Review Article

BIOMEDICAL Journal of Scientific & Technical Research

ISSN: 2574 -1241

DOI: 10.26717/BJSTR.2024.59.009358

Organosulfur Compounds Detected in the Genus *Aloe*

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ARTICLE INFO

Received: November 29, 2024

Published: December 06, 2024

Citation: Adamu Tizazu and Abdela Nebi. Organosulfur Compounds Detected in the Genus *Aloe*. Biomed J Sci & Tech Res 59(5)-2024. BJSTR. MS.ID.009358.

ABSTRACT

An organosulfur compound has at least one carbon-sulfur (C-S) bond. All living things' bodies contain organosulfur compounds in the form of proteins, peptides, enzymes, amino acids, vitamins, coenzymes, hormones, etc. Numerous plants contain organosulfur compounds, and for centuries, folk and traditional medicines have made use of their bioactive qualities. Almost all of the compounds detected from *Aloe* plants are organic compounds among which some of them are organosulfur compounds. Five organosulfur compounds have been reported from the genus *Aloe*. *Aloe* species have been found to contain thiamine/vitamin B1 ($C_{12}H_{17}N_4OS^+$), pluridone ($C_{12}H_{12}O_3S$), methionine ($C_5H_{11}NO_2S$), cysteine ($C_3H_7NO_2S$), and 1-(phenylthioxomethyl) piperidine ($C_{12}H_{15}NS$). The compounds are grouped into various functional groups: sulfide (R-S-R), thiol (R-SH), and thioamide (R=SN). These compounds have potential biological activities that are used in medicine, food, cosmetics, etc. The biological activities of organosulfur compounds are the same as those of *Aloe* species. This agreement shows that organosulfur compounds have roles in the applications of *Aloe* species. Therefore, organosulfur compounds from the genus *Aloe* are strongly recommended to be tested for their potential biological activities and how to extract, isolate, and specifically perform structural characterization.

Keywords: Sulfur; Organosulfur Compounds; Functional Groups; *Aloe* Genus; Biological Activities

Introduction

In all organic compounds carbon and hydrogen elements are common elements [1,2]. However, in addition to carbon and hydrogen, elements such as oxygen, nitrogen, sulfur, phosphorus, halogens, etc. present in organic compounds [3,4]. Sulfur is one of the most mentioned elements in organic compounds [5]. Organosulfur compounds (OSCs) have at least one carbon-sulfur (C-S) bond [6]. Organosulfur compounds are subclass of sulfur-containing organic compounds distinguished by their peculiar characteristics and wide range of occurrence [7]. All living things' bodies contain organosulfur compounds in the form of the protein, peptides, enzymes, amino acids, vitamins, coenzymes, hormones, etc. [8]. Numerous plants contain organosulfur compounds, and for centuries, folk and traditional medicines have made use of their bioactive qualities [9]. *Aloe* plants are rich in phytochemicals because they can tolerate hot and dry weather conditions. Almost all of the compounds detected from the genus *Aloe* are organic compounds among which some of them are organosulfur compounds [10,11]. Phytochemicals containing organosulfur are vital for a variety of uses in medicine, food, cosmetics, agriculture, and other fields [12]. *Aloe* species' uses are typically described in literature as having synergistic effects rather than a single effect [13-15]. Nevertheless, no research has been conducted on the organosulfur compound found in *Aloe* species for their potential uses specifically. As a result, the organosulfur compounds found in *Aloe* genus are the main topic of this review.

Organosulfur Compounds *Aloe* Genus

Thiamine

One of the organosulfur compounds, thiamine has a five-membered heterocyclic structure with sulfur as the heteroatom in additional to the nitrogen atom [16] (Figure 1). The genus *Aloe* has been found to contain vitamin B1 ($C_{12}H_{17}N_4OS^+$) [13]. Like the other vitamins of B complex, vitamin B1 is a water-soluble vitamin and is also referred to as thiamine or thiamin [17]. Although thiamine cannot be produced by the body, it can be obtained as a dietary supplement and is present in a variety of foods [18]. Thiamine is an essential nutrient that plays a critical role in energy metabolism which is necessary for growth, cellular function, and development. It enables the body to use carbohydrates as energy/fuel [19]. In another way, *Aloe* species

have been reported for their metabolism actions [20,21]. In addition to this, *Aloe* species have been reported for the cell function and development [22,23]. Therefore, the role of thiamine in the consuming *Aloe*-based products is observed as synergistic effect in these biological activities of *Aloe* extracts.

