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Review Article

# Chemical and biological properties of bio-active compounds from garlic (*Allium sativum*)

Aigerim Bazaraliyeva[1], Dias Moldashov[1], Aknur Turgumbayeva[1], Elmira Kartbayeva[1], Assem Kalykova[1], Lazzat Sarsenova[1], Raushan Issayeva[1]

1 *Al Farabi Kazakh National University, Almaty, Kazakhstan*

Corresponding author: Aigerim Bazaraliyeva (abazaralieva24@gmail.com)

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## Abstract

Garlic (*Allium sativum*) is one of the oldest cultivated plants. It has been used as a spice, food, and folk medicine for many years. Garlic contains about 2000 biologically active components. For centuries, scientists have obtained a variety of compositions and physiological activities of garlic, depending on the methods of processing and extraction. Many review articles were published, where the object of the study was garlic. But there are very few broad literature reviews where garlic has been fully disclosed as a medicinal raw material. The study found that some garlic products and processing procedures were not standardized or tested for safety. A broad overview of this object can direct the attention of the scientific community in the right direction. This review contains various processing methods and yields from these extracts. In addition, most of the key physiological properties of the active substances of the raw materials are prescribed.

## Keywords

Allicin, alliin, garlic extract, processing methods, pharmacological actions of garlic

## Introduction

Garlic (*Allium sativum*) is one of the oldest cultivated plants on the planet. For over 4000 years, it has been used as a spice, food, and folkloric medicine, and it is the most extensively examined medicinal plant (Thomson and Ali 2003).

The Egyptian medical papyrus Codex Ebers, which dates from around 1550 B.C., has 22 medicinal formulae that reference garlic as a useful medicine for a range of maladies, including heart issues, headaches, bites, worms, and tumors. One of the first documents mentioning the use of garlic for the treatment of aberrant growths is the Codex Ebers. These growths were most likely malignancies of some sort (Block 1985).

According to the Bible, the Jewish slaves in Egypt were fed garlic and other allium vegetables, apparently to give them strength and increase their productivity. Also, in ancient Greece soldiers were fed garlic to give them courage, and garlic was associated with war. During the first Olympic games in ancient Greece, garlic was taken by athletes before they competed. It is used to protect the skin against poisons or toxins. Hippocrates, the Father of Medicine, used garlic (Rivlin 2001). In ancient Rome twenty-three uses for garlic were listed in Historica Naturalis for a variety of disorders (Moyers 1996). The use of garlic as a food and as a medicinal agent has ancient origins in Asia. In ancient Chinese medicine, garlic was prescribed to aid respiration and digestion, most importantly diarrhea and worm infestation (Woodward 1996).

Garlic contains enzymes, sulfur-containing compounds like alliin, and chemicals generated enzymatically from alliin as active components. In aqueous garlic extract and raw garlic products, allicin is the major bioactive component (Elosta et al. 2017). The major components of Allium oils are allyl, methyl, and propyl sulfides, which are typically recovered from onion and garlic bulbs by hydro-distillation and steam stripping. These oils have the usual scent of fried material due to the harsh processing conditions. As a result, near-critical carbon dioxide extraction looks to be an appealing choice, as operating temperatures can be close to ambient (Andreatta et al. 2006).

Garlic has been shown to improve a variety of cardiovascular health indicators in recent years (Ried 2016). Garlic intake appears to slow the course of vascular disease, according to epidemiological research (Rahman 2006; Orekhov 2013). Because different garlic products include different components, the benefits vary (Bayan 2014). Viruses and bacteria are the primary threats to human health, and they have the potential to generate significant social problems. A lot of epidemics and pandemics have occurred on our planet in recent years, as seen by the present situation with the coronavirus pandemic. The SARS-CoV outbreak in 2003, the Middle East respiratory syndrome coronavirus (MARS-CoV) outbreak in 2012 and the Ebola outbreak in West Africa in 2014 are all instances of viral infections that have triggered epidemics or pandemics over the world. Infectious diseases are one of the world's major causes of death, and they continue to be a constant danger to human life.

The purpose of this study is a complete study of bioactive components, methods for obtaining various types of extracts and their physiological properties, and identification of promising areas of raw materials for industry in medicine and pharmacy. The literature was analyzed and fresh studies were combined with older and more detailed sources, where new substances and new processing methods were obtained. The gaps that were revealed by analyzing the review articles have been supplemented.

