the proteins synthesized by the ER and also to modify them.

   (b) Medial Cisternae: These lie in between the entry face and exit face cisternae.

   (c) Exit Face Cisternae: They are concave in shape, face towards the cell membrane and are also termed as maturation face or *trans* face. They modify the proteins, sort and pack them prior to their release.

2. *Vacuoles*

   These spherical elements are found to be closely associated with the exit face cisternae.

3. *Vesicles*

   Vesicles are minute in size which are positioned near the entry or *cis* face cisternae. They function to transfer the materials from the *cis* face to the *trans* face of the Golgi complex.

Functions

1. It is an important organelle involved in the secretion of proteins.
2. In plant cell division, Golgi complex is actively involved in the formation of cell plate during cytokinesis.
3. It is also responsible for the formation of primary lysosome.
4. Helps in the synthesis of glycoproteins and glycolipids.
5. It acts as a passage way for transport of materials within the cell.

Lysosomes

Lysosomes are digestive bodies which digest intracellular components hence are termed as *suicidal bags*. In plants, these are found in meristematic cells. All animal cells except mature mammalian erythrocytes (RBCs) contain lysosomes.

These organelles contain and transport digestive enzymes namely β-glucuronidase, deoxyribonuclease, ribonuclease, lipases, protease, peptidase, phosphatases and sulfatases. These enzymes have the ability to hydrolyze large biological polymers like carbohydrates, proteins, lipids and nucleic acids.

Functions

Lysosomes play a very limited role in plant cell. Most of the functions are related to the animal cell.

1. Lysosomes take part in heterophagy i.e., digestion of foreign food particles.
2. Lysosomes also bring about autolysis i.e., digestion of the cell in which it is contained. This autolysis take place after the death of the cell due to which the lysosomal enzymes get released. Therefore, these cell organelles are also termed as the suicidal bags of the cells.

Peroxisomes (Microbodies)

These are simple, spherical, membrane bound vesicles in the cytoplasm, without DNA or ribosomes, containing more than 50 oxidative enzymes.

Functions

1. Peroxisomes protect the cells and the surrounding area from the harmful effects of H_2O_2.
2. They take part in the catabolism of very long chain fatty acids.
3. They also help in the synthesis of phospholipids.

Glyoxysomes

Glyoxysomes are specialized cytoplasmic organelles that develop especially in lipid rich seeds during germination. They contain enzymes for glyoxylate cycle which catalyze the conversion of fats to carbohydrates.

Cytoskeleton

Cytoskeleton is an expanded network of filamentous, proteinaceous structure that occur abundantly in cytoplasm. Only eukaryotic cells contain cytoskeleton. It consists of three major components,

1. Microfilaments
2. Intermediate filaments
3. Microtubules.

Functions

Main functions of cytoskeleton are as follows,

1. Provide mechanical support to the cell
2. Maintains the shape of the cell
3. Helps in motility of the cell
4. Facilitates intracellular transport
5. Facilitates signaling across the cell
6. Karyokinesis (helps in chromosomal movement during the process of cell division).

2. CELL INCLUSIONS

Cell inclusions refer to the non living components found in the cytoplasm. These include vacuoles, ergastic substances and calcium oxalate crystals.

1. Vacuoles

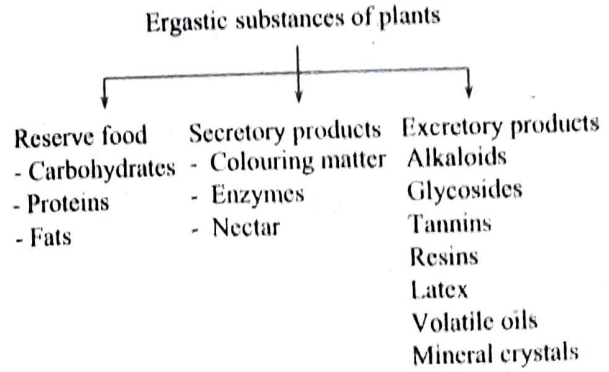
Vacuoles are single membrane, fluid-filled, sac like structures that occupy a large percent of the total volume of a plant cell. The vacuolar membrane is called *tonoplast* and fluid within the vacuole is called *cell sap*. The various components of the cell sap are mineral salts, sugars, organic acids, oxygen, carbon dioxide, blue and pink coloured pigments (anthocyanins), toxic wastes and secondary products of metabolism.

Functions

1. Tonoplast allows the entry of water, ions and other materials into the vacuole by osmosis.
2. The dissolved anthocyanin pigments in the vacuole are responsible for the colour of flowers, fruits, buds and leaves.
3. Some secondary products and other waste by-products such as calcium oxalate crystals, alkaloids and tannins stored in the vacuoles provide protection from herbivores.
4. Reserve food (like sucrose and mineral salts) stored in the vacuole can be used by the cytoplasm when required.

2. Ergastic Substances

Ergastic substances of plants include all those non-living cytoplasmic inclusions which are basically products of plant metabolism. There are of 3 types.



(a) *Reserve Food*

Reserve food refers to the excess food that is stored in an insoluble form for further use. When the need arises, these insoluble food reserves are subjected to enzymatic hydrolysis.

CARBOHYDRATES

CHAPTER

8

CARBOHYDRATES

LEARNING OBJECTIVES

After the completion of this chapter, you should be able to,

- *Define carbohydrates and explain their detailed classification*
- *Elucidate the various identification tests of carbohydrates*
- *Explain the complete pharmacognostic study of some carbohydrate containing drugs such as acacia, agar, isabgol, honey, tragacanth, sterculia gum, guar gum, pectin, starch and bael.*

1. INTRODUCTION

Definition

Carbohydrates are the organic compounds defined as polyhydroxy aldehydes or polyhydroxy ketones or those compounds which yield polyhydroxy aldehydes or polyhydroxy ketones upon hydrolysis. They are made up of carbon (C), hydrogen (H) and oxygen (O) molecules. In simple terms, carbohydrates are 'hydrates of carbon'. These are the main products formed from plants by means of photosynthesis. They act as precursors for the synthesis of other active constituents. These are abundant in plants and animals.

Every carbohydrate consists of the following functional groups,

1. – OH group (alcoholic hydroxy group)
2. $>C=O$ group (keto group) or — CHO group (aldehyde group)

General formula of carbohydrates is $C_m(H_2O)_n$, in which *m* and *n* may be same or different.

Examples

1. Molecular formula of glucose is $C_6H_{12}O_6$ or $C_6(H_2O)_6$, in which *m* and *n* are same.
2. Molecular formula of sucrose is $C_{12}H_{22}O_{11}$ or $C_{12}(H_2O)_{11}$, in which *m* and *n* are different.
3. Certain exceptions include,

Rhamnose – $C_6H_{12}O_5$
Digitoxose – $C_6H_{12}O_4$
} which are carbohydrates but do not correspond to the general formula.