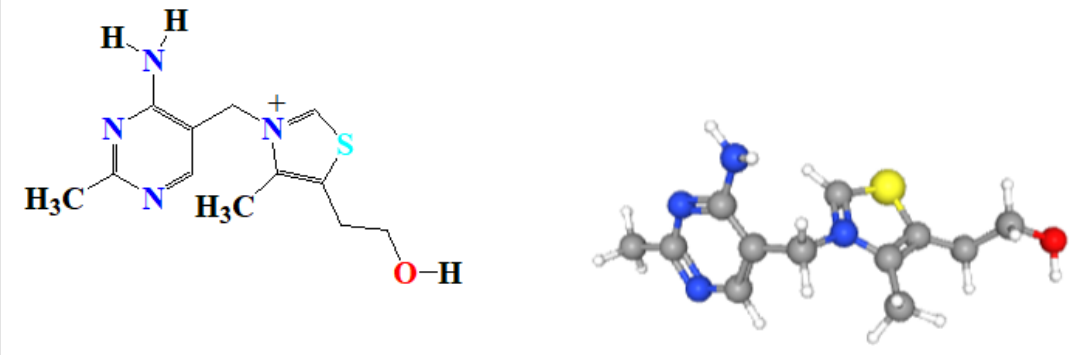

Figure 1: Thiamine.

Pluridone

Pluridone ($C_{12}H_{12}O_3S$) is an organosulfur compound that has sulfide (C-S-C) functional group. Pluridone (Figure 2) was isolated from *Aloe pluridens* Haw. It is a novel insecticide chemical. In works of literature, the insecticide activities of *Aloe* species have been reported [24-26]. The matching of insecticide activities of *Aloe* species and pluridone confirms the presence of pluridone and other bioactive compounds of the genus *Aloe* for insecticide application whether individually or together.

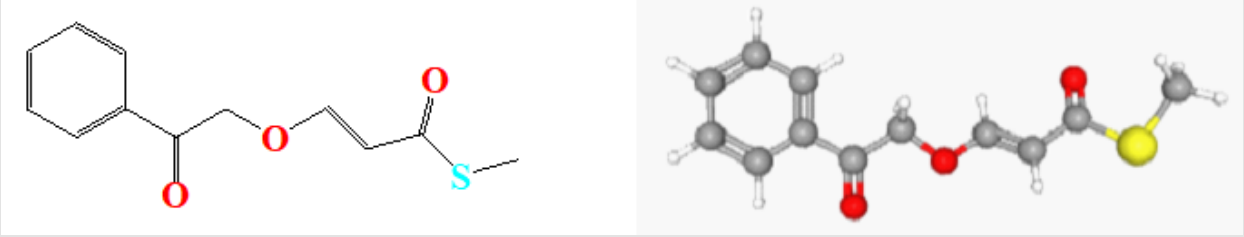

Figure 2: Pluridone.

Methionine

Methionine ($C_5H_{11}NO_2S$) is an organosulfur compound that has a sulfide skeleton. One of the essential amino acids, methionine (Figure 3) has been reported from *Aloe greatheadii* var. davyana quantitatively. Moreover, many *Aloe* species have reported methionine [27-29]. Being essential amino acids, methionine has a variety of applications such as protein biosynthesis, methyl transfer reactions, formation of polyamines, and synthesis of cysteine and other metabolites [30] which are revealed in applications of *Aloe* species.