The literature was analyzed and fresh studies were combined with older and more detailed sources, where new substances and new processing methods were obtained. The gaps that were revealed by analyzing the review articles have been supplemented.

This review article includes studies on the extraction of extract using a variety of methods with a high yield of biologically active ingredients, a thorough examination of garlic as a raw material for pharmaceuticals, a breakdown of its phytochemical makeup, and background information on the study of raw materials. Additionally, information on biologically active substances and their pharmacological properties, harvesting conditions that affected the phytochemical profile of garlic, and the metabolism of organosulfur compounds were gathered to identify promising areas of garlic application in medicine and pharmacy.

# Bio-active compounds of garlic

Garlic contains around 2000 biologically active components, including volatile, water-soluble, and oil-soluble organosulfur compounds (e.g. Diallyl sulfide (DAS), DADS, Diallyl trisulfide (DATS)), essential oils, dietary fiber, sugars (32%), flavonoids, and pectin (Swiderski 2007; Cerny 2013).

Many methods for obtaining extracts and bio-active chemicals from garlic have been developed throughout the history of garlic research. Various practical and well-known ways of producing extracts have been included with biologically active chemicals in the accompanying table (Table 1). Most of the proven extraction methods are aimed at obtaining sulfur-containing components from garlic. Studying bioactive components and their pharmacological action, it was revealed that mainly sulfur-containing components of garlic have a wide range of pharmacological effects.

**Table 1.** Methods of obtaining extracts and bio-active substances.

| Method | Biological active compounds | References |
|---|---|---|
| Water garlic extraction | Allicin(42–50 μg/ml), Allyl sulfide, DADS, Methanethiosulfonik acid S-methyl ester (MMTS) | (Nikolovski 2018) |
| Ethanol garlic extraction | Allicin(4,5 μg/ml), Allyl sulfide, DADS, MMTS | (Nikolovski 2018) |
| Ultrasonic-Assisted method | Allicin | (Mathialagan et al. 2017) |
| Supercritical fluid extraction | Dimethyl thiosulfinate Methyl 2-propenethiosulfinate + Allyl methanethiosulfinate Sl-propenyl methanethiosulfinate + Methyl 1-propene thiosulfinate Allicin w-Propyl2-propenethiosulfinate Sl-propenyl allyl thiosulfmate + Allyl 1-propenyl thiosulfinate | (Nikolovski 2018) |
| Ultrasound-assisted extraction (UAE) | At optimal conditions (sliced garlic, 25 °C, 90 minutes), allicin concentration was 112 g/ml. | (Kamel and Saleh 2000) |
| Pressurized-liquid extraction (PLE) | The concentration of allicin in this sample was 332 g/ml. | (Farías-Campomanes et al. 2014) |
| Soxhlet extraction | Ajoene | (Hepzibha and Anchana 2017) |

Bioactive compounds and the number of substances acquired using the procedures varied, as shown in the table. Water extraction can be used to obtain allicin, allyl sulfide, diallyl disulfide, and methanethiosulfonic acid S-methyl ester. While ajeone can be obtained by soxhlet extraction. Allicin was obtained by PLE, UAE, ultrasonic-Assisted method, ethanol garlic extraction, and water garlic extraction. In addition, it is worth noting that the technology of the method for obtaining garlic by $CO_2$ extraction under subcritical conditions has not been investigated and standardized. Based on these findings, this project is actively proceeding in Kazakhstan.

Whole garlic cloves contain two types of organosulfur compounds: L-cysteine sulfoxides and glutamyl-L-cysteine peptides. Except for these types of organosulfur compounds, there are non-sulfur phytochemicals in garlic are found. Difficulties between the two groups and their chemical structure are shown in the following table (Table 2) (Higdon et al. 2005).