Formaldehyde – HCHO or $C(H_2O)$
Acetic acid – CH_3COOH or $C_2(H_2O)_2$
} which are not carbohydrates but correspond to the general formula.

Classification

Basically, carbohydrates are divided into simple sugars (saccharides) and polysaccharides.

1. Simple Sugars (Saccharides)

Saccharides are low molecular weight carbohydrates, which are water-soluble, crystalline and sweet in taste. These are classified into the following types based on the number of sugar units obtained upon hydrolysis.

(a) *Monosaccharides*

Monosaccharides are the carbohydrates which consist of only a single sugar unit and cannot undergo further hydrolysis.

General formula of monosaccharides is $C_n(H_2O)_n$.

Examples : Glucose, Fructose } $C_6(H_2O)_6$ or $C_6H_{12}O_6$

Glucose or Fructose ($C_6H_{12}O_6$) $\xrightarrow[H_2O]{\text{Hydrolysis}}$ No reaction

Monosaccharides are further classified on the basis of two criteria,

(i) *Carbonyl Functional Group*

Monosaccharides are of two types based on the type of functional group present.

(a) Aldoses - Monosaccharides which consist of an aldehyde as functional group (–CHO) are termed aldoses.
E.gs : Glucose, erythrose, etc.

(b) Ketoses - Monosaccharides which consist of ketone as functional group ($>C=O$) are termed ketoses.
E.gs : Fructose, erythrulose etc.

(ii) *Number of Carbon Atoms*

Number of carbon atoms in monosaccharides may range from 3 to 7. According to this, monosaccharides are categorized as follows,

Number of C-atoms	Class
3 carbon atoms	Trioses ($C_3H_6O_3$)
4 carbon atoms	Tetroses ($C_4H_8O_4$)
5 carbon atoms	Pentoses ($C_5H_{10}O_5$)
6 carbon atoms	Hexoses ($C_6H_{12}O_6$)
7 carbon atoms	Heptoses ($C_7H_{14}O_7$)

Combination of these terms with aldoses or ketoses gives the name *aldohexoses* or *ketohexoses* as tabulated below,

Table: Examples of Aldose and Ketose Monosaccharides

Monosaccharide	Examples
Aldose monosaccharides	
Aldotetrose	Erythrose
Aldopentose	Ribose, Arabinose, Xylose
Aldohexose	Glucose, Mannose, Galactose
Aldoheptose	Glucoheptose, Mannoheptose
Ketose monosaccharides	
Ketotetrose	Erythrulose
Ketopentose	Ribulose
Ketohexose	Fructose, Sorbose
Ketoheptose	Sedoheptulose

(b) ***Oligosaccharides***

Oligosaccharides are the carbohydrates which consist of 2-10 units of monosaccharides and can undergo further hydrolysis. Oligosaccharides are further classified based on the number of monosaccharide units produced upon hydrolysis.

(i) *Disaccharides*

Disaccharides give two units of monosaccharides upon hydrolysis.

Formula of disaccharides is $C_n(H_2O)_{n-1}$, when n = 12 then the formula is $C_{12}H_{22}O_{11}$.

E.gs : Sucrose, maltose, lactose etc.

$$\underset{\text{(Cane-sugar)}}{\text{Sucrose}} \xrightarrow[H_2O]{\text{Hydrolysis}} \text{Glucose + Fructose}$$

$$\underset{\text{(Malt sugar)}}{\text{Maltose}} \xrightarrow{\text{Hydrolysis}} \text{Glucose + Glucose}$$

$$\underset{\text{(Milk sugar)}}{\text{Lactose}} \xrightarrow{\text{Hydrolysis}} \text{Glucose + Galactose}$$

(ii) *Trisaccharides*

Trisaccharides give three units of monosaccharides upon hydrolysis.

Formula of trisaccharides is $C_n(H_2O)_{n-2}$, when n = 18 then the formula is $C_{18}H_{32}O_{16}$ (for raffinose).

E.gs: Raffinose C(in Manna), Gentianose(in gentian), Mannotriose(in Manna), Scillatriose(in Scilla), etc.

$$\text{Raffinose} \xrightarrow{\text{Hydrolysis}} \text{Galactose + Glucose + Fructose}$$

$$\text{Gentianose} \xrightarrow{\text{Hydrolysis}} \text{Glucose + Glucose + Fructose}$$

(iii) *Tetrasaccharides*

They give four units of monosaccharides upon hydrolysis.

Formula of tetrasaccharides is $C_n(H_2O)_{n-3}$, when n = 24 then the formula is $C_{24}H_{42}O_{21}$.

E.g : Stachyose ($C_{24}H_{42}O_{21}$)

$$\text{Stachyose} \xrightarrow{\text{Hydrolysis}} \text{2 Galactose + Glucose + Fructose}$$

2. **Polysaccharides**

Polysaccharides are the carbohydrates which upon hydrolysis yield indefinite number of monosaccharide units. Those polysaccharides which yield pentoses are termed as *pentosans* (like xylan) and those which yield hexoses are termed as *hexosans* (like starch, cellulose, inulin etc.,).

Since the polysaccharides are composed of numerous monosaccharides, they are high molecular weight compounds. Moreover, they are tasteless and relatively less water-soluble when compared to saccharides.

Some important polysaccharides and their derivatives are as follows,

(a) *Cellulose*

It is a polysaccharide which is made up of several glucose units joined by β-1, 4 glycosidic linkages. Cellulose is an important constituent of plant cell wall and is hydrolyzed by an enzyme cellulase present in animals.

(b) *Gums*

These products are obtained when the trees are injured or when they are exposed to unfavourable conditions. Chemically, gums are calcium, potassium and magnesium salts of polyuronides. Upon hydrolysis (achieved by prolonged boiling with acids), gums yield sugars and uronic acids.

(c) *Mucilages*

These are physiological products and chemically are sulphuric acid esters wherein esters are complex polysaccharides.

(d) *Pectin*

Pectin is a water-soluble polysaccharide whose source is the inner rind of the citrus fruits. Pectin is a methoxy ester of pectic acid and finds its use as emulsifying agent, gelling agent, haemostatic agent etc.

Identification Tests for Carbohydrates

For topic refer Chapter-13.

2. AGAR

Synonyms

Agar-agar, Vegetable gelatin, Japanese-Isinglass.

Biological Source

Agar is a dried gelatin like substance obtained from various species of red algae (seaweed) like,

1. *Gelidium amansii* (Family-Gelidaceae) found in Japan
2. *Pterocladia lucida* (Family-Gelidaceae) found in New Zealand
3. *Gracilaria confervoides* (Family-Gracilariaceae) found in Australia.

