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Therapeutic properties and structural characterization of steroidal saponins: a review

https://doi.org/10.32712/2446-4775.2021.1101

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Abstract

Medicinal plants are sources of bioactive substances that can act to maintain human health. Among the compounds widely distributed in medicinal plants, there are steroidal saponins, an important class of secondary metabolites that are characterized as the active principle of these natural products. The structure of steroidal saponins is composed of a steroidal aglycone covalently linked to portions of carbohydrates and due to the complexity of its structure, the structural characterization processes are laborious. Steroidal saponins have been investigated over the years, due to their potent therapeutic properties such as antimicrobial, anti-inflammatory and cytotoxic. In this work were summarized the studies found in the scientific literature in the last two decades, about the investigation of the therapeutic properties and structural characterization of the steroidal saponins. Furthermore, recent studies have suggested that some saponins like candidates for the treatment of patients with Coronavirus disease (COVID-19). Studies on steroidal saponins are of great importance, as they can be potent therapeutic agents.

Keywords: Steroidal saponins. Active principles. Structural characterization. Therapeutic properties.

Introduction

Saponins are a group of bioactive glycosides, widely distributed in the plants. They can be classified into two groups based on the nature of their aglycone skeleton: steroidal saponins which are present mainly in the monocotyledonous angiosperms and triterpenoid saponins which occur mainly in the dicotyledonous angiosperms [1].

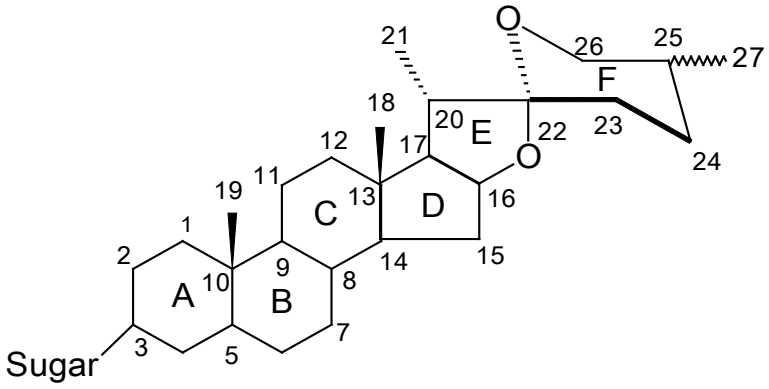
Steroidal saponins are a group of natural compounds that consist of a steroidal aglycone, designated sapogenin, covalently linked to sugar moieties [1]. Because of its amphipathic nature, these substances have the capacity to form a foam when in contact with water and they possess pharmacological and medicinal properties[2], such as antifungal, anti-inflammatory, anticancer and antiulcerogenic activities[1]. There are distributed in various plant species and are found in abundance in the families Agavaceae, Alliaceae, Asparagaceae, Dioscoreaceae, Liliaceae, Melanthiaceae, Solanaceae, Trilliaceae and Zygophillaceae. Many industrial and commercial applications are reports to saponins, they are found in beverages, cosmetics and pharmaceutical products. Furthermore, they are used as raw materials for the production of steroid

hormones, as food additives and due its therapeutic properties, have been investigated over the years, toward the development of new natural medicines[2].

Steroidal saponins possess 27 carbon atoms in the aglycone and can be divided into spirostane and furostane based on the nature of their aglycone skeleton. The type spirostane possess a skeleton hexacycle ABCDEF-ring system and sugar moieties commonly linked at C-3. Already, the furostane type presents a pentacyclic ABCDE-ring system with the sixth open F ring and sugar moieties commonly linked at C-3 and C-26 (**FIGURE 1**)[1,3].

FIGURE 1: Aglycone moiety of saponins**:** (A) Steroidal spirostane (B) Steroidal furostane. R =H or CH_3. The image was adapted of reference [1].

(A)



