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Review Article

Source, isolation & impact of glycone and aglycone in human body

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ABSTRACT

Widely distributed in plants, glycosides comprise a large group of secondary metabolites. Glycosides are structurally diverse and given their proven bioactivities and traditional use, they are of great importance to the regime of Pharmacognosy; still there remains much to be elucidated on their roles and properties. Like all glycosides is a construction consisting of two parts, an aglycone (genin) unit, which is mainly lipophilic, and a glycone unit which is hydrophilic and composed of one or more sugar components. In this chapter, natural plant glycosides, such as phenolic and flavonoids, coumarins, chromones, anthraquinones, saponosides, cardiac, cyanogenic, and thioglycosides have been characterized; their chemistry and structure–activity relationships, plant sources, and extraction methods are also discussed. Further, the chapter reflects the traditional and well documented therapeutic uses, mechanisms of action, possible adverse effects, and toxicity of these metabolites, and the prospects and trends in evaluating natural glycosides as new effective therapeutics.

Keywords: glycoside; aglycone; chemistry; structure; metabolite; activity; toxicity; therapy

INTRODUCTION

Several medicinal plants contain complex organic molecules which are in conjugation with sugar moieties, mostly monosaccharides. The number of these sugar molecules may be one of more. Such compounds are called as glycosides and exert therapeutically significant effects on humans and animals. Many glycosides are used in traditional and modern medicines because of their cardiotonic, purgative, analgesic, anti–rheumatic, demulcent, and other useful actions [1]. Glycosides may be defined, in general, as the organic compounds from plants or animal sources which on enzymatic or acid hydrolysis give one or more sugar moieties along with nonsugar moiety. The former is called as glycone and the later as aglycones or genin. Chemically, they are the acetyls or sugar ethers, formed by interaction of hydroxyl group each of non–sugar and sugar moieties, with a loss of water molecule. The hydroxyl group of aglycones may be alcoholic or phenolic and in some cases from

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amines also. The sugars involved in glycosides are of different types, but most commonly, it is β–D–glucose. The other sugars found are galactose, mannose, rhamnose, digitoxose, cymarose, etc.

Stereochemically, these are alpha and beta glycosides which may be considered as a theoretical aspect, because the plants contain only beta glycosides. The linkage between glycone and aglycones is called glycosidic linkage and on the basis of this linkage, alpha and beta stereoisomers are assigned. In a simplest form, the glycoside with these two isomers can be synthesized from union of methyl alcohol and glucose.

The classification of glycosides is based either on the chemical nature of aglycone part of therapeutic activity exhibited by the same. Another mode of classification is based on the type of linkage existing between the glycone and aglycones part. A brief description of all these methods of classifications is given below.

According to chemical nature of aglycones moiety, they are grouped into:

1. Anthraquinone or anthracene glycosides,
2. Steroidals or cardiac glycosides,
3. Saponin glycosides,
4. Cyanogenetic or cyanophoric glycosides,
5. Isothiocynate glycosides,
6. Flavonoids Flavonol glycosides,
7. Coumarins and Furanocoumarin glycosides,
8. Aldehyde glycosides,
9. Phenol glycosides,
10. Steroidal glycolkaloids,
11. Bitter and Miscellaneous glycosides

The glycosides may be classified, in relation to their therapeutic activity into different groups like cathartics, cardiotonics, analgesics, anti–rheumatics, anti–ulcer etc. Sometimes Glycosides are also classified based on type of sugar or the glycone part of their structure. Accordingly, there are glycosides with glucose, rhamnosides with rhamnose, pentosides with pentose like ribose, etc. The sugars involved in the structure are normally the common type of sugars. Only in few cases, sugars like digitoxose, cymarose are present [2].

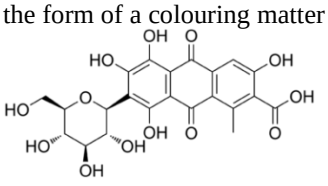
Another approach for their classification is by considering the linkage across glycone and aglycones part. Basically, all types of glycosidal linkages are occurred by interaction of –OH group of glycone and hydrogen coming through any of the radicals like CH, –OH, –SH and –NH present on aglycones part. Hence, by elimination of one water molecule, linkage or a bridge is formed and the type of glycoside formed is named by putting the element as prefix like C–glycoside, N–glycoside, O–glycoside or S–glycoside.

To illustrate the individual pattern, the following brief account of such glycosides is given.

1) **C–glycosides (when sugar moiety is linked to carbon atom):** Some of the anthraquinone glycosides such as cascarosides from cascara [*Frangula purshiana:* Rhamnaceae] and aloin from aloe [*Aloe vera*: Asphodelaceae], as well as some members of flavone type of glycosides show the presence of C–glycosides.

