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Role of Plant Containing Saponin on Livestock Production; A Review

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Abstract: Saponins are naturally occurring in most plants and plant products on surface active glycosides. It is secondary compound structurally diverse molecules that are chemically referred to as triterpene and steroid glycosides. Saponins present in more than 100 plant families and in a few marine sources, in most star fish and sea cucumber species and in a few fish shark repellents. In plants, they occur in different parts such as root, tuber, bark, leaves, seed and fruit. It has a positive and negative impact on animal production and health. They are providing protection to the plants against many pathogens and herbivores. Saponins have a potential health benefits such as hypocholesterolemic, anti-coagulant, anti- carcinogenic, hepato-protective, hypoglycemic, immunomodulatory, neuroprotective, anti- inflammatory, anti-oxidant activity, inhibition of dental caries and platelet aggregation. Saponins also kill protozoans and molluscs and act as antifungal and antiviral agents. However, it has an adverse effect on livestock rumen microorganisms, on rumen fermentation, on digestible tract, on blood parameters, on ruminant reproduction, on growth, wool, egg and milk production. Therefore, along with this review there should be needed a detail research conduct on saponin containing plants which are used for a source of animal feed.

Key word: Effect · Plant · Ruminant · Saponin

INTRODUCTION

Saponins are secondary compounds that are generally known as non-volatile, surface active compounds which are widely distributed in nature, occurring primarily in the plant kingdom. The name ‘saponin’ is derived from the Latin word sapo which means ‘soap’, because saponin molecules form soap-like foams when shaken with water. They are structurally diverse molecules that are chemically referred to as triterpene and steroid glycosides. They consist of nonpolar aglycones coupled with one or more monosaccharide moieties. This combination of polar and non-polar structural elements in their molecules explains their soap-like behaviour in aqueous solutions [1].

The saponins are widely distributed in the plant kingdom and constitute a diverse group of compounds, varying in structure, physicochemical properties and biological effects. Traditionally, saponins have been extensively used as detergents, as piscicides (fish poison) and molluscicides, in addition to their industrial applications as foaming and surface active agents [2]. Saponins were treated as toxic because they seemed to be extremely toxic to fish and cold-blooded animals and many of them possessed strong hemolytic activity [1]. Traditionally, they have been used as detergents, piscicides and molluscicides in addition to industrial applications as foaming and surface active agents [2]. Saponins are sugar and non-carbohydrate complexes that characteristically foam when shaken in water. They are steroid or triterpene glycoside compounds found in a variety of plants [3]. Saponins are the potential bioactive compounds secreted by plants, endophytic fungi and marine organisms. Saponins are the glycosides containing non sugar portion, aglycone (sapogenin) attached to sugar moiety by glycosidic linkage. of the biosynthesis [4]. Some saponin containing plants are toxic which can lead to photosensitisation and subsequent liver and kidney degeneration and gut problems. However it is unlikely these would be used in commercial additives [3].

The structural complexity of saponins results in a number of physical, chemical and biological properties, which include sweetness and bitterness, foaming and emulsifying properties, pharmacological and medicinal

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properties, haemolytic properties, as well as antimicrobial, insecticidal and molluscicidal activities. Saponins have found wide applications in beverages and confectionery, as well as in cosmetics and pharmaceutical products [1]. In addition to this, the main function of secondary metabolites of the plants was providing defense against many pathogens and herbivores. In other words, plants secrete secondary metabolites as their defensive system. As saponins are one of the categories of secondary metabolites, their main function is to provide protection to the plants against many pathogens and herbivores. The various activities of saponins such as antimicrobial, antifungal, antiviral, antihelminthic, insecticidal, larvicidal and molluscicidal activities were very well documented [4].

The efficiency of animal production is dependent upon the optimum utilization of the feed for growth, develop- ment and reproduction. A wide variety of feeds and feedstuffs of different origin are used in animal produc- tion. The nutritional value of feed is influenced by a number of factors and these can affect the efficiency with which the feed is utilized to meet the animal’s particular requirement [5]. Much emphasis is given to various antinutritional factors that are most widespread in nonconventional feedstuffs, which are the tannins and saponins. Therefore, the objective of this review is concerning on saponin.