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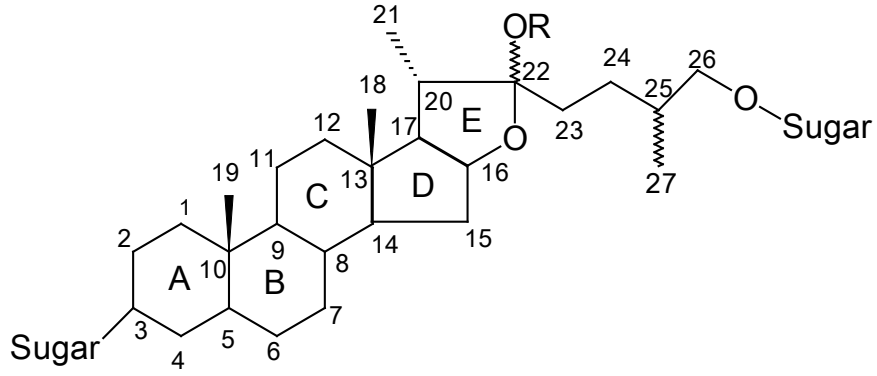
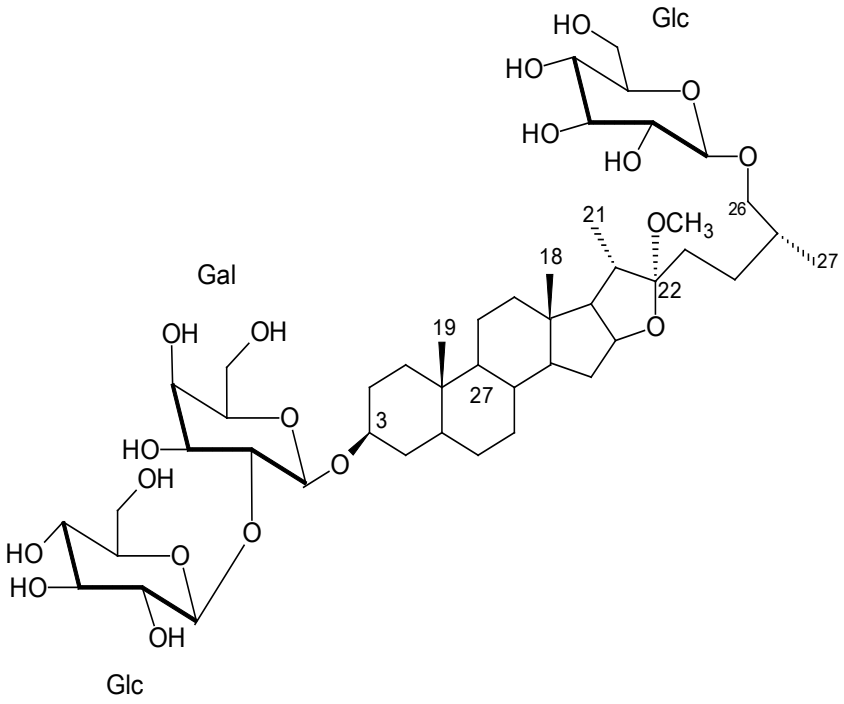


Steroidal saponins can also have functional groups in the aglycone [4] where the most common are -OH and -OCH_3. Furthermore, can also contain insaturations in ring. The sugars usually found are glucose, galactose, arabinose, xylose and rhamnose[5]. According to the literature, the furostane steroidal saponin isolated from *Yucca gloriosa* L. rhizomes (Agavaceae) showed the functional group OCH_3 linked at C-22 and sugar moieties of galactose and glucose (**FIGURE 2A**)[6]. Already, the furostane steroidal saponin from *Allium sativum* L. var. Voghiera (Alliaceae) showed the group OH linked at C-5 and at C-22[7] (**FIGURE 2B**). It's also reported that the spirostane steroidal saponin from *Asparagus filicinus* (Asparagaceae) presented the group OH linked at C-17 and showed moieties of the glucose, arabinose and xylose[8] (**FIGURE 2C**) and the spirostane steroidal saponin from *Smilacina japonica* (Liliaceae) showed a insaturation on C-ring, the functional group OH linked at the C-17 and C-24 and presented the sugars galactose, glucose and xylose[9] (**FIGURE 2D**). This large structural diversity is responsible for the various biologic activities of saponins and because they are complex substances become labor intensive the processes of structural characterization.

FIGURE 2: Examples of saponins. (A) Furostane steroidal saponin from *Yucca gloriosa* L. rhizomes[6]. (B) Furostane steroidal saponin from *Allium sativum* L. var. Voghiera[7]. (C) Spirostane steroidal saponin from *Asparagus filicinus*[8] (D) Spirostane steroidal saponin from *Smilacina japonica*[9].

(A)



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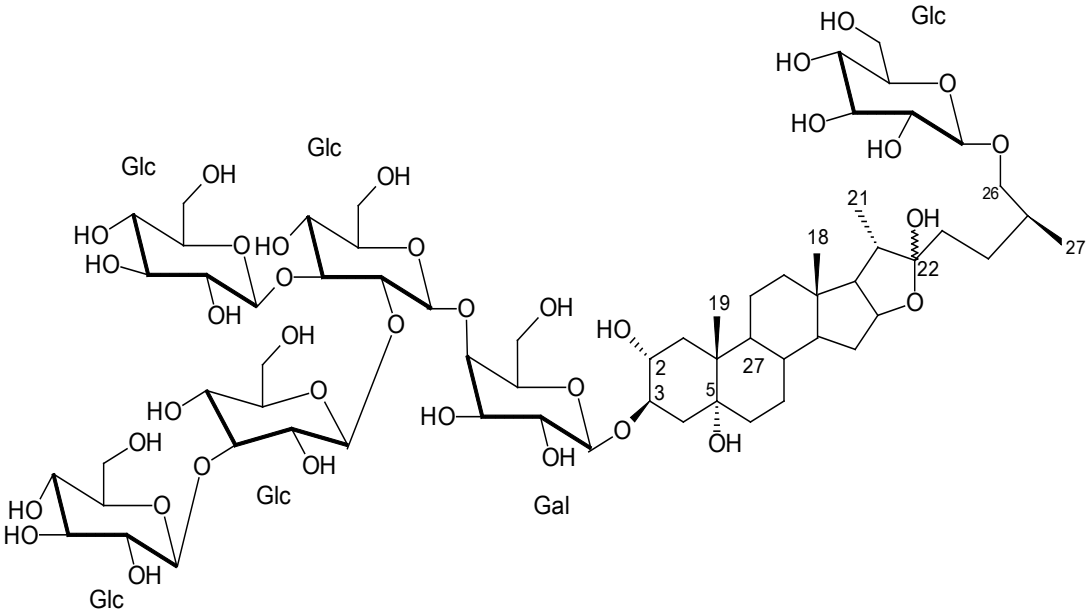

