

Bioactivity of Triterpene Saponins from Quinoa (*Chenopodium Quinoa Willd.*)

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ABSTRACT

Functional food is described as a food, even conventional, with special benefits to human health. Foods which includes particular functional nutrient by processing, enrichment or enhancement. Saponin in quinoa has been used as a many plant drug content and folk medicines for many centuries treatment of diseases. Quinoa seeds are naturally gluten free, high nutrient profile increasing attention has been given to these plants. Therefore, quinoa (*Chenopodium quinoa Willd.*), an Amaranthaceae plant of Andean region, recently became important for the researchers. Saponin has nutritional and pharmacological benefits. In addition to role in plant defense system, saponins possess various biological and pharmacological properties, including hemolytic, cytotoxic, immune modulatory, anti-inflammatory, and antitumor impact. The aim of this review is to plan a detail and recent report of quinoa pharmacological, phytochemical and nutritional aspects, while summary of late improvement link with the use in foods, cosmetics, medicines and botanical supplements.

INTRODUCTION

Functional food security and safety become great importance due to climate change growth of World population, increase of metabolic disease and high median age of the population^[1]. Diet program has great influence on disease treatment and protection when it comes to plan complementary strategy to battle metabolic diseases and age related disorders. Functional food is described as a food, even conventional, with special benefits to human health, or foods which includes particular functional nutrient by processing, enrichment or enhancement^[2]. Recently, an Amaranthaceae plant of Andean region, Quinoa (*Chenopodium quinoa Willd.*) became important for the researchers. Since the seeds are naturally gluten free, high nutrient profile increasing attention has been given to these plants. Functional profile of quinoa has also indorsed researchers about antioxidant properties of this plant^[3,4]. Seeds of quinoa contain high amount of bioactive-polyphenols which assist oxidative stress via changing the antioxidant content of the organism. All quinoa plant parts have gallic acid, one of the main phenolic acids^[5]. The seed also have p-Hydroxybenzoic acid, vanillic acid, p-coumaric acid, caffeic acid and cinnamic acid; however, the sprouts have p-coumaric acid, syringic acid and ferulic acid^[5]. Functional properties of quinoa possess its health benefit potency. Quinoa content has an amino acid lysine which all other cereals do not contain. So, the content of the quinoa makes it unique. Obesity, hypercholesterolemia and cardiovascular disorders could be treated with quinoa due to high fiber and stable polyunsaturated fatty acids. Degenerative diseases may be cured with its antioxidant content, like phenolic compounds. People who have gluten intolerance (celiac disease) could consume regularly because of gluten absence. It can be consumed in daily and healthy diet as breads, cookies, pasta, salads^[6]. It is documented that quinoa seeds are very rich in terms of the soluble antioxidant which the activity rise up to 86%^[7]. The comparison between red and yellow quinoa seeds show that red seeds have the highest level of total phenolic content, total flavonoid content and ferric reducing antioxidant potential than yellow seeds. Thus, red quinoa may be useful for protection and treatment of degenerative diseases due to free radicals^[7]. Recently, consumers are increasing the pressure to food industry prevent high chemical additives to eliminate microbes in food. So, prevention of synthetic preservatives addition to food is recent worldwide request. Thus, demand from the food industry is to utilize natural products as additives to food for prevention of spoiling microbes and oxidation^[4-7]. Quinoa contain exalted amount of flavonoid changing from 36.2-144.3 mg/100^[4-7]. For instance, daidzein and genistein are detected varying concentration in quinoa from different origin^[4-7]. Oven drying after germination of