Location

Japan, Australia, New Zealand, United States of America, South Africa, Korea and India (coastal areas of Bay of Bengal).

Cultivation, Collection and Method of Preparation

Red algae (seaweed) is grown on bamboos which are immersed in deep waters. Seaweed is collected by scrapping it off from the bamboos using rakes between the months of May and October. The product is washed with water, beaten and shaken (to remove shells, adhering sand etc.,) and is bleached by sun rays. When the seaweed is boiled with dilute acidic water for around 5-6 hours, it gets converted to agar. This extract of agar is strained while hot and is collected in wooden trays. Upon cooling, the agar solidifies to give blocks of jelly which is then forced through wire nets thus forming narrow strips of jelly. These strips are dried in sunlight (for several days), thawed, deep-freezed and dried (at 35°C) to remove excess amounts of moisture.

Characteristics

Colour - Yellowish-grey to white or colourless

Odour - Odourless

Taste - Mucilaginous

Size - Sheet : Length 45 to 60 cm
Width 10 to 15 cm

Shape - In the form of strips, bands, sheets, flakes or powder

Appearance - Strips appear translucent

Solubility - Soluble in boiling water, insoluble in cold water and organic solvents

Standards -
(a) Foreign organic matter NMT 1%.
(b) Acid-insoluble ash NMT 1%.
(c) Sulphated ash NMT 5%.
(d) Loss on drying NMT 18%.
(e) The product should not contain starch.

Chemical Constituents

1. Agar consists of two polysaccharides,
   (a) Agarose is responsible for the gel strength of agar. It is composed of *d*-galactose and 3,6-anhydro-*l*-galactose (agarobiose).
   (b) Agaropectin is responsible for the viscous nature of agar solution. It is a sulphonated polysaccharide consisting of galactose and uronic acid moieties esterified by sulphuric acid.
2. It also consists of 3.5% of cellulose and 6% of nitrogenous substances.

Identifying Tests

1. 1.5 gram agar powder + 100 ml water —(Boil and cool to room temperature)→ Stiff jelly
2. Agar powder on a glass slide + Ruthenium red solution —(Observed under microscope)→ Particles acquire pink colour (Indicates mucilage)
3. 0.2% agar solution + Tannic acid solution → No precipitate
4. *Distinction from Acacia and Tragacanth*

   Aqueous agar solution + 0.05 N Iodine solution → Crimson to brown colour
5. *Distinction from Starch, Acacia and Tragacanth*

   Agar solution + Conc. HCl

   ↓ Boil for 5-10 mins

   Above solution + $BaSO_4$

   ↓

   White precipitate (due to SO_4^{2-} ions)

Uses

1. Used as an emulsifying agent in the preparation of emulsions.
2. Used as a bulk laxative in constipation.
3. Used in preparing jellies and other confectionery products.
4. Used as a nutrient medium for bacterial cultures.
5. Used as a gelling agent in suppositories and as a tablet excipient.

3. ISABGOL SEEDS

Synonyms

Isabgol, Ispaghula, Isabgul, Spogel seeds, Indian psyllium.

Biological Source

It consists of dried ripe seeds of *Plantago ovata* (Family - Plantaginaceae).

Location

Persia and India (Gujarat, Punjab, Rajasthan and Maharashtra).

Cultivation and Collection

Isabgol plant is a rabi crop, grown during the months of November to April. Seeds of this plant are sown during November by broadcasting method. It requires loamy soil with pH of 7.5 to 8.5 and cool and dry weather for its cultivation. The field is irrigated once in 10 days. Fertilizers like ammonium sulphate, nitrogen and phosphorous pentoxide are added to increase the yield of the crop. During its growth, plants should be protected from pests. Hence these are sprayed with 5% aldrin to control root eaters and aerofungin to control mild-dew.

Harvesting is done during March or April, when the fruits are fully ripe. These fruits are collected by cutting the plant above the ground level, converting into sheaves and then drying under the sun. Seeds are separated from the fruits by thrashing and sieving.

Macroscopy

Colour - Pinkish grey to brown

Odour - Odourless

Taste - Mild (bland) and mucilaginous

Size - Length 10-35 mm, width 1-1.75 mm.

External appearance - (a) Convex side - Consists of a reddish brown oval spot in the centre of the seed.

(b) Concave side - Consists of hilum which is covered by a thin membrane.

Nature - Hard, transparent and smooth in texture. It is derived from amphitropous ovules.

Microscopy

Transverse section of an isabgol seed shows the following characteristics,

1. *Epidermal Layer* : The outer epidermal layer contains cells which are large in size and mucilage which exudes when brought in contact with water.
2. *Pigment Layer* : It is present beneath the epidermal layer in a collapsed state.
3. *Endosperm* : It is parenchymatous in nature. Outer layer of the endosperm of seed consists of thick walled palisade cells, whereas inner layer consists of thick walled, irregularly shaped oily cells.
4. *Embryo* : It is straight and derived from amphitropous ovules. The embryo consists of two cotyledons.

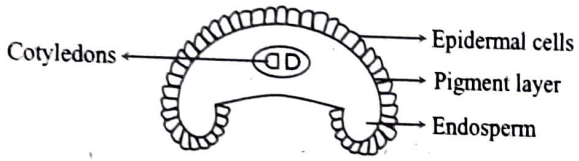


Figure: Transverse Section of Isabgol Seed

Chemical Constituents

Chemical constituents are present in both isabgol seeds and husk.

1. Epidermal cells contain 10% mucilage. Husk contains greater amount of mucilage than the seeds.
2. Mucilage comprises of pentosans and aldobionic acid.

$$\text{Pentosans} \xrightarrow{\text{Hydrolysis}} d\text{-Xylose} + l\text{-Arabinose} + d\text{-Galactose}$$

$$\text{Aldobionic acid} \xrightarrow{\text{Hydrolysis}} d\text{-Galacturonic acid} + \text{Rhamnose}$$

3. Endosperm and embryo consists of proteins and fixed oil.
4. Fixed oil consists of unsaturated fatty acids and β-sitosterol (suppresses cholesterol in blood).