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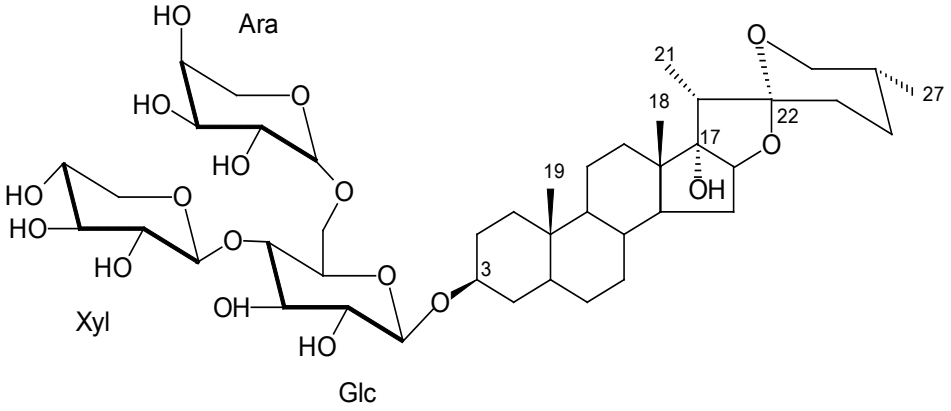

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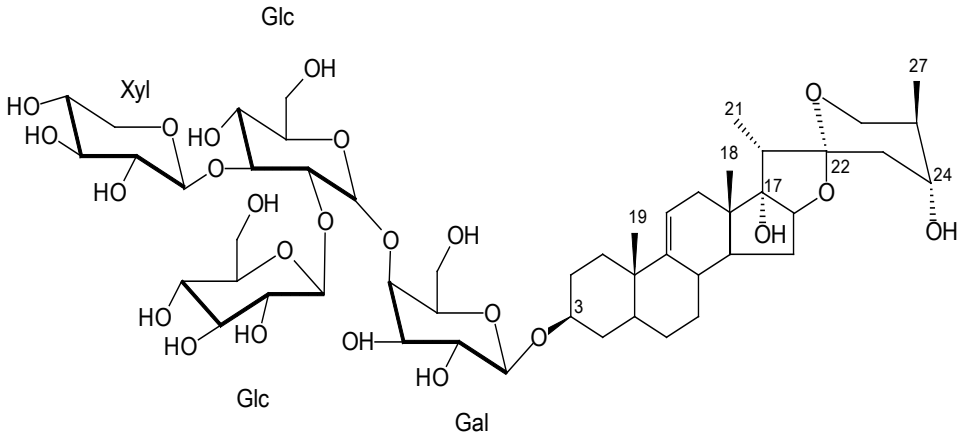

Material and Methods

In this review are summarized the studies found in the scientific literature about structural characterization and main biological activities reported for steroidal saponins in the last two decades. Thus, this review has been prepared by collecting information about biosynthesis, techniques of structural elucidation and therapeutic properties of steroidal saponins. The main scientific bases used for the development of this work were Science Direct, Capes periodicals portal and Google academic.

Results and Discussion

The search in Science Direct, Capes periodicals portal and Google academic using the terms “steroidal saponins” resulted in 11,922; 5,514 and 34,900 articles respectively. This large amount of articles show that research on steroidal saponins is of great relevance arousing the interest primarily of researchers in the field of chemistry and health.

The following topics will address the two biosynthetic pathways described in the literature (**FIGURE 3** and **FIGURE 4**), the techniques by structural characterization and main signals attributed at ^{1}H and ^{13}C NMR (**FIGURE 6**). Finally, will be discussed the therapeutic properties of the steroidal saponins that was summarized in the **TABLE 1**.

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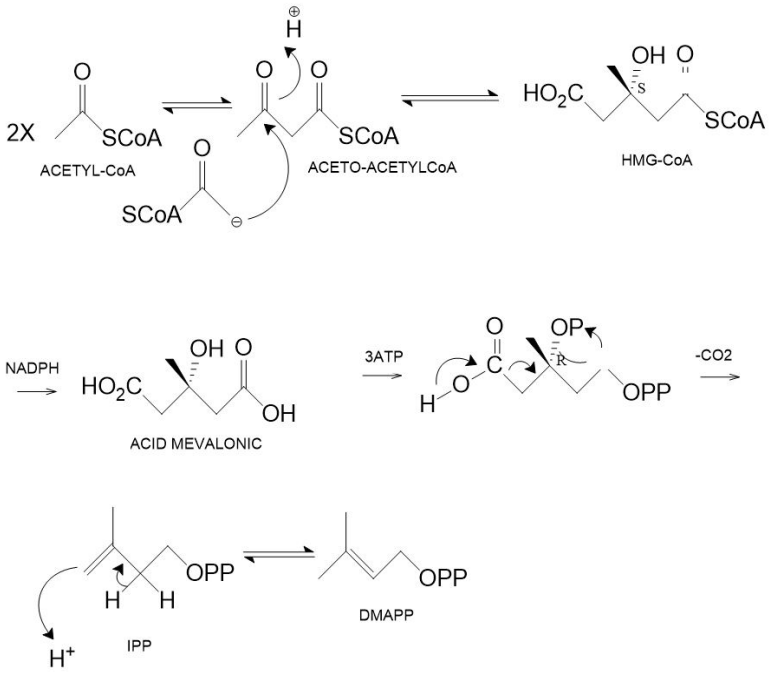
Biosynthesis

Steroidal saponins are derived of the C_5 isoprene units, dimethylallyl diphosphate (DMAPP) and isopentenyl diphosphate (IPP) and is described that such isoprene units can be formed by two biosynthetic pathways, the mevalonate pathway and an alternative pathway known as deoxyxylulose phosphate[10].