quinoa seeds raises the flavonoid concentration 4.4 times ^[4,7]. Plants have many natural secondary products such as saponin. These secondary compounds have key roles, for instance, resistance to plant disease and herbivores and allelopathic competition interactions between plants. Saponin in quinoa has a disadvantage of giving astringent taste caused by the epicarp around the seed. The hulls are having 40-45% of the saponins. The amount of saponin differs between 0.1 and 5% in quinoa ^[4]. Main classification of quinoa has been done according to saponin content, such as, free or 0.11% saponin is called "sweet". Even though saponin has nutritional and pharmacological benefits, it has been considered anti nutrient of quinoa. Saponin in quinoa has antifungal activity which creates damage to fungal membrane integrity with connecting steroids of membranes ^[4]. In addition to role in plant defense system, saponins possess various biological and pharmacological properties, including hemolytic, cytotoxic, immunomodulatory, anti-inflammatory, and antitumor impact. Saponins have been used as a many plant drug content and folk medicines for many centuries for the treatment of diseases ^[8]. Saponins have pharmaceuticals properties, also, all other plant saponins that are not discovered yet, may be crucial potential for new drugs. Saponins are constructed by two different amphipathic subunits which are a hydrophobic triterpene or sterol backbone and a hydrophilic carbohydrate chain. Their biological activities usually based on these amphipathic subunits. On the other hand, some plant saponins have biological activities that are depends on their different structures. Saponins are glycosides that contain one or more sugars on a triterpene or steroid aglycone backbone also called a sapogenin. The complicated contents of saponins are mainly attached to their aglycone skeleton that can be formatted to different levels of glycosylation. Biosynthesis of saponins shows that different groups of glycosylated isoprenoids is synthesis from the mevalonate pathway by the mutual precursor 2,3-oxidosqualene which then convert into aglycone skeletons ^[9,10]. In the way of compiling the skeletons include glycosylations by glycosyltransferases and trans-glycosidases and last completion, for instance, oxidation, rearrangement, and acylation, consequently construction to various structural difference of saponins. When the biosynthesis has been done saponins are consistent of the aglycone core and the sugar moiety. Most of the time, affects of saponins dependent on the aglycone and the sugar chains. On the other hand, in some cases, the sugar chain only improves the pharmacokinetic characteristics via raising the hydrophilicity of the saponin. Saponins may generally be grouped into two main class; steroid and triterpene saponins. The specific steroid saponins for the monocotyledonous angiosperms can be grouped into four class of steroid skeletons, named, hexacyclic spirostane, pentacyclic furostane, tetracyclic cholestane, and lactone-containing cardenolide types ^[11]. Both aglycone triterpenes and sterols surrounded by various structures due to differentiation degree of cyclization and oxidation of the backbone. According to the number and form of sugar molecules, inter-sugar linkages and the existence of sugar chains number. The difference between monodesmosidic saponins and bidesmosidic saponins is to having extra sugar chain at the C-28 (for triterpenoid saponins) or C-26 (steroid saponins) position besides the C-3 position. Advanced enhancement of saponin backbone improves the structural diversity of the molecules, for instance, joinin of acyl- or etherlinked groups formed from organic acids ^[12].

DISCUSSION

Triterpene saponins (**Figure 1**) contain four different types of skeletons; pentacyclic oleanane, ursane, and lupane, as well as tetracyclic dammarane types and common in dicotyledonous angiosperms. Saponins are used not only pharmaceuticals industry but also range of other industries. Cosmetic and beverage industry benefits from surfactant properties of saponins. They play important role in the industries like cosmetics and beverages as surface active agent, it also used as a bubbling factor for different aims along with in fire-extinction. Also, using as a flavor because of their intense sweetness or bitterness. The recognizable of sweetness in liquorice root due to availability of compound named Because of hydrophilic and hydrophobic functions they puncture the membranes surface. Most noticeable feature of saponins is membrane permeabilization, these compounds have more effects on the enzyme activity, transport, redox related functions, organelle integrity and other signal transduction and cellular processes, for example, interfere with the cells by activating programmed cell death. Saponins are found in food crops and taken as a human diet which shows different effects on human health i.e., reducing blood cholesterol levels. Saponin surrounds the plant cell wall due to which the plant cells remain safe. Varieties of saponins have some medicinal value also which are used for different heart diseases. Diseases caused by certain viruses, bacteria and fungi in different food crops such as cereals, beans and also in tomato seedling can be controlled by saponin extracts prior to transplanting ^[12,13].

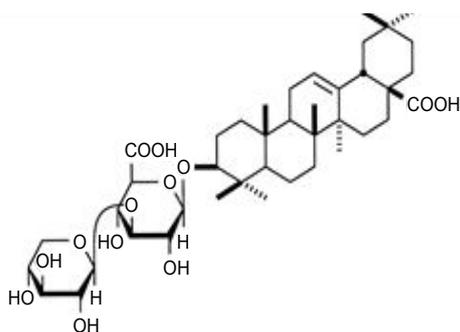


Figure 1. Structure of triterpene saponins.