Identifying Tests

1. Isabgol seeds + Water ⟶ Mucilage layer surrounds the seeds.
2. Swelling Factor: It is used to determine the purity of the drug. Around 1 g of isabgol seeds are taken in a 25 ml measuring cylinder. 20 ml of water is added to it. The contents are left undisturbed for about 24 hours except for occasional shaking. The volume occupied by the seeds after 24 hrs is known as the swelling factor, which for isabgol seeds ranges in between 10 to 14.
3. *Differentiating Test from Acacia*

Isabgol seeds + Ruthenium red solution ⟶ Pink colour due to mucilage

Uses

Seeds and husk of isabgol have the following uses,

1. Used as a laxative in constipation
2. Used in the treatment of both amoebic and bacillary dysentery
3. Used as a demulcent and emollient
4. Used in enteric coating of tablets and as disintegrating agents for tablets
5. Used in sustained release drug formulations
6. Used in kidney infections and febrile conditions
7. Used in cosmetics due to its glaring property
8. Used as a stabilizing agent in the preparation of ice creams
9. The crushed seeds are used as poultice to treat rheumatic pain

4. ISABGOL HUSK

Synonyms

Isapghulae testa, Isafgol ki bhoosi.

Biological Source

Isabgol husk consists of dried seed coats of isabgol seeds obtained from *Plantago ovata* (Family-Plantaginaceae).

Method of Preparation

Isabgol seeds are processed further to remove their seed coats (known as husk) and are freed from any foreign organic matter. These are then crushed in stone grinders to remove the seed kernels. The crushed material is winnowed to separate the husk and seed kernels. The husk is then sieved and graded accordingly.

Characteristics

Colour	-	White-to pale buff
Odour	-	Odourless
Taste	-	Mucilaginous
Size	-	Length 2-3 mm
		Width 0.5-1 mm
Shape	-	Boat shaped, lanceolate or oval-shaped flakes
Swelling factor	-	20

Note: Microscopy, chemical constituents, identifying tests and uses of isabgol husk are same as that of isabgol seeds.

5. GUAR GUM

Synonyms

Jaguar gum, Guar flour, Guaran

Biological Source

It is obtained by grinding the endosperms of the seeds of *Cyamopsis tetragonolobus* (Family-Leguminosae).

Location

United States of America, Pakistan and India (Rajasthan, Gujarat, Maharashtra, Karnataka).

Method of Preparation

Seeds of the plant are freed from debris, foreign organic matter and ground to get bifurcated seeds (separated into husk and cotyledons). The husk so obtained consists of fibrous material, whereas cotyledons contain the embryo. Seeds consist of 14-17% hull, 30-40% endosperm and 45-50% germ. Endosperm (containing the crude guar gum) is separated from the cotyledons by pulverizing (grinding) for 15 minutes. During pulverization, the endosperm remains as such, whereas the cotyledons get powdered which is separated by sifting. The endosperm so obtained (free from the undesirable cotyledons) is again pulverized and sifted simultaneously about 5-6 times to get a white coloured product. The product obtained is passed through sieve no 40-60 to obtain granules and powdered forms of guar gum.

Characteristics

Colour - Pale yellowish-white or colourless
Odour - Characteristic
Taste - Mucilaginous
Shape - Angular and irregular when examined in lactophenol reagent under a microscope.
Solubility - (a) Forms a translucent suspension when comes in contact with water.
(b) Insoluble in alcohol and other organic solvents but soluble in water.
Standards - (a) Acid-insoluble ash NMT 0.5%.
(b) Ash value NMT 1%.
(c) Loss on drying NMT 8%.

Chemical Constituents

1. Guar gum consists of,
   (a) Water soluble portion (85% of gum) which is known as *guaran*

   Guaran $\xrightarrow{\text{Hydrolysis}}$ 65% galactose + 35% mannose
   (Linked by glycosidic bonds)

   (b) Water insoluble portion.
2. It also consists of 5-7% proteins.
3. Endosperm of the seeds contain mucilage known as galactomannan.

Identifying Tests

1. Guar gum solution + 2% Lead acetate solution ⟶ Precipitate
2. Guar gum solution (0.5%) + Litmus paper ⟶ No colour change
   (Indicates the neutral nature of guar gum)
3. *Differentiating Test from Tragacanth and Starch*
   Guar gum + Iodine solution (weak) ⟶ No olive green colour or blue colour
4. *Differentiating Test from Agar*
   Guar gum solution + Ruthenium red solution ⟶ No pink colour
5. *Differentiating Test from Acacia*

   0.5 g guar gum + 20 ml of water
   ↓ Shake vigorously
   Above solution + 0.5 ml H_2O_2 + 0.5 ml 1% alcoholic benzidine solution
   ↓
   No blue colour formed

Uses

1. Used as a pharmaceutical aid. Its thickening power is 5-8 times higher than starch. It is used as a binding and disintegrating agent in the preparation of tablets.
2. Used as an emulsifier.
3. It is used as a bulk laxative in constipation.
4. Since it acts as an appetite suppressant, it is used in the treatment of obesity.
5. It is used in the treatment of peptic ulcer.
6. It is used in paper and food industries.
7. Used as a filtering agent and in the preparation of pharmaceutical jellies.
8. It decreases cholesterol levels.
9. It is believed to have oral hypoglycaemic activity.
10. Hydrolytic products of guaran, galactose and mannose are used in thin layer chromatography (TLC).

6. ACACIA

Synonyms

Gum acacia, Acacia, Indian gum, Gum arabica.

Biological Source

It is the dried gummy exudate obtained from the stems and branches of the plant *Acacia arabica* (Family-Leguminosae).

Location

Sudan (in the territory of Kordafan which provides 85% of the world supply), Sri Lanka, Africa, Morocco and India (Punjab, Rajasthan and Western Ghats).

Cultivation and Method of Preparation

Acacia is an evergreen thorny tree found in dry monsoon Indian forests and attains a height of about 6 metres. Gum is collected from these wild trees twice in a year. Transverse incisions are made on the trees with the aid of an axe, without damaging the cambium and xylem. If the xylem gets exposed, white ants may enter the plant due to which the gum is not produced. The gum exudes from the incisions made and the product (tears) is collected after drying (for 20-30 days). It is made free from bark and foreign organic matter. It is then dried in the sun, which leads to partial bleaching of the gummy exudate. Bleaching of the gum is indicated by the white colour and transparency of the tears. This process of change in the tears of the gum during bleaching is known as *maturation of the gum*.

Characteristics of Tears

Colour	-	Gummy exudate (tears) vary in colour from creamish brown to red. Powdered form of the product is light brown in colour.
Odour	-	Odourless
Taste	-	Mucilaginous
Size	-	Varies
Shape	-	Irregularly shaped
Nature	-	Brittle with minute fissures
Appearance	-	(a) When the tears are intact, they are glossy in nature. (b) When the tears are broken, they exhibit angular fragments with glistering surfaces.
Fracture	-	Conchoidal
Solubility	-	Soluble in water and insoluble in alcohol.
Standards	-	(a) Moisture content of pure drug NMT 15%. (b) Tannins, starch and dextrin should be absent in 5% ash of the gum.