Chemistry of Saponins: Saponins are glycosides that, depending on the structure of the genin (aglycone), may belong either to the class of triterpenoid saponins or to steroidal saponins as shown in Figure 1a and 1b. The aglycone part of triterpenoid saponins can either be a pentacyclic triterpenoid or a tetracyclic triterpenoid, both containing 30 carbon atoms [2]. Saponins possess a variety of glycosyl groups covalently bound to the C3 position but some saponin contain two sugar chains attached at the C3 and C17 (via C28) position [6]. A large number of saponins could be possible depending upon the modifications of the ring structure of aglycone moieties and number of sugars added to it and in turn producing different biological properties [7]. Saponin glycosides are divided into 2 types based on the chemical structure of their aglycones (sapogenins). Saponins on hydrolysis yield an aglycone known as "sapogenin" [7]. That means it is the combination of sugar (Glycone) and Sapogenin (aglycone).

Whether steroidal or triterpenoid, saponins may be mono, bi- or tridesmodic. Monodesmodic saponins have a single sugar chain, normally attached at C-3. Bidesmodic saponins have two sugar chains, often with one attached through an ether linkage at C-3 and the other either attached through an ester linkage at C-28 or through an ether linkage at C-20 (pentacyclic and tertacyclic triterpene saponins, respectively), or through an ether linkage at C-26 (furostane saponins) [8]. The total saponin content in plant tissues generally considered as saponin-bearing can vary considerably, from between 1.5-23 g/kg in seed crops such as quinoa and soybean, 100 g/kg in Madhuca seeds, up to 100-300 g/kg in quillaja bark and licorice root, respectively [8].

Sources of Saponin: Saponins have been reported to be present in more than 100 plant families [9, 8] and in a few marine sources, such as in most star fish and sea cucumber species and even in a few fish that secrete saponins as shark repellents [9]. Saponins can be classified into the two groups: pentacyclic triterpenoid saponins and steroidal saponins. The steroidal saponins are mainly found in monocotyledons (such as in the family’s Agavaceae, Dioscoreaceae and Liliaceae), while triterpenoid saponins mostly are present in dicotyledons