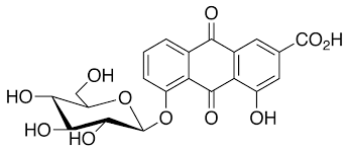
Glycone–OH + HC–aglycones ⟶ glycone–C–aglycones + H_2O

C–glycosides, which are also called as aloin–type glycosides, are mainly present in members of Liliaceae, e.g., Aloe. They are not hydrolysed by heating with dilute acids/alkalis, but by oxidative hydrolysis with ferric chloride. Cochineal [*Coccus cacti*: Dactylopiidae] contains C–glycoside in the form of a colouring matter called carminic acid.

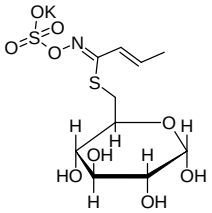


2) **O–glycosides (when sugar moiety is attached to oxygen atom):** They are very common in higher plants e.g., senna [*Senna alexandrina*: Fabaceae], rhubarb frangula [*Rheum hybridum*: Polygonaceae], etc. They are hydrolysed by treatment of acid or alkali into aglycones and sugar, i.e., glucoranillin, amygdaling.

Glycone–OH + HO–aglycones ⟶ glycone–O–aglycones + H_2O



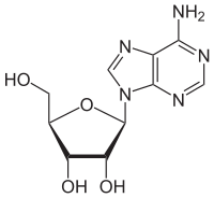
3) **S–glycosides (when sugar is linked to sulphur atom):** Their occurrence is restricted to Isothiocynate glycosides like sinigrin from black mustard [*Brassica nigra*: Brassicaceae]. They are formed by interaction of sulphydryl group of aglycones and hydroxyl group of glycones.



Glycone–OH + HS–aglycones ⟶ glycone–S–aglycones + H_2O

4) **N–glycosides:** The most typical representative example of N–glycosides are nucleosides, where the amino group of base reacts with OH group of ribose/deoxyribose and ultimately give N–glycosidic form.

Glycone–OH + H N–Glycone ⟶ Glycone–N–aglycones + H_2O



The glycosides contain sugars but still the physical, chemical and therapeutic properties a dictated by aglycones part. The sugar moiety facilitates absorption of glycosides and helps in transportation of aglycones portion at the site of action.

Glycosides are crystalline or amorphous substances which are soluble in water and dilute alcohol with an exception of resin glycosides, but insoluble in organic solvent like chloroform, ether. The aglycones moiety is soluble in non–polar solvents like benzene or ether. Glycosides are easily hydrolysed by water, mineral acids and enzymes. They show optical activity, normally wit laevo rotatory effects. Glycosides do not reduce Fehling's solution until they are hydrolysed. They are believed to participate in growth regulation and protection of plant [3].

2. Distribution of Glycosides

Glycosides are the class of compounds abundant in nature. Some plant families containing important glycosides are listed below:

1. Foxglove (*Digitalis purpurea* and *Digitalis lanata*: Scrophulariaceae) Picrorhiza (*Picrorhiza kurroa*: Plantaginaceae).
2. Apocyanaceae (*Nerium oliander* and *Thevetia peruviana*).
3. Liliacea (*Urgenea indica* and *U. maritima, Aloe vera*)
4. Leguminocae (*Cassia acutefolia* and *C. angustefolia, Glycyrrhiza glabra, Psoralea corylifolia*)
5. Dioscoreaceae (*Dioscorea floribunda*)
6. Rosaceae (*Prunus amygdalus, Carategus oxycantha*)
7. Black mustard (*Brassica rapa*: Brassicaceae)
8. Gentian [*Gentiana lutea*: Gentianaceae] and Chirata [*Swertia chirata*: Gentianaceae]
9. Kalmegh [*Andrographis paniculate*: Acanthaceae]
10. Quassia [*Quassia amara*: Simarubaceae]
11. Bishop's weed [*Ammi majus, Ammi visnaga*: Apiaceae]
12. Rue Citrus sp. (*Ruta graveolens*: Rutaceae)
13. Buckwheat [*Fagopyrum esculentum*: Polygonaceae]
14. Eucalyptus [*Eucalyptus obliqua*: Myrtaceae]

3. Chemical Tests of Glycosides

Glycosides are the compounds with organic molecules having attached glucose or any mono–oligo saccharide unit. Usually, these are crystalline or amorphous solids; optically active, soluble in water and alcohol but insoluble in organic solvents like ether, chloroform and benzene etc. Generally, aqueous or alcoholic extracts of crude drugs are tested with specific reagents for presence of various types of glycosides.

3.1 Chemical Tests for Anthraquinone Glycosides

Borntrager's test: To 1 gm of drug add 5–10 ml of dilute HCl boil on water bath for 10 min and filter. Filtrate was extracted with CCl_4/Benzene and add equal amount of ammonia solution to filtrate and shake. Formation of pink or red colour in

ammonical layer due to presence of anthraquinone moiety.

