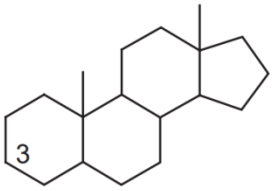
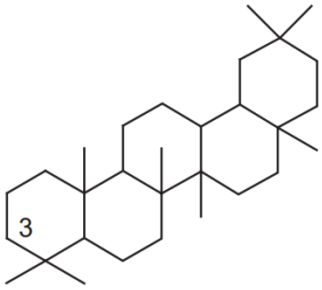
Saponin glycosides

Saponin glycosides possess ‘soaplike’ behaviour in water, i.e. they produce foam. On hydrolysis, an aglycone is produced, which is called sapogenin. There are two types of sapogenin: **steroidal** and **triterpenoidal**. Usually, the sugar is attached at C-3 in saponins, because in most sapogenins there is a hydroxyl group at C-3.



A steroid nucleus



A triterpenoid nucleus

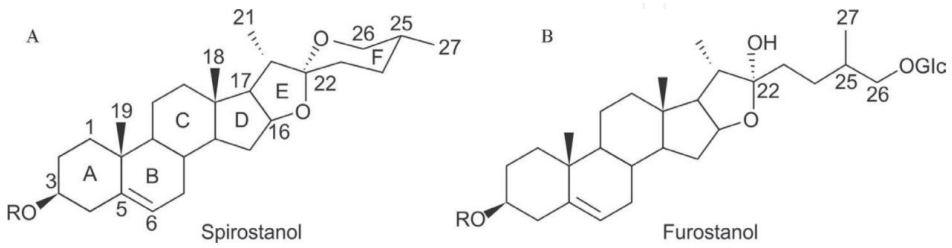
Saponins, due to the presence of a lipid-soluble aglycone and water-soluble sugar chain, show amphiphilic nature. Saponins with one sugar chain have the best foaming characteristics. The compounds with two or three sugar chains show decreasing of foaming ability.

Sapogenins are used as therapeutic agents; serve as a useful starting material for the chemical synthesis & the practical production of a number of steroidal hormons which are medicinally important agents. Much of the recent researches conducted on the saponin-containing plants was to discover a precursor for cortisone. Steroidal sapogenins as an important requirement based on its having (OH) groups

in the (3 & 11) positions on the molecule or having the ability to be readily converted to this structure. The most outstanding plant steroids for cortisone production are: diosgenin, sarsapogenin, hecogenin.

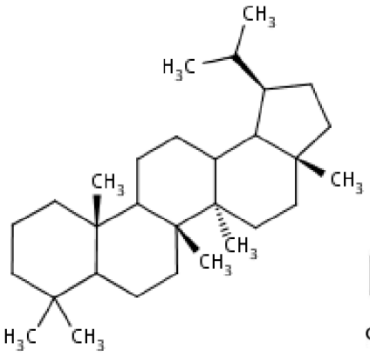
Classification and Molecular Characteristics

Saponin glycosides are subdivided into **triterpenoid** and **steroid** glycosides. Steroidal saponins are mainly compounds containing 27 carbon atoms. Steroidal saponins are usually divided into two broad structural classes, namely **spirostanol** and **furostanol** saponins. The core structure for steroidal saponins is derivative of steroids with a spiroketal side chain.

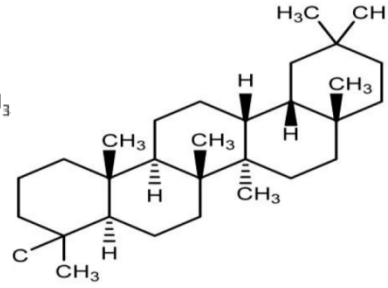


Structures of (**A**) spirostanol and (**B**) furostanol saponins

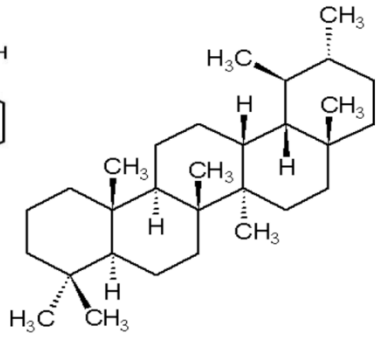
In triterpenoidal saponins, the aglycone is a triterpene. Most aglycones of triterpenoidal saponins are pentacyclic compounds derived from one of the three basic structural classes represented by Lupane, a-amyrin and b-amyrin