In the mevalonate pathway occurs the formation of the mevalonic acid as precursor of the reaction. Initially, two molecules of acetyl-coenzyme A are connected for Claisen condensation to give acetoacetyl-CoA. Subsequently, another molecule of acetyl coenzyme A is incorporated via a stereospecific aldol addition giving the ester β-hydroxy-β-methylglutaryl-CoA (HMG-CoA). Subsequently occurs a hydrolysis and enzymatic reduction giving the mevalonic acid. Then, the mevalonic acid is transformed in the isoprene unit isopentenyl diphosphate (IPP), through the successive phosphorylation of the hydroxyl groups, followed by decarboxylation and elimination of a group pyrophosphate. Subsequently, an isomerase removes a proton at C-2 of IPP giving the dimethylallyl diphosphate (DMAPP) (**FIGURE 3**)[10].

FIGURE 3: Mevalonate biosynthetic pathway[10]. β-hydroxy-β-methylglutaryl CoA (HMG-CoA); isopentenyl diphosphate (IPP); dimethylallyl diphosphate (DMAPP).



Deoxyxylulose phosphate pathway was posteriorly discovered and probably is more widely utilized in nature than is the mevalonate pathway. The compound 1-Deoxy-D-xylulose 5-phosphate is the precursor of the reaction and is formed from two products of glycolysis, pyruvic acid and D-glyceraldehyde 3-phosphate.

In this biosynthetic pathway, initially the pyruvic acid reacts with the thiamine diphosphate (TPP) that mediates the decarboxylation of pyruvate producing an acetaldehyde equivalent bound in the form of an enamine. This, reacts as a nucleophile, in an addition reaction with the D-glyceraldehyde 3-phosphate. Subsequent release from the TPP carrier generates 1-Deoxy-D-xylulose 5-phosphate (DXP), that through of a rearrangement type pinacol-pinacolone, followed by reduction, the DXP is converted to 2-methyl-D-erythritol-4-phosphate, resulting in the isoprene unit isopentenyl pyrophosphate (IPP) in a sequence that not fully elucidated yet (**FIGURE 4**)[10].

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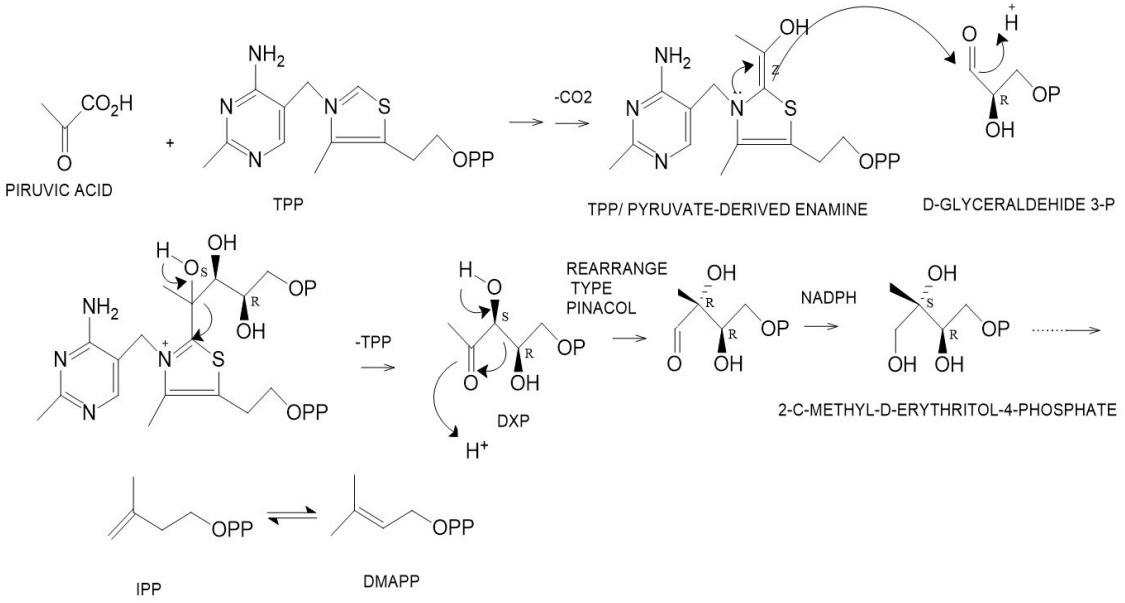
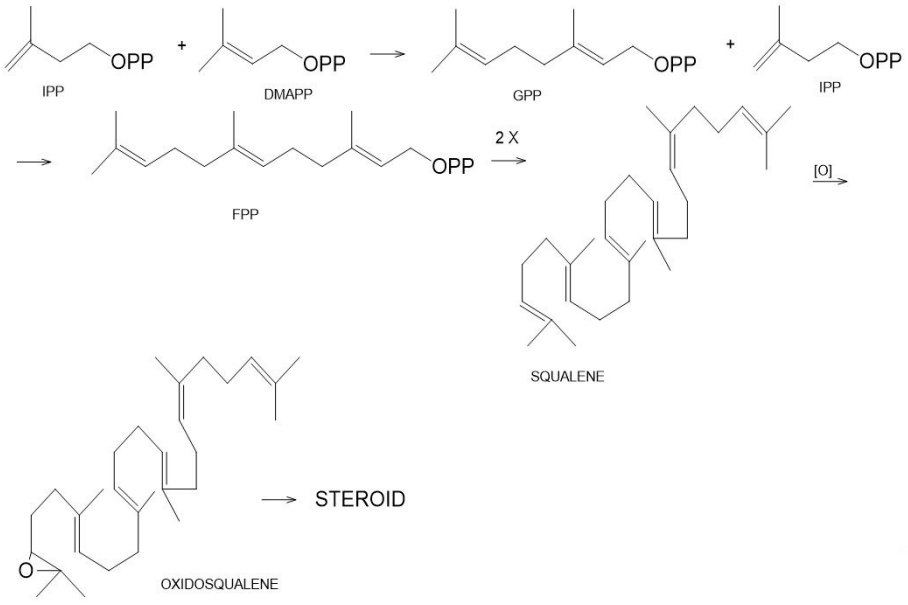
FIGURE 4: Deoxyxylulose phosphate biosynthetic pathway[10]. Thiamine diphosphate (TPP); 1-Deoxy-D-xylulose 5-phosphate (DXP); Isopentenyl pyrophosphate (IPP); Dimethylallyl diphosphate (DMAPP).