Modified borntrager's test: To 1 gm of drug, add 5 ml dilute HCl followed by 5 ml ferric chloride (5% w/v). Boil for 10 min on water bath, cool and filter, filtrate was extracted with carbon tetrachloride or benzene and add equal volume of ammonia solution, formation of pink to red colour due to presence of anthraquinone moiety. This is used C–type of anthraquinone glycosides.

3.2 Chemical Tests for Saponin Glycosides

Haemolysis test: A drop blood on slide was mixed with few drops of aq. Saponin solution, RBCs becomes ruptured in presence of saponins.

Foam test: To 1 gm of drug add 10–20 ml of water, shake for few minutes, formation frothing which persists for 60–120s in presence of saponins.

3.3 Chemical Tests for Steroid and Triterpenoid Glycosides

Liebermann Burchard test: Alcoholic extract of drug was evaporated to dryness and extracted with $CHCl_3$, add few drops of acetic anhydride followed by conc. H_2SO_4 from side wall of test tube to the $CHCl_3$ extract. Formation of violet to blue coloured ring at the junction of two liquid, indicate the presence of steroid moiety.

Salkowaski test: Alcoholic extract of drug was evaporated to dryness and extracted with $CHCl_3$, add conc. H_2SO_4 from sidewall of test tube to the $CHCl_3$ extract. Formation of yellow coloured ring at the junction of two liquid, which turns red after 2 min, indicate the presence of steroid moiety.

Antimony trichloride test: Alcoholic extract of drug was evaporated to dryness and extracted with $CHCl_3$, add saturated solution of $SbCl_3$ in $CHCl_3$ containing 20% acetic anhydride. Formation of pink colour on heating indicates presence of steroids and triterpenoids.

Trichloro acetic acid test: Triterpenes on addition of saturated solution of trichloro acetic acid forms coloured precipitate.

Tetranitro methane test: It forms yellow colour with unsaturated steroids and triterpenes.

Zimmermann test: Meta dinitrobenzene solution was added to the alcoholic solution of drug containing alkali, on heating it forms violet colour in presence of keto steroid.

3.4 Chemical Tests for Cardiac Glycosides

Keller–Kiliani test: To the alcoholic extract of drug equal volume of water and 0.5 ml of strong lead acetate solution was added, shaked and filtered. Filtrate was extracted with equal volume of chloroform. Chloroform extract was evaporated to dryness and residue was dissolved in 3 ml of glacial acetic acid followed by addition of few drops of $FeCl_3$ solution. The resultant solution was transferred to a test tube containing 2 ml of conc. H_2SO_4. Reddish brown layer is formed, which turns bluish green after standing due to presence of digitoxose.

Legal test: To the alcoholic extract of drug equal volume of water and 0.5 ml of strong lead acetate solution was added, shaked and filtered. Filtrate was extracted with equal volume of chloroform and the chloroform extract was evaporated to dryness. The residue was dissolved in 2 ml of pyridine and sodium nitropruside 2 ml was added followed by addition of NaOH solution to make alkaline. Formation of pink colour in presence of glycosides or aglycon moiety.

Baljet test: Thick section of leaf of digitalis or the part of drug containing cardiac glycoside, when dipped in sodium picrate solution, it forms yellow to orange colour in presence of aglycones or glycosides.

3.5 Chemical Tests for Coumarin Glycosides

$FeCl_3$ test: To the concentrated alcoholic extract of drug few drops of alcoholic $FeCl_3$ solution was added. Formation of deep green colour, which turned yellow on addition of conc. HNO_3, indicates presence of coumarins.

Fluorescence test: The alcoholic extract of drug was mixed with 1N NaOH solution (one ml each). Development of blue–green fluorescence indicates presence of coumarins.

3.6 Chemical Tests for Cynophoric Glycoside

Sodium picrate test: Powdered drug was moistened with water in a conical flask and few drops of conc. Sulphuric acid was added. Filter paper impregnated with sodium picrate solution followed by sodium carbonate solution was trapped on the neck of flask using cork. Formation of brick red colour due to volatile HCN in presence of cynophoric glycosides takes place.

3.7 Chemical Tests for Flavonoid Glycosides

Ammonia test: Filter paper dipped in alcoholic solution of drug was exposed to ammonia vapor. Formation of yellow spot–on filter paper.

Shinoda test: To the alcoholic extract of drug magnesium turning and dil. HCl was added, formation of red colour indicates the presence of flavonoids. To the alcoholic extract of drug zinc turning and dil. HCl was added, formation of deep red to magenta colour indicates the presence of dihydro flavonoids.

Vanillin HCl test: Vanillin HCl was added to the alcoholic solution of drug, formation of pink colour due to presence of flavonoids.