**Table 2.** Compounds of garlic.

| L-cysteine sulfoxides | glutamyl-L-cysteine peptides | Non-sulfur phytochemicals |
|---|---|---|
| Alliin | γ-glutamyl-S-allyl-L-cysteine | Flavonoids |
| DATS | γ-glutamylmethylcysteine | Steroid saponins |
| DADS | γ-glutamylpropylcysteine | Organoselenium |
| DAS | S-allyl-L-cysteine (SAC) | compounds |
| Ajoene vinyldithiins | | |

L-cysteine sulfoxides are alliin, fat-soluble organosulfur compounds such as DATS, DADS, DAS, ajoene, and vinyldithiins. Alliin is 80% of the cysteine sulfoxides of garlic. The physical description of alliin or 2-amino-3-prop-2-enylsulfinylpropanoic acid is solid. The boiling point is 416.13 °C and the melting point is 163 °C. Solubility 1e+006 mg/L 25 °C (Bijun Cheng and Tianjiao Li 2020). Fat-soluble organosulfur compounds: DATS, DADS, DAS, ajoene, vinyldithiins (Amagase 2006).

While glutamyl-L-cysteine peptides are water-soluble dipeptides. Difference between L-cysteine sulfoxides and glutamyl-L-cysteine peptides, garlic's -glutamyl-L-cysteine peptide content does not change when crushed. Non-sulfur phytochemicals are flavonoids, steroid saponins, organoselenium compounds, and allixin.

The specific flavor of garlic cloves, which is the consequence of complicated biochemical activities, is the most important qualitative trait of garlic products. Thiosulfinates are the major chemicals responsible for that flavor, with alliin or S-allyl-cysteine sulfoxide being the most common garlic flavor precursor. Ajoenes, as well as various sulfur-containing compounds including allicin, 1,2-vinyldithiin, allixin, and S-allyl-cysteine, and sulfides like diallyl-, methyl allyl-, and dipropyl mono-, di-, tri-, and tetra-sulfides, are generated during the breakdown of thiosulfinates (Martins 2016).

Several bioactive compounds have different chemical structures and biological functions. The chemical structure and biological functions of garlic`s key components are shown in the table below (Table 3).

Antioxidant functions have bio-active compounds such as alliin, allicin, allyl sulfide, DADS, 1,2-vinyldithiin, ajeons. Allicin or diallylthiosulfinate has anticancer, anti-inflammatory, antimicrobial, antioxidant, cardioprotective, and immunomodulatory effects. DADS has anti-inflammatory, antioxidant, anticancer, regulation of metabolism, detoxifying effects, antimicrobial activity, antifungal activity, antiviral activity, cardiovascular protection, and neuroprotection activities. It was found that DAS has a wide range of pharmacological effects in comparison with other biologically active substances.

The thiosulfinates (e.g. allicin), ajoenes (e.g. E-ajoene, Z-ajoene), vinyldithiins (e.g. vinyl-1,3-dithiin, vinyl-1,2-dithiin), and sulfides (e.g. DADS, DATS) are breakdown products of the naturally occurring cysteine sulfoxide, alliin. The metabolism of allin and breakdown products are shown in the diagram below (Fig. 1). Allicin is an unstable component in the composition of garlic and is converted into various chemicals. Therefore, it is very difficult and unprofitable to obtain extracts containing alliin.

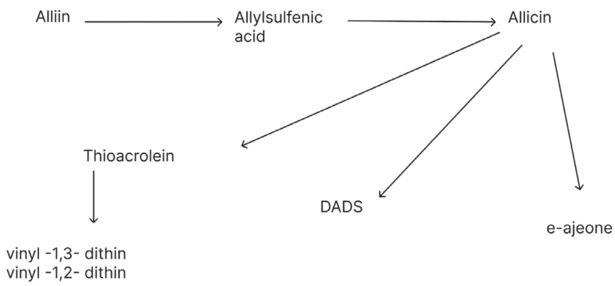


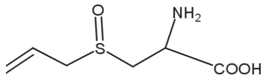
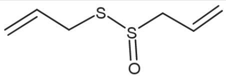
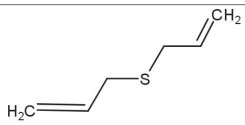
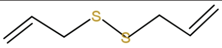
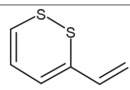
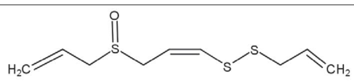
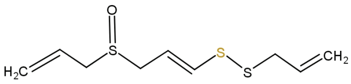
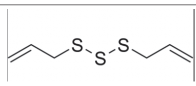