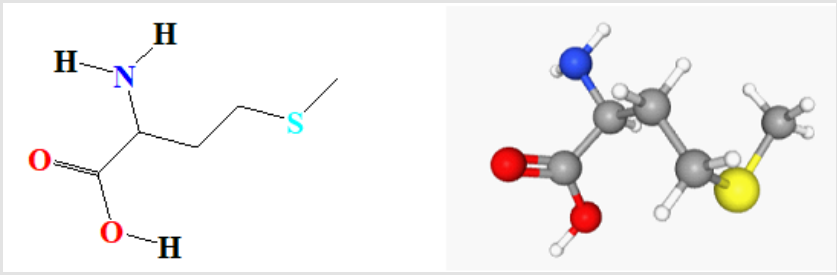

Figure 3: Methionine.

Cysteine

In addition to methionine, cysteine ($C_3H_7NO_2S$) has also been reported from the genus *Aloe* (Figure 4) [29]. Cysteine is a thiol (C-SH or R-SH) containing amino acid. It has crucial role for synthesizing sulfur-containing biomolecules that control multiple essential cellular activities [31]. Cysteine is applicable for normal growth rate of hair, reduce the effects of aging on the skin, healing burns and protect the skin from radiation injury [32-34]. Cysteine also helps the burning of fat and increase muscle mass [35]. All these applications have been reported from *Aloe* species extracts [36-38]. This reflects the role of cysteine in the *Aloe* species indirectly.

Figure 4: Cysteine.

1-(Phenylthioxomethyl) Piperidine

The organosulfur compound called 1-(phenylthioxomethyl) piperidine ($C_{12}H_{15}NS$) (Figure 5) has been detected in *Aloe* vera [39]. The compound has the amide-like functional group except carbonyl oxygen is replaced by sulfur. Therefore, it is called thioamide (R=SN) [40]. The applications of 1-(phenylthioxomethyl) piperidine have not been reported widely. However, the presence of piperidine, phenyl, and thioxomethyl groups in the compound may be effective to antimicrobial, anti-inflammatory, antioxidant, etc. [41-43]. For these applications, *Aloe* species have been reported. This shows the role of 1-(phenylthioxomethyl) piperidine together with other compounds [44,45].

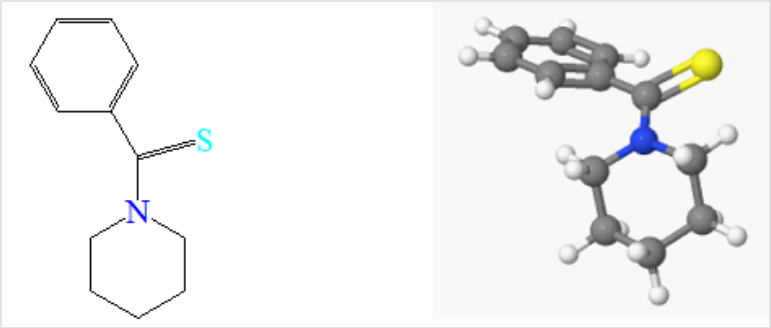

Figure 5: 1-(phenylthioxomethyl) piperidine.

Conclusion and Future Aspects

Five organosulfur compounds have been reported in the *Aloe* species. The detected compounds are neither sulfur element nor sulfur inorganic compounds. The Organosulfur compounds detected from the genus *Aloe* are classified in vitamin (thiamine), amino acids (methionine and cysteine), and other organic compounds (pluridone and 1-(phenylthioxomethyl)piperidine). These compounds are also classified based on the organic chemistry functional groups. According to this classification thiamine, pluridone, and methionine have sulfide (R-S-R) functional group while Cysteine and 1-(phenylthioxomethyl) piperidine have thiol (R-SH) and thiomide (R=SN) functional groups respectively. These compounds have potential biological activities that are used in medicine, food, cosmetics, etc. The biological activities of organosulfur compounds reflect the biological activities of *Aloe* species. This agreement shows that organosulfur compounds have roles in the applications of *Aloe* species. Therefore, it is strongly recommended to test organosulfur compounds from the genus *Aloe* for the potential biological activities and how to extract, isolate, and structural characterization organosulfur compounds specifically.

Conflict of Interest

The authors declare that they have no conflict of interest.

Authors' Role

Adamu Tizazu: Propose idea, write original draft, data collection, and Chemdraw software; Abdela Nebi: Reviewing, editing, and data collection.

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ISSN: 2574-1241

DOI: 10.26717/BJSTR.2024.59.009358

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