4. Isolation

Stas–Otto Method: The drug containing glycoside is finely powdered and the powder is extracted by continuous hot percolation using Soxhlet apparatus

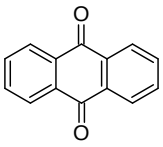
with alcohol as solvent. During this process, various enzymes present in plant parts are also deactivated due to heating. The thermolabile glycosides, however, should be extracted at temperature preferably below 45°C. The extract is treated with lead acetate to precipitate tannins and thus eliminate nonglycosidal impurities. The excess of lead acetate is precipitated as lead sulphide by passing hydrogen sulphide gas through solution. The extract is filtered, concentrated to get crude glycosides. From the crude extract, the glycosides are obtained in pure form by making use of processes like fractional solubility, fractional crystallization and chromatographic techniques such as preparative thin layer and column chromatography.

The characterization of isolated purified compounds is done by IR, UV, visible, NMR and mass spectrometry and elemental analysis [4].

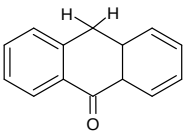
5. Anthracene Glycosides

Anthracene glycosides are chiefly found in dicot plants but to some extent it is also found in monocot and lower plants. It consists of glycosides formed from aglycone moieties like anthraquinones, anthranols, anthrones or dimers of anthrones or their derivatives. Anthrones are insoluble in alkali and do not show strong fluorescence with them, while anthronols which are soluble in alkali show strong fluorescence. The reduced anthraquinones are biologically more active. Anthroquinones that are present in fresh drugs are in reduced form, which on long storage get oxidized and hydrolysed, Glycosides of reduced derivatives are more active than oxidized aglycones. This is due to the fact that sugars take the glycosides to the site of action and thus are more active. Anthraquinone is an aromatic organic compound and a derivative of anthracene. It has the appearance of yellow or light grey to grey–green solid crystalline powder. Its chemical formula is $C_{14}H_8O_2$. It melts at 286°C, boils at 379.8°C. It is insoluble in water or alcohol, but dissolves in nitrobenzene and aniline. It is chemically fairly stable under normal conditions.

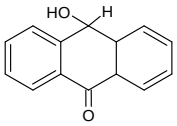
Anthraquinone naturally occurs in some plants (e.g., aloe, senna, rhubarb and cascara), fungi, lichens and insects, where it serves as a basic skeleton for their pigments. Natural anthraquinone derivates tend to have laxative effects. These glycosides are characterized by a chemical test, known as Borntrager test and show the property of microsublimation. Most of the glycosides are O–glycosides and S–glycosides, by their hydrolysis derivatives of 1,8–dihydroxy anthraquinone, anthranol, anthrone, or dianthrone are obtained. The common aglycones are aloe–emodin, emodin, rhein, chrysophanol and physcion which may exist as anthraquinones, anthranols or anthrones. The sugars presents are usually arabinose, rhamnose and glucose. In the drug originally glycosides of reduced derivatives or their dimers are present. During drying and storage by hydrolysis and oxidation free anthraquinones are produced.



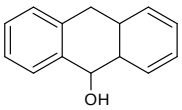
Anthraquinone



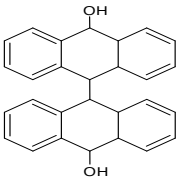
Anthrone



Oxanthrone



Anthranol



Dianthranol

Name of Drug and Synonym	Biological source	Active constituent	Uses
1. Aloes	Dried juice of leaves of *Aloe vera, Aloe barbadensis, Aloe ferox*, Liliaceae	Barbaloin, aloe Emodin	Purgative
2. Cascara	Dried bark of *Rhamnus purshiana*, Rhamnaceae	Cascarosides A, B, C and D	Mild purgative
3. Hypericum	Dried aerial parts of *Hypericum perforatum*, Hypericaceae	Hypericin, Hyperforin	Anti–depressant
4. Rhubarb	Dried rhizome of *Rheum palmatum*, Polygonaceae	Rhein, aloe emodin	Purgative, bitter stomachic
5. Alexandrian senna	Dried leaflets of *Cassia acutifolia*, Leguminosae	Sennoside A and B	Purgative
6. Indian senna	Dried leaflets of *Cassia angustifolia*, Leguminosae	Sennoside A and B	Purgative
7. Senna pods	Dried nearby ripe fruits of *Cassia acutifolia* or *C. angustifolia*, Leguminosae	Sennoside A and B	Purgative

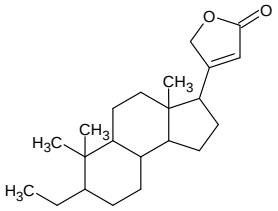
6. Sterol or Cardiac Glycosides

The cardiac glycosides are an important class of naturally occurring drugs whose actions include both beneficial and toxic effects on the heart. Plants containing cardiac steroids have been used as poisons and heart drugs at least since 1500 B.C. Throughout history these plants or their extracts have been variously used as arrow poisons, emetics, diuretics and heart tonics. Cardiac steroids are widely used in the modern treatment of congestive heart failure and for treatment of atrial fibrillation and flutter. Yet their toxicity remains a serious problem. These drugs all act by affecting the availability of intracellular Ca^{2+} for myocardial contraction or increasing the sensitivity of myocardial contractile proteins.