Chemical Constituents

1. Main constituent is arabin (mixture of calcium, magnesium and potassium salts of arabic acid).
2. Arabic acid $\xrightarrow{\text{Hydrolysis}}$ *l*-arabinose + *l*-rhamnose + *d*-galactose + *d*-glucuronic acid
3. Contains enzymes such as oxidase, peroxidase and pectinase.

Identifying Tests

1. 1 ml gum acacia solution + 2 ml water + Few drops of lead subacetate → Gelatinous precipitate
2. *Differentiating Test from Guar gum*

   5 ml of gum acacia solution + 0.5 ml hydrogen peroxide + 0.5 ml alcoholic benzidine solution → Blue colour due to enzyme oxidase

   Guar gum does not give any colour with this reagent
3. *Differentiating Test from Agar and Isabgol*

   Gum acacia + Ruthenium red solution → No pink colour

Tests for Purity

1. 1 ml of gum acacia solution + 10 ml of water —(On standing for few hours)→ No sedimentation of particles indicates that the substance is pure

2. 1 ml of gum acacia solution + 0.1% $FeCl_3$ ——→ Blue/Black colour (Indicates the presence of tannins)

3. 1 ml of gum acacia solution + 4 ml of water
   ↓ Boil and cool
   Above mixture + 2 drops 0.1 N iodine soluton
   ↓
   Blue colour (Indicates the presence of starch) | Brown colour (Indicates the presence of dextrin)

4. 1 ml of gum acacia solution + 4 ml of water + Lead acetate solution ——→ No precipitate should be produced with the pure product

Uses

1. Used as a demulcent (provides soothing or protective effect on the mucosa of the alimentary canal).
2. During haemolysis, it is administered via i.v route.
3. Used as a suspending agent especially for resinous mixtures.
4. Used as an emulsifying agent for fixed oils, volatile oils and liquid paraffin.
5. Used in the process of microencapsulation along with gelatin.
6. Used as a binder for tablets, pills, lozenges, pastilles, etc.

7. HONEY

Synonyms

Purified honey, Mel, Madhu, Shehad, Asal.

Biological Source

Honey is a sugary secretion or saccharine liquid obtained from the nectar of flowers, processed and deposited in honey combs by the honey bees *Apis mellifera* and *Apis dorsata* (Family - Apidae).

Location

Africa, Australia, England, New Zealand, California and India.

Collection and Preparation

Nectar present in the flowers comprises of 25% sucrose and 75% water. This nectar is sucked by worker bees through a hollow tube called proboscis. Nectar is stored in the honey-sac or crop present in the abdomen of the bees. Saliva of the worker bees consists of invertase enzyme. Sucrose (from the nectar) and invertase enzyme (in saliva of bees) enter the honey sac, where they get hydrolysed into invert sugar.

$$\text{Sucrose} \xrightarrow{\text{Invertase}} \text{Invert sugar}$$

A part of the invert sugar is utilized by the worker bee for nutrition, while the rest is regurgitated into the cells of the beehive. Water initially present in the sucrose gets evaporated and the honey gets formed within three days on deposition of the invert sugar. Honey comprises 80% invert sugar and 20% water. When the honey cells get filled with honey, the worker bee seals it with wax (bees wax).

The honey comb is smoked to drive away the honey bees. Honey is then removed from the honey comb by applying pressure on it or honey is allowed to drain by itself. Honey collected is heated up to a temperature of 80°C, cooled rapidly and then left undisturbed for certain time period. This method is especially utilized when honey has been obtained by exerting pressure onto the honey comb. It helps to remove any impurities which float at the surface and also helps to prevent the fermentation of honey. Another method of obtaining honey in pure form from the honey comb is by centrifugation.

Characteristics

Colour - Pale yellow or yellowish brown

Odour - Pleasant and characteristic

Taste - Sweet to faint acrid

Nature - (a) When fresh, honey is a clear, syrupy liquid.
(b) On long standing, honey becomes translucent, opaque, granular and tends to crystallize.

Solubility - Soluble in water but insoluble in alcohol and other organic solvents.

Standards - (a) Weight per ml : 1.35 gram.
(b) Specific rotation : + 3° to – 10°.
(c) Total ash value : 0.1-0.8%
(d) Honey should pass the limit tests for chlorides and sulphates.

Chemical Constituents

1. Honey comprises of 35% glucose, 45% fructose and 2% sucrose.
2. It also consists of maltose, gum, dextrin, volatile oil and pollen grains (indicative of the source of honey).
3. It also includes formic acid, succinic acid, acetic acid, colouring matter, enzymes (invertase, diastase and inulase), traces of vitamins and proteins.

Identifying Tests

1. 1 ml of honey solution + 1 ml of Fehling's solution $\xrightarrow[\text{water bath}]{\text{Warm on}}$ Brick red precipitate (Presence of reducing sugars)

2. *Fiehe's Test*

10 ml honey shaken with 5 ml ether for 5-10 minutes

↓

Separated ethereal layer + Resorcinol in HCl

↓

Red colour developed is transient (Indicates pure honey)	Red colour developed persists for some time (Honey adulterated with artificial invert sugar)

Uses

1. Used as a sweetening agent and as a nutritive for infants and patients.
2. Possesses antiseptic property, hence applied to burns.
3. Due to its demulcent action, honey is used in expectorant preparations.
4. It is used in cosmetics, usually in the preparation of creams and lotions.
5. It has mild laxative (aperient) action.
6. Used as a vehicle for ayurvedic formulations.

8. PECTIN

Synonyms

E_{440}, kaopectate.

Biological Source

Pectin is a complex purified polysaccharide obtained from the inner part of the rind of citrus peels by acid hydrolysis. Citrus fruits include *Citrus aurantium*, *Citrus simon* (Family - Rutaceae).

Location

United States of America, United Kingdom and Switzerland produce pectin on commercial basis.

Method of Preparation

Pectin can be isolated from the following sources,

Table: Sources of Pectin

Source	Content of pectin
Sunflower heads	5%
Carrots	10%
Orange peel	10-12%
Apple pomace, lemon peel	10-15%
Papaya, guavas, mangoes	Rich source

(a) ***Isolating Pectin from Lemon Peels***

(i) About 20 times water is added to fresh or preserved lemon peels.

(ii) The above solution is boiled at 90°C for half an hour.

(iii) pH of the solution is maintained between 3.5 to 4.0 with lactic acid, citric acid or tartaric acid.

(iv) After boiling, the peels are pressed to obtain a solution which is then rendered clear by sedimentation or centrifugation.

(v) Proteins and starch present in the solution are removed by enzymatic hydrolysis. To deactivate the enzymatic property, the solution is further heated and decolourized with activated carbon.

(vi) Water soluble organic solvents are used for precipitating the pectin.

(vii) The pectin so obtained is washed and dried in a vacuum drier.

(viii) It is then packed in tightly closed containers (due to its hygroscopic nature) or polyethylene bags.

