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REVIEW ARTICLE

Alliicin: A Chemical Compound

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Abstract

Garlic is known for its beneficial effects in literature. Allicin which is a component of garlic extract is majorly responsible for it. Allicin is a hydrophobic compound that is formed by alliin by the enzyme alliinase. Allicin is known to have antimicrobial activity like antifungal, antiviral and antibacterial properties. Allicin is also known to have inhibitory effects on tumors. It also provides protection against cardiovascular diseases. In this review, we have covered biosynthesis, production and the beneficial effects of allicin.

Introduction

Natural compounds present in the organic products can be potential source for new drugs (Newman et al., 2000). Aspirin is an example of biological compound that has medicinal properties which been turned into a FDA approved drug (Jeffreys 2008). Similarly, other compounds like caffeine, morphine and morphine are also known to have medicinal uses. Allicin is the active biological compound in garlic that accounts for 70% of thiosulfinate in garlic (Kubec et al., 2000). It is formed by the catalytic action of alliinase using alliin as a substrate (Granroth 1970; Stoll & Seebeck, 1949). Allicin is known to have antibacterial, antifungal and antiviral properties. Allicin has been used in the treatment of soldiers during World War II. It is also known to have antioxidant properties. Allicin is found to be effective against both Gram negative and Gram-positive bacteria. It is also effective against some drug resistant bacteria Staphyloccus aureus (Cutler, 2004). Many sulphur containing compounds in garlic including allicin have anti- cancerous properties. Garlic consumption is correlated with anti tumor properties like skin, uterus, colon and breasts. This review covers the synthesis, benefits and mechanism of action of allicin against bacterial and fungi. It also includes the benefit of allicin in cardiovascular system and immune system.

Biosynthesis of Allicin

Alliin ((+)-(S)-allyl-L-cysteine-sulfoxide) is converted into Allicin by alliinase enzyme only after garlic clove is crushed. It is so because the alliinase enzyme and its substrate are found in different compartments. Alliinase first converts allicin into an intermediate compound known as allyl sulfenic acid, ammonia and pyruvic acid as shown in figure. Allyl sulfenic acid is unstable and reactive and therefore 2 molecules of allyl sulfenic acid together form allicin with the release of a water molecule as shown in (Fig. 1).

Synthesis of Allicin

Industrial production and isolation of allicin is tedious task because of the instability and volatile nature of allicin. For the industrial production of allicin, diallyl disulphide is taken as a substate. Along with diallyl disulphide, hydrogen peroxide and acetic acid are added. Here, acetic acid act as a catalyst to catalyse the reaction between diallyl disulphide and hydrogen peroxide. Acetic acid reacts with peroxide and form peracetic acid. Peracetic acid reacts with diallyl disulphide to form allyl sulfenic acid and allyl radicals. Allyl radicals reacts with peroxide to form allyl sulfenic acid. Two molecules of allyl sulfenic acid reacts to form allicin (Villalon, 2001). Allicin can be synthesized using diallyl disulphide and chloroperbenzoic acid (Cellini, 1996).

Pharmacology of Allicin

Antibacterial properties of allicin

The antibacterial properties of garlic are due to allicin was first demonstrated by Cavallito and Bailey. Allicin also has antifungal

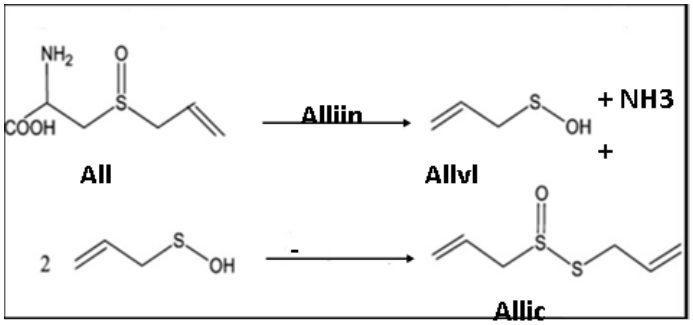

Figure 1. Mechanism of formation of allicin

Table 1. Allicin sensitivity of various bacterial species.

Bacteria	LD50 Value of Allicin(ug/ml)
Staphyloccocus aureus	12
Escherichia coli	15
Strptococcus pyogenes	3
Streptococcus hemolyticus	>100
Proteus mirabilis	15
Pseudomonas aeruginosa	15
Acinetobacter baumanii	15
Klebsiella pneumoniae	8
Enterococcus faecium	>100

and antiviral properties. Allicin is found to be effective against many Gram positive and Gram-negative bacteria like Escherichia, Clostridium, Bacillus, Staphylococcus, Streptococcus, Proteus. List of bacteria that are susceptible to allicin are listed in table 1. Allicin is found to be effective against ulcer causing bacteria Helicobacter pylori (Cellini, 1996). It is also effective against some enterotoxin producing bacteria like Staphylococcus (Gonzalez, 1194). Have demonstrated that allicin targets the DNA gyrase enzyme in the bacteria and hence preventing the proliferation of the bacteria (Reiter, 2020).