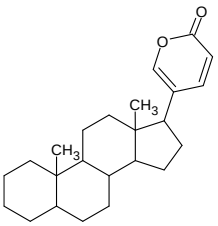
Cardiac glycosides are composed of two structural features: the sugar (glycone) and the non-sugar (aglycone–steroid) moieties. The steroid nucleus has a unique set of fused ring system that makes the aglycone moiety structurally distinct from the other more common steroid ring systems. The steroid nucleus has hydroxyls at 3– and 14–positions of which the sugar attachment uses the 3–OH group. 14–OH is normally unsubstituted. Many genins have OH groups at 12– and 16–positions. These additional hydroxyl groups influence the partitioning of the cardiac glycosides into the aqueous media and greatly affect the duration of action. The lactone moiety at C–17 position is an important structural feature. The size and degree of unsaturation varies with the source of the glycoside. Normally plant sources provide a five membered unsaturated lactone while animal sources give a six–membered unsaturated lactone.

One to four sugars are found to be present in most cardiac glycosides attached to the 3β–OH group. The sugars most commonly used include L–rhamnose, D–glucose, D–digitoxose, D–digitalose, D–digginose, D–sarmentose, L–vallarose and D–fructose. These sugars predominantly exist in the cardiac glycosides in the β–conformation. The presence of acetyl group on the sugar affects the lipophilic character and the kinetics of the entire glycoside. Two classes have been observed in nature—the cardenolides and the bufadienolides.

The cardenolides have an unsaturated butyrolactone ring while the bufadienolides have a pyrone ring. The lactone of cardenolides has a single double bond and is attached at the C–17 position of steroidal nucleus. They are five–membered lactone ring and form a C_{23} steroids (Leguminosae, Cruciferae, Euphorbiaceae, etc.), while the lactone of bufadienolids have two double bond which is attached at the 17 α–position of the steroidal nucleus. They are six–membered lactone ring and form C24 steroids (Liliaceae, Ranunculaceae) [5].

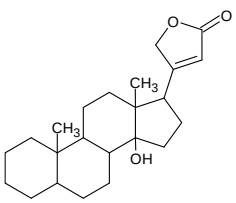


Cardenolide

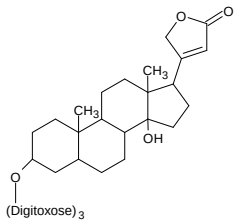


Bufadenolide

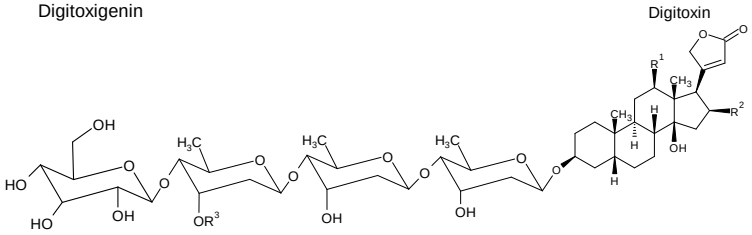
Name of Drug and Synonym	Biological source	Active constituent	uses
1. Digitalis (foxglove leaves)	Dried leaves of *Digitalis purpurea*, Scrophulariaceae, and dried leaves of *Digitalis lanata*, Scrophulariaceae.	Purpurea glycoside A B, digitoxin lanatosides A, B and C, digoxin	Cardiotonic
2. European squill (Scilla)	Dried sliced bulbs of *Urginea maritima*, Liliaceae	Scillaren A and B	Cardiotonic
3. Indian squill (Urginea)	Dried bulbs of *Urginea indica*	Scillaren A and B	Cardiotonic
4. Ouabain	Dried seeds of *Strophanthus gratus*, Apocynaceae	Ouabain	Cardiotonic
5. Strophantus (Arrow–poison)	Dried ripe seeds of *Strophanthus kombe*, Apocynaceae	Strophanthidin	Cardiotonic
6. Thevetia (Lucky–nut–tree)	Dried seeds of *Thevetia nerifolia*, Apocynaceae	Thevetin	Cardiotonic



Digitoxigenin



Digitoxin



Lanatoside

	R1	R2	R3
Lanatoside A	H	H	CH_3CO
Lanatoside B	H	OH	CH_3CO
Lanatoside C	OH	H	CH_3CO