Saponins have as precursor the oxidosqualene, that is formed from the isoprene units IPP and DMAPP. Initially a unit C5 of the IPP is condensed with a unit C5 of DMAPP resulting in the molecule C10 of the geranyl diphosphate (GPP). This is linked with a unit of IPP resulting in a unit C15 of farnesyl diphosphate (FPP). The union of two molecules of FPP originates the squalene, that by action of squalene monooxygenase form oxidosqualene. In sequently, occur a series of reactions of the cyclization, rearrangement, migration of hydride, methyl, formation of carbocation, forming a great diversity of steroid skeletons[2] (**FIGURE 5**)[10]. It is reported that oxidosqualene cyclization can proceed via the “chair-chair-chair” or via the ‘chair-boat-chair’ conformation. Triterpenes saponins originate from the ‘chair-chair-chair’ conformation, while steroids saponins arise from the ‘chair-boat-chair conformation[11].

FIGURE 5: The cyclization of oxidosqualene to the various steroids skeletons[10]. Isopentenyl diphosphate (IPP); Dimethylallyl diphosphate (DMAPP); Geranil diphosphate (GPP); Farnesil diphosphate (FPP).



Spirostane saponins are formed by enzymatic hydrolysis of furostane saponins, such hydrolysis occurs by action of the enzyme β-glucosidase, that is an enzyme specific to cleave the glucose unit linked to C-26 allowing that the oxygen to be free and make an intramolecular bond with the carbon in C-22, leading to the closure of the F ring, but this mechanism isn't fully elucidated[12].

The biogenetic relationship between the furostane and spirostane derivatives also is still contestable[3]. It's reported that furostanolic saponins to be usually contained in fresh plants and it are gradually converted into spirostanol saponins during the drying process. Moreover, there are reports that usually furostane saponins showed low toxicity, while spirostanes are highly toxic[3].

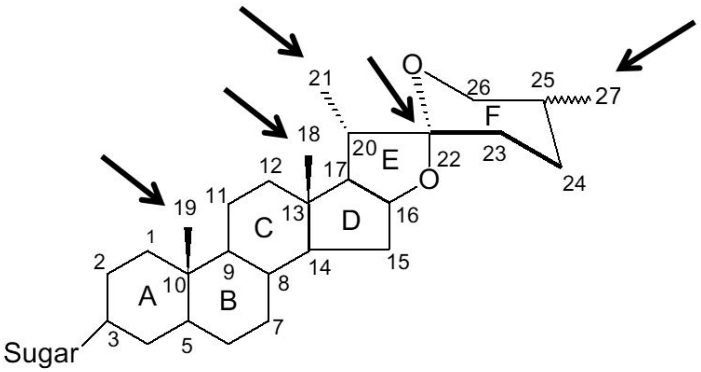
Structural characterization

Steroidal saponins are complex substances, so the structural characterization process takes a lot of work, requiring to comparisons with the literature data and a big numbers techniques, being the most common: the indispensable ^{1}D and ^{2}D Nuclear Magnetic Resonance (NMR), Mass Spectrometry to determine mass molecular, acid hydrolysis and chromatographic techniques for identification the sugars.

In the ^{1}H NMR spectrum of steroidal saponins, extensive interproton couplings are observed and, consequently, only a few signals can be attributed. Some examples are the singlets of the angular methyl groups (H3-18, H3-19) and doublets for the methyl groups (H3-21, H3-27)[7] (**FIGURE 6**).

FIGURE 6: Main groups of aglycone identified by NMR.**:** (A) Methyl groups (CH_3-18, CH_3-19, CH_3-21) and spirostanic carbon (C-22) by Steroidal spirostane (B) Methyl groups (CH_3-18, CH_3-19, CH_3-21, CH_3-27), furostane carbon (C-22), methyl group (CH-25) and methylene group (CH_2-26) by Steroidal furostane. The image was adapted of reference[1].