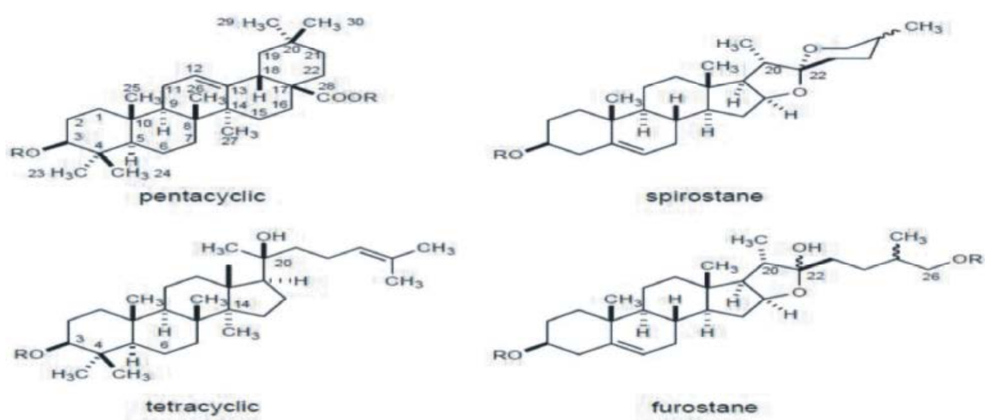

Fig. 1: a) triterpenoid saponins b) steroidal saponins

Table 1: Saponin-Containing Forages Commonly Used as Livestock Feed

family and species	plant part	saponin or sapogenin name	ref
		Fabaceae	
Acacia auriculoformis	fruit	acaciaside	14
Albizia lebbeck	pods, bark	albiziasaponin	15
E. cyclocarpum	leaf, fruit	saponin content 3.9 mg/g	16
Gliricidia sepium	root, fruit	hederagenin	17, 18
Glycine maxima (soybean)	seed	soyasapogenol	10
Lupinus spp. (lupin)	seed	soyasapogenol	19
Medicago sativa (alfalfa, lucerne)	leaf, root, seed	medicagenic (aglycone), soyasapogenol	2
Melilotus alba (white sweet clover)	leaf, flower, root	melitonin	20
Medicago hispida (burr clover)	leaf	hispidacin (soyasapogenol)	6
P. saman	fruit	saponin content 3.4 mg/g	16
Pueraria montana var. *lobata* (Kudzu)	root	kudzusaponins (soyasapogenol)	21
S. sesban	leaf, seed	glucuronide-oleanolic acid, stigmasta galactopyranoside	22
S. pachycarpa	leaf	saponin	23
Trifolium repens (ladino clover)	leaf	cloversaponins (soyasapogenol)	24
Trifolium pratense (red clover)	leaf	soyasapogenin	25
T. foenum-graecum (fenugreek)	leaf, seed	steroid saponin	26
		Moringaceae	
M. oleifera	leaf	80 g/kg diosgenin equivalent	27
		Poaceae	
Avena sativa (oat)	leaf, root, seed	avenacin	28
B. decumbens (signal grass)	leaf	dioscin, diosgenin, yamogenin	29

Source- (Wina, 2016)

(Fabaceae, Araliaceae and Caryophyllaceae) [9]. According to the structure of the carbon skeleton of the aglycone, saponins are sometimes further classified into 12 main classes, namely the: dammaranes, tirucallanes, lupanes, hopanes, oleananes, 23-nor oleananes, taraxasteranes,ursanes, cycloartanes, lanostanes, cucurbitanes and steroids [6].

In addition to this, [10] also reported on saponin source plants which was saponins are found in a large number of plants and some animals (such as the sea cucumber). In plants, they occur in different parts such as root, tuber, bark, leaves, seed and fruit. Triterpenoid saponins are found principally in dicotyledons while steroidal saponins occur in monocots. However, some plant species contain both triterpenoid and steroidal saponins [11]. Many leguminous plants contain triterpenoid saponins, an exception being Trigonella foenum-graecum, which contains steroidal saponins. They are mainly found in leaves but also in seeds. Although only one major structure of saponin or sapogenin in these plants is mentioned on Table 1, it is actually found not as a single compound but as several compounds with different sugar moieties. a single compound but as several compounds with different sugar moieties. For example, 29 saponins have been identified in alfalfa roots, leaves and seeds with medicagenic acid as the major sapogenin. These saponins exert different biological activities due to differences in the sugar moiety, in the position of sugar attachment and in the aglycone. Not all saponins have been isolated and identified in other forages [11]. Generally, saponins are found in tissues that are most vulnerable to fungal or bacterial attack or insect predation to act as a chemical barrier or shield in the plant defense system.

Benefits of Saponion for Ruminal Animal: According to the report of [7] which was cited from [12, 8] saponins from a variety of sources have been shown to have a range of biological activities and potential health benefits such as hypocholesterolemic, anti-coagulant, anti-carcinogenic, hepato-protective, hypoglycemic, immunomodulatory, neuroprotective, anti- inflammatory, anti-oxidant activity, inhibition of dental caries and platelet aggregation. They might also be used in the treatment of hypercalciuria and have also been found to significantly affect growth, feed intake and reproduction in animals. Saponins have also been observed to kill protozoans and molluscs and act as antifungal and antiviral agents [7].

Side Effects on Livestock: There are different adverse effects of saponins on livestock such as it affects on rumen microorganisms, on rumen fermentation, on digestible tract, on blood parameters, on ruminant reproduction, on growth, wool, egg and milk production. Saponin mixtures present in plants and plant products possess diverse biological effects when present in the animal body [13].

Effects on Growth: There is limited information or research output on the effect of plant saponin on growth performance of cattle, shoats or other animals. Animal nutritionists have generally considered saponins to be deleterious compounds. In ruminants and other domestic animals the dietary saponins have significant effects on all phases of metabolism, from the ingestion of feed to the excretion of wastes [13]. Yucca extract or powder is the main source of saponin used for growth experiments since it is commercially available [11]. According to the report of [14] supplement of 30 mg/kg DM of sarsaponin (Y. schidigera extract) to a diet of hay to concentrate ratio did not increase the body mass gain of sheep. However, according to the report of [15] supplementation of 150 mg/day of sarsaponin and 1% urea in corn silage improved the body mass gain of steers during the first 28 days of an experiment, but by the end of the trial (62 days), there was no significant treatment effect. A number of feeding experiments have been performed in cattle where Madhuca press cakes (i.e. from M. latifolia or M. butyracea) or further processed (extracted) cakes (to reduce the saponin content), were fed to ruminants [2]. These feed materials were reasonably accepted and had no significant effect of body weight gain, or other toxicological effects, at inclusion levels of around 20% crude press cake in the diet [16]. Unprocessed Madhuca cake at an inclusion rate of 20% did not affect their growth rate adversely, but 30% did so. Lucerne and soya beans are the main examples of saponin-rich plants that serve extensively in human, ruminant and poultry diets [13]. High levels of alfalfa meal in diets for monogastrics have growth depressing effects, beyond those that may be accounted for by effects of fiber on caloric intake or indigenous nitrogen loss [17].