7. Saponin Glycosides

Saponins are glycoside compounds often referred to as a 'natural detergent' because of their foamy texture. They get their name from the soap wort plant (Saponaria), the root of which was used historically as a soap (Latin sapo— oap). Foremost among this is the strong tendency to froth formation when shaken with water. The other properties are haemolytic activity, sneezing effect, toxicity, complex formation with cholesterol and antibiotic properties. Saponins have long been known to have strong biological activity. When studying the effect that saponins have on plants, it has been discovered that saponins are the plants active immune system. They are found in many plants; they consist of a polycyclic aglycone that is either a choline steroid or triterpenoid attached via C3 and an ether bond to a sugar side chain. The aglycone is referred to as the sapogenin and steroid saponins are called Sar saponins. The ability of a saponin to foam is caused by the combination of the nonpolar sapogenin and the water-soluble side chain. Saponins are bitter and reduce the palatability of livestock feeds. However, if they have a triterpenoid aglycone they may instead have a liquorice taste as glucuronic acid replaces sugar in triterpenoids. Some saponins reduce the feed intake and growth rate of nonruminant animals while others are not very harmful. For example, the saponins found in oats and spinach increase and accelerate the body's ability to absorb calcium and silicon, thus assisting in digestion. As mentioned earlier they are composed of a steroid (C–27) or triterpenoid (C–30) saponin nucleus with one or more carbohydrate branches.

7.1 Steroid Saponins: Steroid saponins are similar to the sapogenins and related to the cardiac glycosides. They have ability to interact medically and beneficially with the cardiac glycosides, sex hormones, Vitamin D and other factors, render these phytochemicals components of great medical significance. Diosgenin is the important steroid sapogenin. Recently from these saponins steroid hormones like progesterone, cortisone etc. are obtained by partial synthesis and thus their importance has increased considerably. Some of the families with steroidal saponins are Solanaceae, Apocynaceae, Liliaceae, Leguminosae, etc.

7.2 Triterpenoid Saponins: Triterpenoid saponins, or sapogenins, are plant glycosides which lather in water and are used in detergents, or as foaming agents or emulsifiers, and have enormous medical implications due to their antifungal, antimicrobial, and adaptogenic properties. Triterpene saponins are usually β–amyrine derivatives and some are also α–amyrine and lupeol derivatives. It has a pentacyclic triterpenoid nucleus which is linked with either sugar or uronic acid. Glycyrrhizin, from liquorice root, is an example of a saponin used for anti–inflammatory purposes in place of cortisone. They are commonly available in dicot plants belonging to the family Rubiaceae, Compositae, Rutaceae, Umbelliferae, etc. Saponins are rarely crystalline and generally amorphous powder with high molecular weight. They carry many asymmetric centres and are optically active. They are generally soluble in water and form colloidal solutions. These are also soluble in ethyl and methyl alcohol and are usually insoluble in organic solvents like petroleum ether, chloroform and acetone etc. They are bitter in taste and no alkaline in nature, produce sneezing and have the property of lowering surface tension. They are hydrolysed by acids, alkalis to yield aglycone called sapogenin and one or more molecule of same or different sugars or their oxidation products. They can also be hydrolysed by

enzymes, soil bacteria, and by photolysis. In mild conditions using very dilute acids (0.01–0.1N), organic acids give rise to partially hydrolysed saponins called prosapogenin. Saponins are extremely toxic to fishes but do not render them inedible, as saponins are not poisonous to man when taken orally. Very dilute solution of saponins hemolyses red blood corpuscles. The hemolysis take place due to the formation of complex with the cholesterol of erythrocyte membrane causing its destruction, this is a chief property of saponin, very rarely shown by any other plants product. Saponins accelerate the germination and growth of the seeds. Saponins show fungicidal, bactericidal activity, antiviral activity, antibiotic property, inflammation inhibition activity, spermicidal, antifertility, molluscicidal, etc. Saponins have been reported to possess blood purifying and abortion causing properties, anthelmintic effect, sedative property and antispasmodic effects. Saponins find wide occurrence in plant kingdom. In a systematic study, 672 triterpenic and 125 steroidal saponins were found in 1730 species belonging to 104 families. In the whole 75% of the families showed the presence of saponins. The wide occurrence and its comparatively higher contents (0.1–30%) in plants, the saponins can be regarded as the most occurring plant materials. Saponins from the different parts of the same plants have found to possess different properties. Saponins may be distributed throughout the plant; their content is affected by variety and stage of growth. Their function in the plant is as storage in form of carbohydrate in the plant and act as immune system of the plant. Saponins have also been identified in the animal kingdom in snake venom, starfish and sea cucumber etc [6].

Name of Drug and Synonym	Biological source	Active constituent	Uses
1. **Brahmi**	Leaves and stems *Bacopa moniera*, Scrophulariaceae	Bacosides A and B	Nervine tonic
2. **Dioscorea**	Dried tubers of *Dioscorea deltoidea*, Dioscoreaceae	Diosgenin (steroidal sapogenin)	Synthesis of medicinal steroids
3. **Ginseng**	Dried root of *Panax ginseng*, Araliaceae	Ginsenosides & panaxosides (Triterpenoid saponins)	Adaptogen, tonic and stimulant
4. **Gokhru**	Dried fruits *Tribulus terrestris*, Zygophyllaceae	Steroidal sapogenins	Diuretic
5. **Jalbrahmi**	Dried herb of *Centella asiatica*, umbelliferae	Asiaticoside	Nervine tonic
6. **Momordica**	Dried fruits of *Momordica charantia*, Cucurbitaceae	Charantin, Momordicin	Hypoglycemic
7. **Senega**	Dried roots of *Polygala senega*, Polygalaceae	Senegin, polygallic acid (triterpenoid saponin)	Stimulant, expectorant
8. **Shatavari**	Dried roots and leaves *Asparagus racemosus*, Liliaceae	Shatavarin I, II	Galactogogue
9. **Yasti**	Dried roots and stolon of *Glycyrrhiza glabra*, Leguminosae	Glycyrrhizin (Triterpenoid saponin), β 18– –glycyrrhetinic acid	Expectorant, treatment of peptic ulcer