(A)



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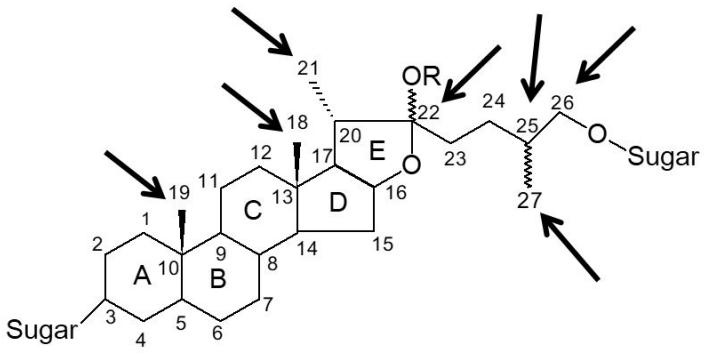

A steroidal saponin from *Dioscorea althaeoides* R. Knuth showed the typical signals for singlets of H3-18 at δ0.83 ppm; H3-19 at δ 1.02 ppm and doublets H3-21 at δ1.15ppm and H3-27 at δ 0.7 ppm[14]. In ^{13}C NMR spectrum of steroidal saponin the methyl groups of the steroid (CH_3-18, CH_3-19 and CH_3-21) have positions and stereochemistry defined of biosynthetic origin and their signals can be observed in the ^{13}C NMR spectrum in the region of δ16.0-16.8; δ12.2-19.0 and δ14.3-16.8 ppm, respectively, what can vary according to the nature of the saponin to be furostane or spirostane and also with the fact of the present unsaturation or functional groups in the aglycone[14-17]. The signal of spirostane carbon (C-22) (**FIGURE 6**) is observed generally in the region at the δ109.0-110.0 ppm. The spirostane saponin from *Dioscorea althaeoides* R. Knuth showed the C_{22} at δ109.2 ppm[13] and the spirostane saponin from *Smilax officinalis* (Liliaceae) showed the C_{22} at δ110.0 ppm[14]. The furostane carbon (**FIGURE 6**) commonly it is observed at the δ112-112.5 ppm. Five furostanes saponin from *Dioscorea althaeoides* R. Knuth showed the C_{22} at δ111.8 (two saponins), δ111.9 (one saponin) and δ112 ppm (two saponin)[7].

According to the literature, through the difference of the chemical shift between the diastereotopic hydrogens H26a and H26b, it is possible to identify the configuration at the C-25. The stereochemistry is defined S if ≠ a,b ≥ 0.57 ppm and defined R if ≠ a,b≤ 0,48 ppm[6,18]. Furostane steroidal saponin from *Yucca gloriosa* L. rhizomes showed C-25 configuration was deduced to be R based on the difference of chemical shifts (**FIGURE 2A**)[6].

The complete assignments of the overall structure of the aglycone skeleton are achieved by a combination of ^{1}H, ^{13}C, DEPT and ^{2}D NMR methods, such HSQC, ^{1}H–^{1}H COSY and HMBC experiments.

In aglycone steroidal saponin from *Smilacina japonica* (**FIGURE 2D**) were found HMBC correlations for methyls hydrogens for H_3-18, H_3-19, H_3-21 and H_3-27. The H_3-18 showed correlations with C-12 (δC 41.1), C-13 (δC 38.3), C-14 (δC 53.2) and C-17 (δC 61.3). H3-19 with C-1 (δC 35.1), C-5 (δC 42.5), C-9 (δC 146.8), C-10 (δC 37.7). H3-21 with δC C-17, C-20 (δC 42.1), C-22 (δC 108.9) and spirostane H_3-27 with C-24 (δC 25.4), C-25 (δC26.4), C-26 (δC 64.3) [9]. In addition, were found HMBC correlations of the olefinic hydrogen H-11 with C-10, C-12, C-13 and C-14[9].

Some aglycones also have a hydroxyl group at C-17 (**FIGURE 2C; 2D**). The presence the OH at C-17 in the saponin from *Asparagus filicinus* (**FIGURE 2C**) was also supported by the HMBC correlations between OH-17 ((δH 5.06) and the C-13 (δC 45.4); C-16 (δC 90.0); C-17 (δC 90.0) and C-20 (δC 44.8)[8].

Acid hydrolysis is generally used to identity the sugars portion. The literature commonly reports acid hydrolysis or HCl[9-13] or H_2SO_4 [8-16].

The acid hydrolysis with HCl 2M of the sugars of the saponin from *Smilacina japonica* (**FIGURE 2D**) generated glucose, galactose and xylose, which were identified by thin layer chromatography[9]. The anomeric carbons were determined by the analysis of the 1D and 2D NMR spectra showed xylose anomeric (δH 4.49; δC 103.3); galactose anomeric (δH 4.20; δC 101.1) and two glucose anomerics [(δH 4.71; δC 102.4), (δH 4.41; δC 103.3)][9]. To determine the sequence of the oligosaccharide chain and the correlation between sugars and aglycone are use analysis of the ^{2}D NMR spectra.

Therapeutic properties

Steroidal saponins are bioactive compounds and over the years has been reported many studies about their biological properties, where is widely described the antifungal, antibacterial, anti-inflammatory, cytotoxicity and gastroprotective activities[19-44]. Others therapeutic properties, such as, antianoxia, anti-hyperlipidemia, anti-thrombotic, molluscicidal, anthelmintic and anti-tumor also are related[43-50]. **TABLE 1** shows a summary of the main biological activities.