Lupane



Oleanane (β-amyrin)

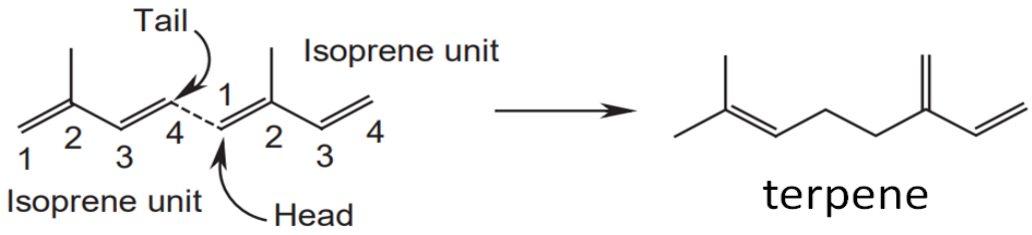


Ursane (α-amyrin)

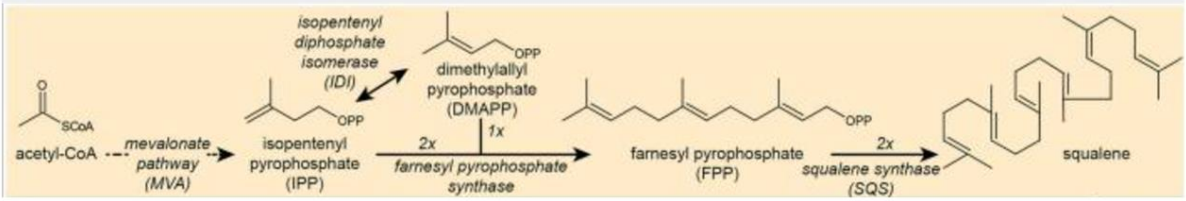
Saponins with the carbohydrate or oligosaccharide groups attached at the C-3 position are monodesmosidic, while saponins with carbohydrates attached at both the C-3 and C-26 or C-28 positions are bidesmosidic. The variety of a glycones, carbohydrates, and different attachment positions result in numerous types of saponins. The carbohydrate chains of saponins usually include: D-glucose, D-galactose, L-rhamnose, L-arabinose, D-xylose, D-fucose, and D-glucuronic acid. The linkages between the sugar chain and the aglycones as well as between the sugar residues can undergo hydrolysis during acid or base treatment, hydrothermolysis or enzymatic/microbial transformations, resulting in the formation of aglycones, prosapogenins (partially hydrolyzed saponins), and sugar residues.

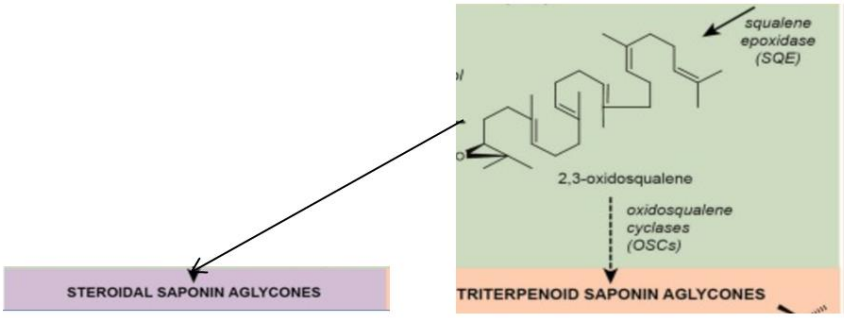
Biosynthesis of saponin glycosides

Isoprene is a five carbon unit. Carbon 1 is called the 'head' and carbon 4 is the 'tail'.