Anti-inflammatory Activity

A research study that were conducted on rats displayed a result that consumption of quinoa on regular basis reduce the highness of inflammation in adipose tissues in rats and also the inner layer in their intestine. The anti-inflammatory characteristics of plants saponins can act as active components in drugs. The saponins extracted from Amaranth family provide a remedy aid in different diseases that caused by pathological levels of nitric oxide work as outcome in atherosclerosis, inflammation and carcinogenesis. Quinoa saponin fractions decreased the production of inflammatory mediator nitric oxide (NO) induced by lipopolysaccharide (LPS) and inhibited the release of inflammatory cytokines including tumor necrosis factor- α and interleukin-6 in lipopolysaccharide-induced RAW264.7 cells murine macrophage cells [13,14]. These results suggest that the quinoa saponins can be used for the prevention and treatment on inflammation [13,14].

Immunomodulatory Activity

In ovalbumin immunized mice, administration of saponin fraction extracted from quinoa increased the amount of IgG, IgG1, and IgG2b. Also, the effect of saponins can be improved by increase permeability of mucosca resulting in high uptake of antigen [4,13]. Quinoa saponins has a role as mucosal adjuvants upon their intragastric or intranasal administration together with model antigens in mice.

Antifungal and Antimicrobial Activity

Saponins obtained from quinoa seed and crude saponins were studied for antifungal response against *Candida albicans*. The growth of *Candida albicans* was blocked via the total saponin fraction of quinoa at the rate of 50 lg/mL. Although both bis-desmosidic and monodesmosides saponins which are produced by hydrolysis did not show antifungal impact with the minimal inhibitory concentration (MIC) values ranging from 100 lg/mL to more than 500 lg/mL. Therefore, the synergistic impact of tested compounds cannot be excluded [13].

Antioxidant Activity

Diseases that are alloy with oxidative stress, metal overload, along with cardiovascular diseases, neurodegenerative disorders and cancer also distinguished by reduction of or decrease in glutathione (GSH) / oxidised glutathione (GSSG) ratio. Function of microsomal glutathione S-transferase (GST) determined by the formation of its active catalyst eSeS-dimer. Extraction of quinoa reverse the oxidative GST by H_2O_2 and also prohibit its activation. The extract of quinoa has capability of disulfide reducing agent with the thiol compounds in the extract composition. Saponins with thiol compounds act as disulfide reducing agent, however this ability of quinoa extract containing thiol compounds is still in research phase [14,15].

As accompanied by outstanding nutritional description such as ability to diversity the shrinking lunch, resistance to unfavorable weather conditions and the potential ability of grain health benefits against the malnutrition [14]. The outer coat of the quinoa seed has high contents of triterpene saponin which make them with bitter taste for normal human intake. This feature allows us the commercialization of by-products such as surfactant. So it helps in development of hemolysis and changes in intestinal permeability [4,12]. Oxidative stress conditions develop in plants due to solar energy although it is a main source of energy for plants too. Plant cells developed antioxidant defense to control reactive oxygen species (ROS) generation. Oxidative stress occurs as a result of overcome of ROS generation the activity of cellular antioxidant. A protective shield provided for biomolecules by polyphenols from oxidative vandalize by various process which consist of chelating transition metal ions and direct scavenging of oxygen free radicals [3,5]. Pathologies widely associated with the oxidative stress mainly treated with polyphenols, i.e., cancer neurodegenerative disorders and cardiovascular diseases [16].

CONCLUSION

Biological actions of saponins are not only bounded to our conventional uses, nowadays also playing an important role in pharmaceutical areas such as hemolytic, antiparasitic, antiviral, antitumor, anti-inflammatory, antifungal and antibacterial actions [11]. Saponins also used as key factor in pharmaceutical industry for the formation of semi-synthesis of steroidal drugs. Vascular and metabolic diseases can be treated with triterpene saponins. Pharmaceutical companies quicken the skeeing of cancer treatment from saponins plant materials. To accommodate these needs with the objective of increasing the current output is ambitious by the evolution of different new technologies in the field of saponins extractions [13,16]. A part of new research has been conducted as an important source of chemical components of quinoa treatment characteristics to reflect the harvest for functional food development. New scientific investigation and understanding of modern modification are essential for development of quinoa role in human health. Production of quinoa also meets the demand of health benefits of sustainable agriculture policy to advance the overall access policy. The purpose/aim of this study is to plan a detail and recent report of quinoa pharmacological, phytochemical and nutritional aspects, while summary of late improvement link with the use in foods, cosmetics, medicines and botanical supplements [15,17].

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