Antifungal activity

The antifungal activity is very reported in the Alliaceae[7,19,20] and Dioscoreaceae[21,22] families. The aginoside, a spirostane steroidal saponin from *Allium nigrum* L. was evaluated against phytopathogens showed a significant antifungal activity[20]. Furostane and spirostane steroidal saponins from *Persian leek* were evaluated against various fungal pathogens (*Penicillium italicum, Aspergillus niger, Trichoderma harzianum* and *Botrytis cinerea*) and Persicosides A and B, two spirostane steroidal saponins showed the highest activity on the tested fungi than the other tested saponins based on furostanol[20]. A spirostane saponins from *Dioscorea villosa* (discoreae) presented antifungal activity against *Candida albicans*, *Candida glabrata* and *Candida tropicalis* [21]. These results show the relationship of the spirostane skeleton on the activity, indicating that a spirostane aglycon is a structural feature increasing the antifungal activity of saponin compounds[20].

Antibacterial activity

Antibacterial activity is also reported for spirostane saponins. Seven spirostanol saponins from *P. polyphylla* var. *yunnanensis* showed significant antimicrobial activity against *P. acnes*[23]. One spirostanol saponin from *Cordyline fruticosa (L.) A. Chev.* also showed a moderate antibacterial activity against the Gram-positive *Enterococcus faecalis*[24]. The authors point out that saponins deserve more attention as antibacterials, since this property is often assumed as less important over the antifungal activity. They believe that saponins might represent new and effective antibacterial agents[24].

Anti-inflammatory activity

Saponins with anti-inflammatory activity are reported in various families of plants, such as Liliaceae, Asparagaceae, Alliaceae, Agavaceae, Orchidaceae and others[25-30]. Steroidal saponins from *Smilax china* (Liliaceae) showed anti-inflammatory properties, inhibited the effects on cyclooxygenase-2 enzyme (COX-2)[25]. Sun *et al.*[26] isolated four steroidal furostanol saponins from the rhizomes of *Aspidistra elatior* Blume (Asparagaceae), their structures were determined based on chemical methods and spectral data and the isolated compounds, named aspidsaponins E-H were tested in *vitro* assay for inhibitory activities against LPS-induced nitric oxide production in RAW264.7 macrophages. Among them, compounds aspidsaponins G and aspidsaponins H showed excellent anti-inflammatory activities with IC50 values 82.1 and 65.9 μM, respectively[26].

Cytotoxic activity

Cytotoxic activity is one of the most common reported for saponins, there are reported of this activity in families Agavaceae, Taccaceae, Orchidaceae, Dracaenaceae, Liliaceae, Amaryllidaceae, Asparagaceae, Solanaceae and others[31-42].

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Three steroidal saponin from *Allium flavum* (Amaryllidaceae) exhibited moderate cytotoxicity against human colorectal cancer cell line (SW480)[31]. Five steroidal saponins from *Ophiopogon japonicus* (Liliaceae) showed cytotoxicity activity against five human cancer cell lines (HepG2, HLE, BEL7402, BEL7403 and Hela)[32]. A phytochemical study on *T. Tschonoskii* rhizomes, result in the isolated of twenty-four steroidal saponins. The citotoxic activity was analyzed against HepG2 cells and the results showed that two compounds that possess aglycone of pennogenin exhibited a remarkable cytotoxic activity, which presumed that the aglycone of pennogenin is critical for the cytotoxic activity. The authors believe that the structural changes on pennogenin due to substituents or the configuration difference could result in the activity disappeared[33]. Seven steroidal saponins from *Dioscorea zingiberensis* Wright (Dioscoreaceae) inhibited the proliferation of a panel of established human and murine cancer cell lines *in vitro*, where the zingiberensis saponin had more cytotoxic effect than the other saponins, demonstrated that this saponin is an effective natural agent for cancer therapy[34].

Gastroprotective activity

It is reported that four steroid saponins from *Paris polyphylla* var. *yunnanensis* (Liliaceae) strongly inhibited gastric lesions induced by ethanol and indomethacin[43]. Preliminary biological investigations made with a furostane saponin isolated from *Agave angustifolia* var. *marginata*, indicated a significant protective effect against induced gastric ulcers using *in vivo* experimental models and demonstrated negligible toxicity on membrane integrity in the *in vitro* assays[44].

TABLE 1: Main biological activities of steroidal saponins in families and plant species.

Active biologic	Family	Species	References
Antifungal	Alliaceae	*Allium sativum* L. var. *Voghiera*	[7]
	Alliaceae	*Allium cepa* L.	[7]
	Alliaceae	*Allium nigrum* L.	[19]
	Alliaceae	*Persian leek*	[20]
	Dioscoreaceae	*Dioscorea villosa*	[21]
	Dioscoreaceae	*Dioscorea nipponica*	[22]
Antibacterial	Melanthiaceae	*Paris polyphylla* var. *yunnanensis*	[23]
	Agavaceae	*Cordyline fruticosa* (L.) A. Chev.	[24]
Antiinflammatory	Liliaceae	*Smilax china*	[25]
	Asparagaceae	*Aspidistra elatior Blume*	[26]
	Alliaceae	*Allium ampeloprasum* var. *porrum*	[27]
	Agavaceae	*Agave attenuata*	[28]
	Agavaceae	*Agave brittoniana*	[29]
	Orchidaceae	*Bletilla striata*	[30]
Cytotoxic	Amaryllidaceae	*Allium flavum*	[31]
	Liliaceae	*Ophiopogon japonicus*	[32]