The triterpenoid and steroidal aglycone backbones are isoprenoids that are synthesized from isopentenyl pyrophosphate (IPP) units generated by the mevalonate (MVA) pathway. The multistep in MVA/ pathway catalyzes the conversion of acetyl-CoA to the five-carbon terpene precursor IPP, which is then isomerized to its allylic isomer dimethylallyl pyrophosphate (DMAPP) by the enzyme isopentenyl diphosphate isomerase (IDI). The subsequent condensation of two IPP units with one DMAPP unit results in the formation of 15-carbon farnesyl pyrophosphate (FPP), the immediate prenylated precursor of the saponins. Finally, the condensation of two FPP units by squalene synthase (SQS) generates the linear 30-carbon the squalene, which is further epoxidized to 2,3-oxidosqualene by the enzyme squalene epoxidase (SQE). The 2,3-oxidosqualene is typically cyclized to polycyclic structures. The triterpenoid saponins are synthesized from 2,3-oxidosqualene that is cyclized to specialized triterpene aglycones. The steroidal saponins are synthesized by a series of oxygenations and glycosylations of the cholesterol backbone that produced from2,3-oxidosqualene.





Plant sources

Plants containing steroidal saponins glycoside

Two major types of steroidal sapogenin are diosgenin and hecogenin. Steroidal saponins are used in the commercial production of sex hormones for clinical use. The most abundant starting material for the synthesis of progesterone is diosgenin isolated from *Dioscorea* species and *Trigonella*

1. **Dried tubers** of ***Dioscorea villosa***

Synonym: **Yam**

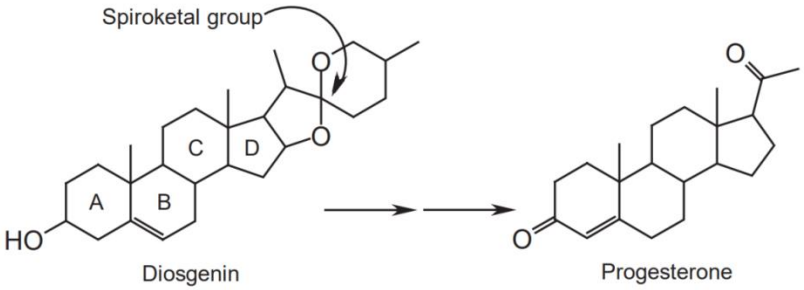
Family: Dioscoreaceae

2. Seeds of *Trigonella foenum-graecum L.*

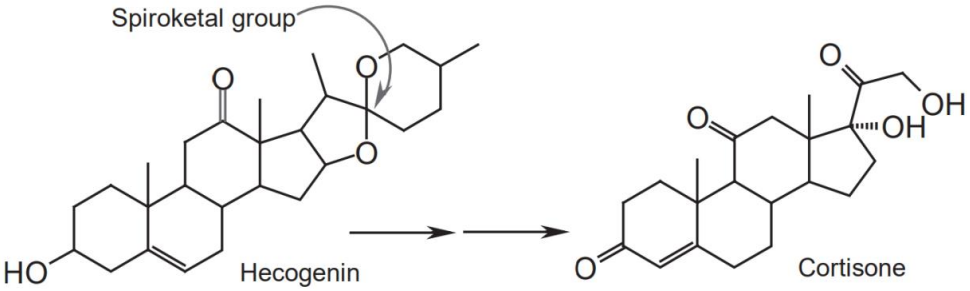
Synonym: **Fenugreek**

Family : Fabaceae

Other steroidal hormones, e.g. cortisone and hydrocortisone, can be prepared from the starting material hecogenin, which can be isolated from Sisal leave (Agave species)



The spiroketal group attached to the D ring of diosgenin can easily be removed



Plants containing triterpenoid pentacyclic saponin

1-glycyrrhiza (licorice)

Glycyrrhiza glabra

Family: Leguminoseae

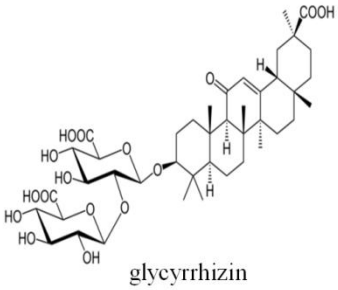
Source : dried root

Glycyrrhizin or glycyrrhetinic acid

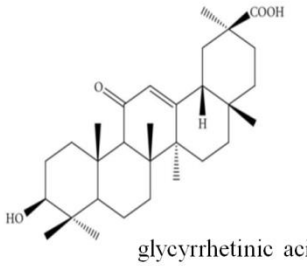
Glycyrrhizin is the main triterpenoid saponin in licorice root. Glycyrrhizin 50 times as sweet as sugar is used as a sweetener and as a flavouring agent. Upon

hydrolysis the glycoside converted to the aglycone glycyrrhetinic acid (glycyrrhizic acid) plus two molecules of glucoronic acid. Used as anti-inflammatory& in treatment of rheumatoid arthritis use as flavouring & sweeting agent, to numerous medicines e.g. quinine. Liquorice extract contains (10-15% glycerhizin) is used in cough reliever as expectorant