Note : As pectin is incompatible with calcium and its salts, due care should be taken to prevent its contact with metallic salts during the extraction procedure.

(b) ***Isolating Pectin from Orange Peels***

(i) Around 50 g of orange peels are taken and thoroughly washed.

(ii) These are then cut into small pieces and immersed in a beaker containing 200 ml demineralized water.

(iii) pH is maintained at 4.0 with lactic acid, citric acid, tartaric acid or 3N sulphuric acid.

(iv) The orange peels are boiled at 90°C for an hour with occasional stirring.

(v) The solution is filtered while hot and the filtrate is allowed to cool which is then slowly poured into three volumes of acidic isopropanol, ethanol or acetone.

(vi) The solution is stirred thoroughly to enable the precipitation of pectin.

(vii) The pectin so obtained is filtered through nylon cloth and washed several times with small quantity of 70% isopropanol or acetone (to make the solution free from acidic ions).

(viii) Pectin obtained from orange peels is dried in a vacuum drier and stored in tightly closed containers.

Characteristics

Colour - Creamish yellow

Odour - Odourless

Taste - Mucilaginous

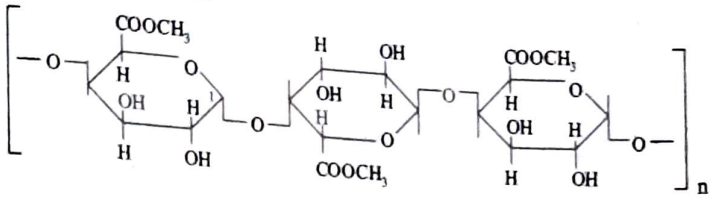
Nature - Present as coarse or fine powder which has hygroscopic character.

Solubility - (a) 1 part of pectin is soluble in 20 parts of water.
(b) Insoluble in alcohol and other organic solvents.

Standards - (a) Acid-insoluble NMT 0.4%.
(b) Ash value NMT 4%.
(c) Loss on drying ash NMT 10%.
(d) Microbial limits: 1 g of pectin should be free from *Salmonella*.

Chemical Constituents

1. Pectin is a methoxy ester of pectic acid.



Pectin

2. Pectin $\xrightarrow{\text{Hydrolysis}}$ Methyl alcohol + *d*-galacturonic acid + Galactose + Arabinose.
3. It is a polyuronide consisting of pectic substances like protopectin, pectin, pectinic acid and calcium pectate.

Identifying Tests

1. 1% aqueous pectin solution + Alcohol in equal quantity ⟶ Translucent gelatinous precipitate
2. 10% aqueous pectin solution $\xrightarrow{\text{Heat and cool}}$ Stiff jelly is formed
3. Pectin + Water ⟶ Lumps are formed $\xrightarrow{\text{Heating}}$ Lumps dissolve in the solution.
   The solution so formed is clear when observed under transmitted light and cloudy when observed under reflected light.
4. *Differentiating Test from Tragacanth*

5 ml pectin solution + 1 ml KOH (2%) solution
↓ Set aside for 15 mins
Transparent gel is formed + Dil. HCl
↓ Shake well
Gelatinous precipitate
↓ Boil
White, flocculent precipitate

Uses

1. Due to its absorbing property, pectin is used in the treatment of diarrhoea in infants and children.
2. Acts as a haemostatic agent for both internal and external haemorrhage.
3. Used as an emulsifier and jelling agent.
4. Used in microencapsulation for sustained release action.
5. Used in cosmetic products.
6. It is effective in controlling blood cholesterol levels and prevents cardiovascular diseases.
7. Used as a thickening agent in condiments like sauces, ketchup etc.

Synonym

Amylum

Biological Source

Starch is a reserved food of plants found as polysaccharide granules and is obtained from,

1. Maize grains (*Zea mays*)
2. Rice grains (*Oryza sativa*) } Family-Graminae
3. Wheat grains (*Triticum aestivum*)
4. Potato tubers (*Solanum tuberosum*) – Family-Solanaceae

Location

Starch is commercially produced in India, China, Japan, Argentina, USA and several other tropical and sub-tropical countries.

Methods of Preparation

Method of preparation of starch varies with the part of the plant from which it is extracted.

1. ***From Maize***

Maize grains are thoroughly washed to remove any adhering dirt and foreign organic matter. The grains are soaked in warm water containing 0.2% sulphurous acid (at a temperature of 50°C) for two days. Sulphurous acid is added to prevent the fermentation process. Softened grains are disintegrated by attrition mill, thereby liberating starch. During the process of disintegration, germ (embryo) gets separated from the grains. Crushed grains and the endosperm (containing fixed oil) are separated by adding water. The germ floating on the surface of water is collected to prepare germ oil or corn oil, a source of vitamin E and fatty acids like linoleic acid and linolenic acid. Starchy material which is obtained from the softened grains comprises gluten, which gets separated when passed through a sieve shaker of 160 mesh followed by washing. Corn starch is then obtained by repeatedly washing the product with cold water and later subjecting it to drying process.

2. ***From Wheat***

Wheat flour is kneaded into dough with water and allowed to stand for an hour during which the gluten present in the dough swells. The dough is then made into lumps and passed through grooved rollers by subsequently wetting them with water. This process enables the collection of starchy liquid, which is devoid of gluten. The starch is collected by washing repeatedly with cold water and subjecting it to sedimentation. The product obtained is dried and sifted.

3. ***From Rice***

Rice starch is prepared from broken rice grains. It is obtained by macerating the grains with water containing 0.4% dilute sodium hydroxide. This process dissolves the gluten but keeps the starch granules intact. The softened grains are ground in stone mills with dilute sodium hydroxide, thus forming a suspension. This suspension is repeatedly washed with water and subjected to centrifugation to obtain starch. The damp starch obtained is subjected to drying in an oven at a temperature of 50-60°C for 2 days.

4. ***From Potatoes***

Potatoes are washed and peeled to remove any adhering foreign matter and dirt. They are then cut into small pieces and pulverized into a slurry. The slurry obtained is filtered through a suitable mesh to remove the cellular matter. Potatoes lack gluten, hence the process of obtaining starch is easier. The obtained slurry is repeatedly washed, subjected to sedimentation and purified by centrifugation process. It is then dried and passed through sieves to obtain fine potato starch.

Characteristics of Starch Granules

Colour - White, light yellow or cream colour

Odour - Odourless

Taste - Mucilaginous

Microscopy

(a) Hilum - It is the starting point of formation of granules. It is not clearly visible when observed under a microscope, especially in case of small granules.

(b) Striations - These are concentric rings surrounding the granules. They are clearly visible in larger granules.