Effects on Reproduction: The negative effects of saponins on animal reproduction have long been known and have been ascribed to their abortifacient, antizygotic and anti-implantation [18, 19]. Saponins from broom weed (Gutierrezia sp.) and lechu- guilla (Agave lecheguilla) or commercial pharmaceutical- grade saponins caused abortion or death or both in rabbits, goats and cows when administered intravenously at con- centrations above 2•3 mg/kg body weight [20]. Saponins isolated from the crude extract of Gledi-tischia horrida, Costus speciosus Sm and Phytolacca dodecandra caused sterility in mice [21, 18, 19]. According to [22] found that the butanol extract of Mussaenda pubescens was capable of terminating preg- nancy in rats. Saponins were found to be extremely strong stimulators of luteinising hormone release from cultured hypophysial cells [23, 24]. 1989; Benie *et al*. 1990) but their action was neutralised in the presence of serum indicating a passive membrane-permeabilising effect [23]in this case.

Effects on Animal Health: Saponins from different sources have been found to be detrimental to protozoa and have been identified as possible defaunating agents in the rumen [25, 26]. The toxicity of saponins to protozoans seems to be widespread and non- specific and is obviously the result of their detergent effect on the cell membranes [13]. According to the report of [27] saponins suppres's ruminal protozoa by the action of complexing with cholesterol in protozoal cell membranes. Antiprotozoal activity against ruminal protozoa raises the question of whether saponins would be effective against protozoal diseases that afflict humans, livestock and poultry. Those protozoal diseases in which part of the life cycle occurs in the gastrointestinal tract would be expected to be responsive to antiprotozoal activity of saponins.

Bloat in sheep was experimentally demonstrated to be the effect of intraruminal administration of alfalfa saponins. Production of slime from alfalfa saponins by rumen bacteria and alteration of the surface tension by rumen content were suggested as factors contributing to bloat formation [5]. Alfalfa saponins and their interaction with alfalfa proteins proved that alfalfa saponins do not contribute to pasture bloat by either the toxic or the foaming modes of action. Alfalfa saponins possess the property of lowering the plasma cholesterol concentration by forming insoluble complexes and this may be considered as an important factor in human diets to reduce the risk of heart disease [5]. Saponins increase the effectiveness of oral vaccines by altering the permeability of the intestinal mucosa. some saponins increase the permeability of intestinal mucosal cells, facilitating the uptake of substances to which the gut would normally be impermeable [28].

Some saponin also has toxicity which leads to photosensitization followed by liver and kidney degeneration in ruminants and gut problems such as gastroenteritis and diarrhea [11]. Brachiaria decumbens is one grass that was reported to cause photosensitization in animals. Interestingly, this only occurs in some areas and even then, not all the animals in a flock or herd were affected. When animals suffer from photosensitization, weeds containing saponins are usually the first suspects, although many toxic weeds or plants have yet to be analyzed for their saponin content. Most saponins that have been identified in the toxic plants are steroidal saponins.

CONCLUSION

Saponins present in more than 100 plant families and in a few marine sources, in most star fish and sea cucumber species and in a few fish shark repellents. In plants, they occur in different parts such as root, tuber, bark, leaves, seed and fruit. It has a positive and negative impact on animal production and health. They are providing protection to the plants against many pathogens and herbivores. Saponins have a potential health benefits such as hypocholesterolemic, anti-coagulant, anti- carcinogenic, hepato-protective, hypoglycemic, immunomodulatory, neuroprotective, anti-inflammatory, anti-oxidant activity, inhibition of dental caries and platelet aggregation. Saponins also kill protozoans and molluscs and act as antifungalandantiviralagents.

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