	Liliaceae	*Trillium tschonoskii*	[33]
	Dioscoreaceae	*Dioscorea zingiberensis* Wright	[34]
	Agavaceae	*Cordyline fruticosa* (L.) A. Chev.	[24]
	Agavaceae	*Agave utahensis*	[35]
	Taccaceae	*Tacca chantrieri*	[36]
	Orchidaceae	*Bletilla striata*	[30]
	Amaryllidaceae	*Allium schoenoprasum*	[37]
	Amaryllidaceae	*Allium flavum*	[31]
	Dracaenaceae	*Dracaena draco*	[38]
	Liliaceae	*Smilax aspera* L.	[39]
	Asparagaceae	*Anemarrhena asphodeloides*	[40]
	Solanaceae	*Cestrum parqui*	[41]
	Asparagaceae	*Sansevieria cylindrica Bojer*	[42]
Gastroprotective	Liliaceae	*Paris polyphylla* var.*yunnanensis*	[43]
	Agavaceae	*Agave angustifoliva*.var *marginata*	[44]
	Alliaceae	*Allium ampeloprasum* var. *porrum*	[27]
Anti-anoxia	Selaginellaceae	*Selaginella uncinata*	[45]
Anti-hyperlipidemia	Dioscoreaceae	*Dioscorea nipponica*	[46]
Anti-thrombotic	Dioscoreaceae	*Dioscorea zingiberensis* C.H. Wright	[47]
Molluscicidal	Agavaceae	*Yucca desmettiana*	[48]
Anthelmintic	Melanthiaceae	*Paris polyphylla*	[49]
Anti-tumor	Asparagaceae	*Liriope graminifolia*	[50]

Saponins and COVID-19

The emergence of Corona Virus Disease 2019 (COVID-19) has been declared as a pandemic by the World Health Organization. Scientists around the world aim to find an effective treatment for COVID-19. Some hypotheses are found in the literature that saponins can help in the treatment of symptoms caused by the disease.

He et al.[51] investigated therapeutic potentials of Chinese Herbal Medicine (CHM) to combat renal injury in COVID-19 patients. In this study, were selected active ingredients from CHM, contends mainly flavonoids and saponins which generally have the effects of anti-inflammation and anti-tumor. The diosgenin, a sapogenin that can reduce apoptosis by regulating PI3K/Akt, ERK and JNK signaling pathways was a the top listed one[51,52]. Furthermore, the authors believe that the stigmasterol and sitogluside sapogenins may play the role of preventing renal injury by acting on multiple targets in oxidativestress, inflammation, or apoptotic pathways. The authors suggest that CHM are promising to protect the kidney through the mechanisms of anti-oxidation, inhibition of inflammation and apoptosis pathways[51].

Revista Fitos. Rio de Janeiro. 2021; 15(3): 403-417 | e-ISSN: 2446-4775 | www.revistafitos.far.fiocruz.br | CC-BY 4.0

Bailly et al.[53] believe that triterpenoid saponins Saikosaponin A, Saikosaponin B, and Saikosaponin D from Bupleurum falcatum L. are candidate treatment for COVID-19 owing to their anti-inflammatory, immunomodulatory, and antiviral activities. The authors recommend future welldesigned randomized controlled trials to evaluate the safety and efficacy of Saikosaponins in patients with COVID-19[53]. Bailly et al.[53] analyzed the anti-coronavirus potential of the glycyrrhizic acid (GLR), a triterpene saponin non-hemolytic, potent immuno-active anti-inflammatory agent, It is used to treat liver diseases and specific cutaneous inflammation. GLR has shown activities against different viruses, including SARS-associated Human and animal corona viruses. Bailly et al.[53] conclude that glycyrrhizic acid should be further considered and rapidly evaluated for the treatment of patients with COVID-19.

Conclusion

Steroidal saponins are macromolecules distributed in various plant species. The studies about this compounds class is greatly important, because they are very bioactive, can be potent therapeutic agents. Some results have been showing the relationship of the skeleton on the activity, so lots of chemical groups in skeleton saponin have influence directly in higher or lower biological activity. The largest records of bioactive saponins are found in the Agavaceae, Alliaceae, Dioscoreaceae and Liliaceae families and the main biological activities registered are antifungal, antibacterial, anti-inflammatory, cytotoxic and gastroprotective. Besides that, in this review was showed the importance of chemical and physical methods for the complete assignments of the overall structure of steroidal saponins. Some hypotheses are found in the literature that saponins can help in the symptoms caused by COVID-19, being appointed with candidates the treatment of patients with by this disease. Further clinical studies are needed regarding the action of these saponins on Sars-CoV-2.

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Histórico do artigo | Submissão: 07/10/2020 | **Aceite:** 27/11/2020 | **Publicação:** 30/09/2021
Conflito de interesses: O presente artigo não apresenta conflitos de interesse.
Como citar este artigo: Pereira GM, Cruz MFSJ. Therapeutic properties and structural characterization of steroidal saponins: a review. **Rev Fitos**. Rio de Janeiro. 2021; 15(3): 403-417. e-ISSN 2446.4775. Disponível em: <http://revistafitos.far.fiocruz.br/index.php/revista-fitos/article/view/1101>. Acesso em: dd/mm/aaaa.