Most of the bacteria have developed antibacterial resistance against several drugs. One of the reasons for the development of this resistance is that bacteria form biofilm that is difficult to be penetrated by antibiotics. But allicin prevent the formation of biofilm which makes it effective against antibiotic resistant bacteria. Bacteria like Mycobacteria tuberculosis which is known to develop quick antibiotic resistance is found sensitive for allicin. Therefore, use of allicin in combination with already prescribed drugs can be very useful.

Antifungal properties of allicin

Garlic is known to be effective against the fungal infections. The main component of the extract that prevent the fungal growth was found to be allicin (Lawson, 1996). Allicin has been shown to be effective against Candida, Trichophyton and Cryptococcus species. It is effective against Candida at minimum IC (inhibitory concentration) of 7 microgram/mL.

Antiviral property of allicin

Allicin is found to have antiviral property as well. It is found effective against some viruses like Influenza B, Herpes simplex virus type 1 and type 2, Human Rhinovirus type 2, Vaccinia virus and vascular stomatitis virus (Tsai, 1985). The mechanism by which allicin inhibits viruses is not yet explored.

Health benefits of Allicin Anticancer

Properties of Allicin

Allicin has been demonstrated to have antitumor effects. In a study is was shown that a tumor explant treated with allicin did not show proliferative properties when grafted onto mice in comparison to untreated control (DiPaolo & Christopher, 1960). Allicin is found paly precautious role again liver cancer, colorectal cancer and stomach cancer. Anti-cancerous property of allicin is due to its ability to induce apoptosis by altering the redox potential in the cell. Therefore, it induces apoptosis in both caspase dependent and independent manner (Oommen, 2004; Park, 2005). Allicin has been demonstrated to prevent stomach cancer by arresting cells in G2/M phase and by apoptosis induction by ER stress and mitochondrial damage (Luo, 2016). Allicin also has inhibitory effects against liver cancer. Yun- Lin Chu etal have demonstrated that allicin induces p53 mediated autophagy in hepatic cells and hence preventing the proliferation of liver cancer (Chu, 2012; Chu et al., 2013). Allicin sensitises hepatic carcinoma cells by ROS mediated mitochondrial pathway and enhances cytotoxic activity of 5- flurouracil against these hepatic carcinogenic cells (Zou et al., 2016). Allicin has also been demonstrated effective against treatment of glioma tumor. Treatment of Hepatic cells with allicin increases caspases activity and the expression of Fas/FasL. Hence, indicating that allicin inhibit hepatic cancer cells by inducing apoptosis of these cells (Li et al., 2018).

Benefits of Allicin in Cardiovascular Diseases

Cardiovascular disease is a chronic disease related to heart that is a major reason of mortality in world. Allicin has been found to provide protection against cardiovascular diseases. Allicin induces vasodilation and increases angiogenesis, platelet aggregation, hence preventing cardiovascular diseases. Allicin bring about the dilation of vessels by Nitric oxide (Ku, 2002). Since, allicin is hydrophobic in nature so it can easily permeabilize through the lipid bilayer and carry out its effects required for protection against cardiovascular diseases. Allicin has been shown to be effective against hyperlipidaemia which is a condition where the amount of low-density lipids exceeds the healthy limits (Ghorai et al., 2000; Gonen et al., 2005). Allicin is also known to prevent cardiac hypertrophy where the cardiac cells increase in size (Sun & David 2005; Liu et al., 2010). Allicin inhibits angiogenesis (increase in the number of blood vessels) which is a key factor that play role in tumorigenesis (Sela et al., 2008). Allicin has shown to have antithrombic activity. Therefore, it prevents blood coagulation and hence, arthrosclerosis. Allicin act as an antioxidant and prevent the reactive oxygen species and hence protect against the cardiovascular diseases.

Conclusion

Allicin is one of the components of garlic extract that is formed from alliin by alliinase enzyme. Allicin is known to have antibacterial, antifungal and antiviral properties. It is also shown to be protective against cardiovascular diseases. There are many benefits of allicin that have been reported in literature. It will be beneficial to find out the mechanism of action of allicin against bacteria, viruses and other pathogen. Its antitumor property is worth exploring and it can a potential drug that can be used in cancer treatment. It can be concluded that allicin has many benefits that can explored to develop potential health product.

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