Starch comprises of two polysaccharides,

Amylose or β-amylose which accounts for 27% of starch

Amylopectin or α-amylose which accounts for 73% of starch.

Table : Distinguishing Characteristics of Different Starches

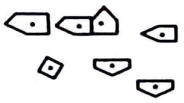
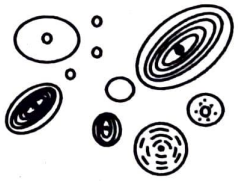
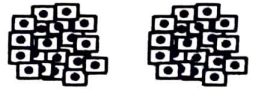
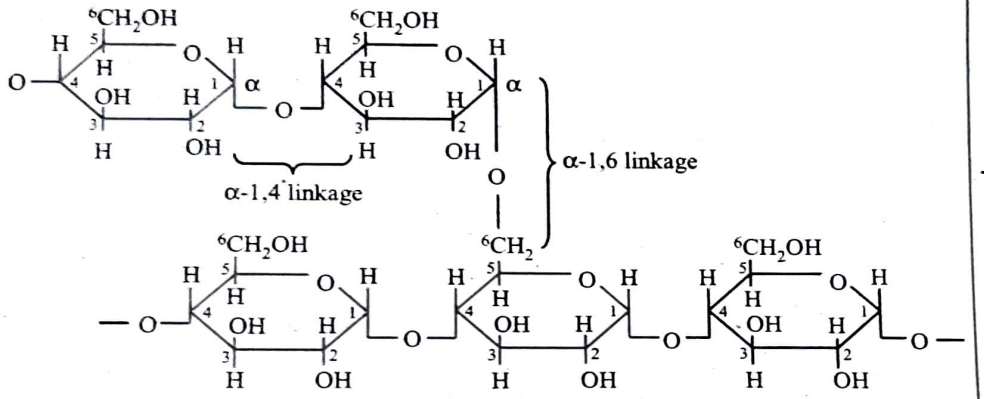
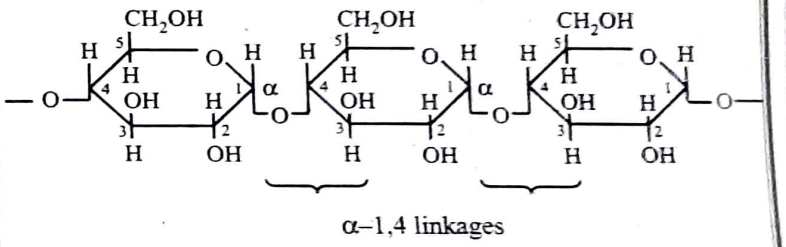
Characteristic	Maize starch	Wheat starch	Rice starch	Potato starch
Colour of starch grains	White	Cream coloured	White	Slightly yellow
Microscopic characters				
(a) Appearance	Uniform sized granules	Large and small sized granules	Simple or compound (2-150 components) granules	Simple or compound (2-3 components) granules
(b) Shape	- Polyhedral with blunt angles. - Absence of striations. 	- Large granules are discoid or lenticular in shape. - Small granules are round. - Hilum is in the center. - Faint striations are seen. 	- Polyhedral with sharp pointed angles. - Compound granules are discoid or lenticular in shape. - Hilum is present. - No evidence of striations. 	- Flattened, ovoid, sub-spherical, pyriform granules. - Hilum is present near the narrow end of granules. - Striations are visible. 
(c) Size	10-35 μ in diameter.	5-50 μ in diameter.	10-45 μ in diameter.	2-110 μ in diameter.
Standards (a) Loss on drying	NMT 15%.	NMT 15%.	NMT 15%.	NMT 20%.
(b) Ash value	NMT 0.3%.	NMT 0.3%.	NMT 0.6%.	NMT 0.3%.

Table: Characteristic Features of Amylopectin and Amylose

Feature	Amylopectin (α-amylose)	Amylose (β-amylose)
Solubility	Water-insoluble, swells when comes in contact with water. It is responsible for the gelatinising and pasty property of starch.	Water - soluble
Structure	It is a branched chain compound which consists of α-1,4 and α-1,6 linkages.  	It is a linear compound which consists of α-1,4 glucosidic linkage.  α–1,4 linkages
Reaction with iodine	Amylopectin + Iodine ⟶ Bluish-black colour	Amylose + Iodine ⟶ Blue colour
Methylation reaction	Amylopectin $\xrightarrow{\text{Methylation}}$ 2,3-di-o-methyl glucose + 2,3,6,-tri-o-methyl glucose + 2,3,4,6-tetra-o-methyl glucose	Amylose $\xrightarrow{\text{Methylation}}$ 2,3,6-tri-o-methyl glucose
Acid hydrolysis	Amylopectin $\xrightarrow[\text{hydrolysis}]{\text{Acid}}$ D-glucose + Phosphoric acid [Note : Phosphoric acid liberated upon acid hydrolysis of amylopectin is responsible for gelatinising and pasty property of starch]	Amylose $\xrightarrow[\text{hydrolysis}]{\text{Acid}}$ D-glucose
Enzymatic hydrolysis	Amylopectin $\xrightarrow[\beta\text{-amylase}]{}$ Maltose (50 - 60%) + Amylodextrin	Amylose $\xrightarrow[\beta\text{-amylase}]{}$ Maltose (100%) $\xrightarrow[\text{Glucose}]{\downarrow\ \alpha\text{-glucosidase}}$

Identifying Test

1 g starch + 15 ml of water —Boil and cool→ Translucent viscous jelly —Iodine solution→ Blue colour which disappears upon warming.

Uses

1. It is used as a nutritive substance, as it gets converted to glucose during the process of digestion.
2. It is used as an antidote in the treatment of iodine poisoning.
3. It is used in dermatological preparations.
4. It is used as a protectant, adsorbent and demulcent.
5. It is used as a pharmaceutical aid i.e., as a filler, binding or disintegrating agent in the manufacture of pills and tablets.
6. It is one of the constituents of dusting powders i.e., zinc starch dusting powder BPC, zinc oxide paste IP etc.
7. It is used as a base for suppositories.
8. It is used in paper and cloth industry.

10. STERCULIA GUM

Synonyms

Gum karaya, Indian tragacanth.

Biological Source

It is derived from the dried gummy exudate of the tree *Sterculia urens*, *Sterculia villosa*, *Sterculia tragacanth* or other species of *Sterculia* (Family-Sterculiaceae).

Location

It is found all over India, especially in north central regions.

Method of Preparation

Trees having a girth of 1 metre are selected and tapped for gum in the months of March-April which is continued until June. The exudation oozes soon after the tapping and is maximum in the first 24 hours.

1. Each tree yields about 1-5 kg per year and is tapped five times during its lifetime.
2. Irregular and large tears are broken into small pieces, and sand particles and foreign organic matter is removed by gravity.
3. Particle size of granulated or crystal gum karaya is between 6 and 30 mesh while fine powder is 150 mesh.