8. Cyanogenic Glycosides

These are the glycosides which on hydrolysis yields hydrocynic acid (HCN), benzaldehyde and sugars. The medicinal activity of cyanogenetic glycosides is due to presence of hydrocyanic acid and these are the characteristics of family rosaceae. For examples Amygdalin obtained from bitter almond (Prunus amygdalus), Prunasin obtained from wild cherry bark [7].

Name of Drug and Synonym	Biological source	Active constituent	Uses
Bitter almond	Dried ripe seeds of *Prunus amygdalus*, Rosaceae	Amygdalin	Demulcent, sedative
Wild cherry	Dried bark of *Prunus serotina*, Rosaceae	Prunasin	Mild sedative, flavouring agent

8.1 Isothiocyanate Glycosides: These are sulphur–containing compounds rich in family cruciferae, also known as glucosinolates and on hydrolysis yields isothiocyanate (–NCS) group. These glycosides are generally irritant and hence used externally as counter irritant, for example, Sinigrin

from black mustard, sinalbin from white mustard and gluconapin from rapeseed.

Name of Drug and Synonym	Biological source	Active constituent	Uses
Mustard seeds	Dried ripe seeds of *Brassica nigra*, Cruciferae	Sinigrin	Counter irritant, Rubefacient externally and emetic internally

9. Flavone Glycosides

These are complex organic compounds containing phenyl benzopyrone ring system. Flavones are present in plants in a free state or in glycosidal state (O–glycoside or C–glycoside) with its different derivatives like flavane, flavonol, flavonone, isoflavone and chalcones, for example, Rutin, quercitrin, hyperoside, diosmin (buchu leaf), hesperidin (lemon and orange peel) and vitexin (Carategus) [8].

Name of Drug and Synonym	Biological source	Active constituent	Uses
1. Buck wheat	Dried fruits of *Fagopyrum esculentum*, Polygonaceae	Rutin (also from Ruta graveolens)	Treatment of capillary bleeding
2. Citrus fruits	Rind of unripe, green lemon fruits, *citrus lemonis* or orange fruits *citrus aurantium*, Rutaceae	Hesperidin	In capillary fragility
3. Gingko	*Gingko biloba*, Gingkoaceae	Gingkolide A, B, C	Vascular disorders
4. Milk–Thistle	*Silybus marianum*, Asteraceae	Silybin, Silycrystin	Liver disorders

10. Coumarin & Furanocoumarin Glycosides

In this type of glycosides, the aglycone is coumarin. Coumarin is a chemical compound found in many plants, notably in high concentration in the tonka bean, woodruff, and sweet grass. They are benzopyrone derivative have aromatic smell and their alcoholic solutions when made alkaline show blue or green fluorescence. The biosynthesis of coumarin in plants is via hydroxylation, glycolysis and cyclization of cinnamic acid. It has clinical value as the precursor for several anticoagulants, notably warfarin. Some naturally occuring coumarin derivatives include umbelliferone (7–hydroxycoumarin), herniarin (7–methoxy–coumarin), psoralen and imperatorin. Coumarins have flavouring property but they cause damage to liver. Coumarin drugs also cause drug interactions with many other drugs. Medicinally, coumarin glycosides have been shown to have hemorrhagic, antifungicidal and antitumor activities. Furanocoumarins are toxic compounds that consist of a coumarin nucleus bonded to a furan ring. Several plants contain the psoralens that are generally the precursors of furocoumarins. Furanoccumarins are found especially in Rutaceae, Umbelliferae and Leguminosae. They are also produced by some plants, for example, celery and parsnips, in response to fungal infestation [9].