The aglycone of glycyrrhizin has aketo group at C11, a structure feature shown also by cortisone. This may explain the reported dexycortixone effect of liquorice



glycyrrhizin



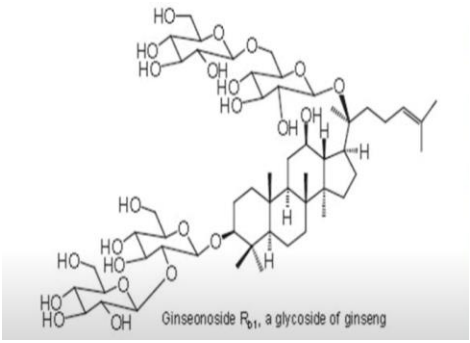
glycyrrhetinic acid

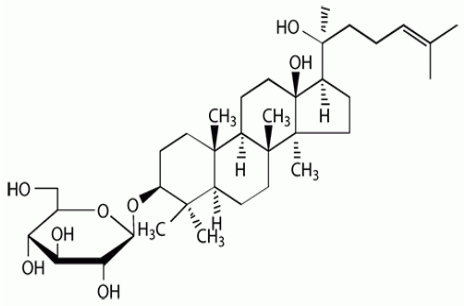
2. Ginsenoside (panaxoside) a triterpenoid steroidal nucleus

Biological source:

Dried root of *Panax ginseng*

They are C30 triterpenoids classified as steroidal glycosides as they have a typical steroidal nucleus

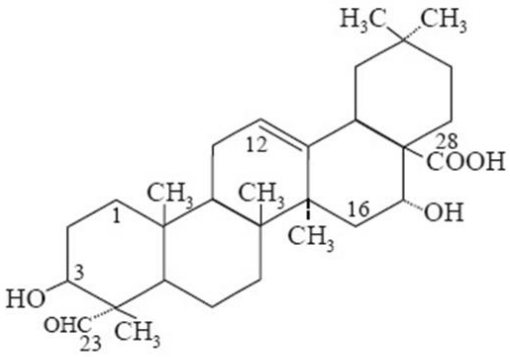




Ginsenoside structure

3-Quillaia bark dried bark *Quillaja saponaria* Family : Rosaceae

The main plant sources of saponins used in medicine and industrial applications are soap bark tree (*Quillaja saponaria*). Unpurified extracts contain over 60 triterpenoid saponins, consisting predominantly of glycosides of quillaic acid .

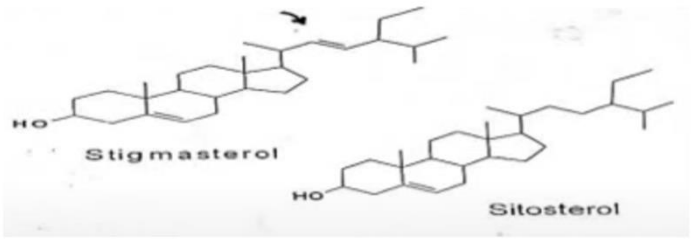


Quillaic Acid

- soybean **Soya Bean steroids**

Contain phytosterol, **sitosterol** an **stigmasterol**

They are not sapogenins, but described here due to their uses in steroidal synthesis



Biological activity

Due to their amphiphilic nature, saponins show a wide range of biological activities. Saponins have been shown to swell and rupture erythrocytes causing a release of hemoglobin. The effect of saponin on erythrocyte death or hemolysis may limit the therapeutic use of the substances. On the other hand, saponins have been proposed for the treatment of a variety of diseases, including diabetes, effects of saponins include stimulation of immune responses used as adjuvant. Their efficacy against cancer has been attributed to their ability to inhibit cell proliferation, reductions of cholesterol concentrations.