Characteristics

Colour	-	White-brown
Odour	-	Acetous
Taste	-	Bland mucilaginous
Shape	-	Irregular mucilaginous
State	-	Powder/Crystal
Solubility	-	Water insoluble but swells in water
Standards	-	Foreign organic matter NLT 3% Acid insoluble ash NLT 1%

Chemical Constituents

1. Acetyl group (8%)
2. Uronic acid residues NLT 37%
3. On hydrolysis it gives *d*-galactose, *l*-rhamnose, *d*-galacturonic acid, aldobiuronic acid and acid trisaccharides.

Identifying Test

Addition of ruthenium red to gum karaya gives pink colour (tragacanth is an exception).

Uses

1. It is used as a bulk laxative.
2. Karaya gum is used as denture adhesive in dental treatment.
3. It is used as an emulsifier, thickener and stabilizer in pharmaceuticals.
4. Used in paper and textile industries.
5. Karaya gum is used on large scale for the production of ice pops, cheese spread, sherbets and ground meat products, as it is listed in the Food Chemical Codex.

11. TRAGACANTH

Synonym

Gum tragacanth

Biological Source

It is the dried gummy exudate obtained from the stems and branches of *Astragalus* species like *Astragalus gummifer* and other species of *Astragalus* (Family-Leguminosae).

Location

Iran and Syria (both these countries supply Persian tragacanth), Turkey (supplies Smyrna tragacanth), India (Punjab, Garhwal and Kumaon) and Greece.

Collection and Method of Preparation

Gum is collected from thorny shrubs which grow in mountains at an altitude of 1000-3000 metres. The gum exudes as soon as an injury is made onto the plant and is collected upon drying (i.e., after 2 days of exudation).

Gum formation occurs when the pith cells and medullary rays transform into a gummy substance. The gum so formed is obtained from the plants from April to November annually and dried. The gum which is obtained in the first year is of low grade quality, whereas that obtained from the second year onwards is of superior quality.

Characteristics

Colour	-	White to pale yellowish-white
Odour	-	Odourless
Taste	-	Mucilaginous
Size	-	2.5 cm length, 1.2 cm breadth and 0.2 cm in thickness
Shape	-	Flattened, ribbon-like, thin and curvy flakes
Nature	-	Horny, translucent with ridges
Fracture	-	Short
Solubility	-	Partially soluble in water but insoluble in alcohol

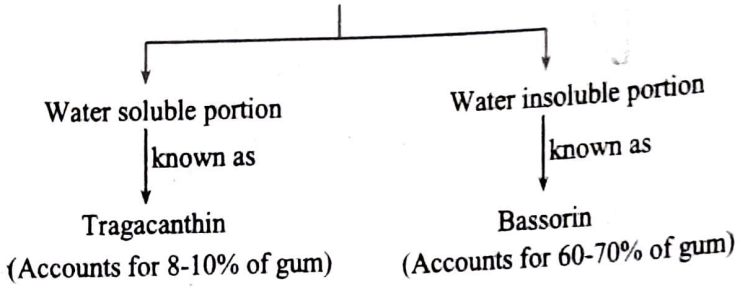
Standards - (a) Foreign organic matter (like bark, thorns) NMT 1%

(b) Sulphated ash NMT 4%

(c) Moisture content NMT 15%

Chemical Constituents

1. Tragacanth



2. Tragacanth $\xrightarrow{\text{Hydrolysis}}$ Galactouronic acid + *l*-arabino-rhamnose + *d*-galactopyranose + *d*-xylopyranose

3. Tragacanthin $\xrightarrow{\text{Hydrolysis}}$ Glucuronic acid + Arabinose

4. Bassorin contains 15% of methoxy groups. It is responsible for swelling of the gum in water and viscosity of gum. Viscosity of tragacanth should not be less than 250 centipoise.

5. Tragacanth also contains starch and protein.

Identifying Tests

1. Boiled tragacanth solution + 10% $FeCl_3$ solution ⟶ Deep yellow precipitate

2. Tragacanth + Conc. NH_4OH + Precipitated copper oxide ⟶ Stringy precipitate is obtained

3. Tragacanth solution + NaOH solution $\xrightarrow{\text{Warm}}$ Canary yellow colour

4. Tragacanth solution + Strong iodine solution ⟶ Olive green colour

Uses

1. Used as a demulcent for sore throat.
2. As an emollient (soothes the skin) in cosmetic products.
3. As a suspending agent along with acacia and also as an emulsifying agent.
4. Used as a binder in tablets and as an excipient (inert substance) in pills.
5. It is used as a laxative in constipation due to its swelling properties.
6. It is used as a stabilizer in the preparation of ice creams.
7. It is also used in spermicidal jellies.

12. BAEL

Synonyms

Bilva, Bel, Indian Bael, Bengal quince, Stone apple, Bhilwa.

Biological Source

Bilva consists of unripe or partially ripen fruits of the plant *Aegle marmelos* belonging to the family Rutaceae.

Location

Bael is indigenous to Central, North and South India. It is also found in Burma and Sri Lanka.

Characteristics

Fruit

Colour - Unripe fruit - Green
Ripe fruit - Yellowish brown

Diameter - 10-20 cm

Shape - Sub-spherical

Appearance - Woody

Fruit Pulp

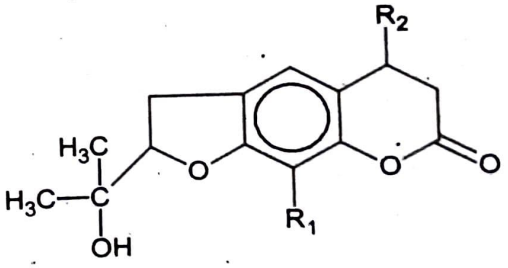
Colour - Reddish-brown

Odour - Faint and aromatic

Taste - Mucilaginous and sweet.

Chemical Constituents

1. Fruits contain furanocoumarins namely marmelosin A, B and C (0.5%) as the main constituent.



	R_1	R_2
Marmelosin A	H	H
Marmelosin B	H	CH_3
Marmelosin C	CH_3	H

2. Ripe fruits contain marmesin, umbelliferone and psoralin.
3. The other constituents of the plant includes carbohydrates (11-17%), proteins (1%), volatile oil, tannins (20%), vitamin A and vitamin C.

Uses

1. Tender fruits are used as appetizer, digestive and tonic. They are also used to treat diarrhoea and dysentery.
2. Ripe fruits have cooling effect. They are used to treat indigestion and helps to improve vision.
3. Pulp of the fruit mixed with sugar, water and lemon is used as a refreshening drink.