Name of Drug and Synonym	Biological source	Active constituent	Uses
1. Ammi	Dried fruits of Ammi majus, Umbelliferae	Xanthotoxin	Treatment of vitiligo
2. Psoralea fruit (Bavchi)	Dried ripe fruits of *Psoralea corylifolia*, Leguminosae	Psoralen, corylifolin	Treatment of leucoderma
3. Tonka bean	Dried seeds of *Dipteryxodorata*, leguminosae	Coumarin	Flavouring agent
4. Visnaga (Khella)	Dried ripe fruits of *Ammi visnaga*, Umbelliferae	Khellin, visnagin	Smooth musle relaxant, coronary vasodilator

11. Aldehyde Glycosides:

Name of Drug and Synonym	Biological source	Active constituent	Uses
1. Anantmul (Sariva)	Dried roots of *Hemidesmis Indicus*, Asclepiadaceae	Iso–vanillin	Anti–inflammatory, flavouring agent
2. Vanilla (Vanilla pods)	Unripe fruits of Vanilla planifolia, Orchidaceae	Gluco–vanillin	Flavouring agent

12. Phenol Glycosides:

Name of Drug and Synonym	Biological source	Active constituent	Uses
1. Bearberry (Uva ursi)	Dried leaves of *Arctostaphylos uvaursi*, Ericaceae	Arbutin	Diuretic in urethritis

13. Steroidal Glyco–Alkaloids:

Name of Drug and Synonym	Biological source	Active constituent	Uses
1. Solanum	Dried fruits of *Solanum khasianum*, Solanaceae	Solasodine	For steroidal synthesis

14. Bitter and Miscellaneous Glycosides

Bitter glycosides are a class of compounds that plays an important role in the digestive process. Bitter drugs and bitter constituents are used since a very early period as stomachic, febrifuges, and bitter tonics and in digestive disturbances. The bitterness of food on the tongue plays a very important role as the taste of bitter foods stimulates the appetite and triggers the secretion of digestive juices in the stomach, which in turn improves the breakdown of food. Bitters begin by stimulating the taste buds. This triggers off a reflex nerve action which increases the flow of saliva and stomach enzymes. At the same time, the hormone gastrin is secreted by the walls of the stomach. This improves the digestive process, by improving the passage of food from the stomach to the intestines. The sum total of this is an improvement in the digestive function of the stomach and small intestines. Bitters can also be very useful to improve immune disorders resulting from food intolerance or dietary antigen leakage, protect gut tissue (by increasing the tone of the gastro–esophageal sphincter thereby preventing reflux of corrosive stomach contents into the esophagus in 'heart burn', hiatus hernia, or esophageal inflammation), promote bile flow (thereby providing for increased ability of the liver to remove a toxic load from incomplete digestion and also provide for better digestion in the duodenum and small intestine), and enhance pancreatic function (normalizing hormone secretions to moderate excessive swings in blood–sugar levels). Bitter drugs preparations should be taken before or during meals otherwise they cause digestive disturbances like diarrhoea, and pain in the stomach [10].

Name of Drug and Synonym	Biological source	Active constituent	Uses
1. Chirata (chirayata)	Dried plant of *Swertia chirata*, Gentianaceae	Gentiopicrin from sweroside),	Stomachic, antipyretic
2. Gentian	Dried roots of *Gentiana lutea*, Gentianaceae	Gentiopicrin, amaro gentin	Bitter stomachic, tonic
3. Guduchi	Dried leaves and stems of *Tinospora cordifolia*, Minispermaceae	Tinosporoside cardiofoliside	Bitter tonic and general debility
4. Henna	*Lawsonia inermis*, Lythraceae	Lawson	Anti–fungal
5. Kalmegh (Andrographis)	Dried leaves and tender shoots of *Andrographis paniculata*, Acanthaceae	Andrographolide	Bitter tonic, anthelmentic, hepato protective
6. Manjishta	Dired stems of *Rubia cordifolia*, Rubiaceae	Rubiandin, purpurin (anthraquiuones)	In leucoderma and cosmetic products to gain glow and lusttre.

CONCLUSIONS

In chemistry, a **glycoside** /ˈglaɪkəsaɪd/ is a molecule in which a sugar is bound to another functional group via a glycosidic bond. Glycosides play numerous important roles in living organisms. Many plants store chemicals in the form of inactive glycosides. These can be activated by enzyme hydrolysis, which causes the sugar part to be broken off, making the chemical available for use. Many such plant glycosides are used as medications. Several species of *Heliconius* butterfly are capable of incorporating these plant compounds as a form of chemical defense against predators. In animals and humans, poisons are often bound to sugar molecules as part of their elimination from the body.

In formal terms, a glycoside is any molecule in which a sugar group is bonded through its anomeric carbon to another group via a glycosidic bond. Glycosides can be linked by an O– (an *O–glycoside*), N– (a *glycosylamine*), S– (a *thioglycoside*), or C– (a *C–glycoside*) glycosidic bond. According to the IUPAC, the name "*C–*

glycoside" is a misnomer; the preferred term is "*C*–glycosyl compound". The given definition is the one used by IUPAC, which recommends the Haworth projection to correctly assign stereochemical configurations. Many authors require in addition that the sugar be bonded to a *non–sugar* for the molecule to qualify as a glycoside, thus excluding polysaccharides. The sugar group is then known as the *glycone* and the non–sugar group as the *aglycone* or *genin* part of the glycoside. The glycone can consist of a single sugar group (monosaccharide), two sugar groups (disaccharide), or several sugar groups (oligosaccharide).

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