**Figure 1.** Alliin metabolism diagram.

Alliin is released from compartments and interacts with the enzyme alliinase when the garlic bulb is crushed, chopped, or processed in any way. Allicin is a stronger antibiotic than penicillin or tetracycline and is formed by hydrolysis and rapid condensation of the reactive intermediate (allyl sulfenic acid). Allicin is a volatile compound that, depending on environmental and processing circumstances, will undergo further reactions to generate different derivatives. Alliin was obtained by extracting garlic cloves with ethanol at temperatures below 0 °C; allicin was obtained by extracting garlic cloves with ethanol and water at 25 °C, and alliin was transformed completely to diallyl sulfides by steam distillation at 100 °C. The sulfur chemical profiles of Alium products mirror the processing procedure: bulb, mostly alliin; dry powder, primarily alliin; volatile oil, virtually exclusively DAS, DADS, DATS; oil macerate, primarily vinyl-1,3-dithiin, vinyl-1,2-dithiin, E-ajoene, and Z-ajoene. With hydrogen peroxide or peracetic acid, diallyl disulfide may be converted to allicin quickly. Hydrolysis of allicin produces diallyl disulfide and trisulfide (Yi and Su 2013).

## Garlic products

Pre-harvest conditions which determine the chemical composition of garlic are genotype, climate requirements, growing conditions, irrigation, fertilization, and harvesting stage. Post-harvest conditions point out processing methods, consumption forms (aged garlic, fresh garlic, cooked garlic, dried garlic, etc.), humidity, and harvesting time. The relationship between the conditions is drawn in the following figure (Fig. 2) (Martins et al. 2016).

**Table 3.** Chemical structure of garlic biological active compounds and their biological functions.

| Biological active compound | Chemical structure | Biological functions | References |
|---|---|---|---|
| Alliin | <br>S-allylcysteine sul foxi de (Al liin) | Antioxidant<br>Antimicrobial | (Pârvu et al. 2011) |
| Allicin | <br>Dia llylthi osulfi nate(Al Lic in) | Anticancer<br>Anti-inflammatory<br>Antimicrobial<br>Antioxidant<br>Cardioprotective<br>Imunomodulatory | (Pârvu et al. 2011) |
| Allyl sulfide | <br>Allyl sulfide | Anticancer<br>Antimicrobials<br>Antioxidant<br>Antithrombotic | (Pârvu et al. 2011) |
| DADS | <br>Diallyl disulfide (DADS) | Anti-inflammatory<br>Antioxidant<br>Anticancer<br>Regulation of Metabolism<br>Detoxifying effects<br>Antimicrobial Activity<br>Antifungal Activity<br>Antiviral Activity<br>Cardiovascular protection<br>Neuroprotection | (Xiuxiu et al. 2021) |
| 1,2-vinyldithiin | <br>1,2-vinyldithiin | Antimicrobials<br>Antioxidants<br>Antithrombotic | (Higuchi 2003) |
| Ajeons | <br>(Z)-ajoene | Anticancer<br>Antimicrobials | (Capasso 2013) |
| | <br>(E)-ajoene | Antioxidant Cardioprotective | |
| DATS |  | Antioxidant<br>Anticancer | (Fukao et al. 2004; Xiao et al. 2004) |

Processing methods and garlic products. Allicin is an unstable compound that, depending on environmental and processing circumstances, will undergo further reactions to generate various derivatives. Alliin was obtained by extracting garlic cloves with ethanol at temperatures below 0 °C; allicin was obtained by extracting garlic cloves with ethanol and water at 25 °C, and alliin was completely transformed to diallyl sulfides by steam distillation at 100 °C (Yi and Su 2013).

Garlic products offered for therapeutic purposes come in a wide range of flavors. Depending on the manner of production, the amount of active components varies. Allicin is a very unstable molecule that swiftly transforms into another. Garlic products and their content are described in the following table (Table 4).

According to the information in the table, raw fresh garlic has an alliin and water. Dried garlic has alliin and low levels of sulfur compounds. Garlic essential oil doesn`t contain any allicin and has sulfur compounds, like vegetable oil. Oil garlic extract contains alliin, and sulfur compounds and doesn`t contain allicin. Aged garlic extract doesn`t contain allicin and contains water-soluble compounds and sulfur compounds. Despite the great knowledge of this object, some extraction methods are still not standardized.

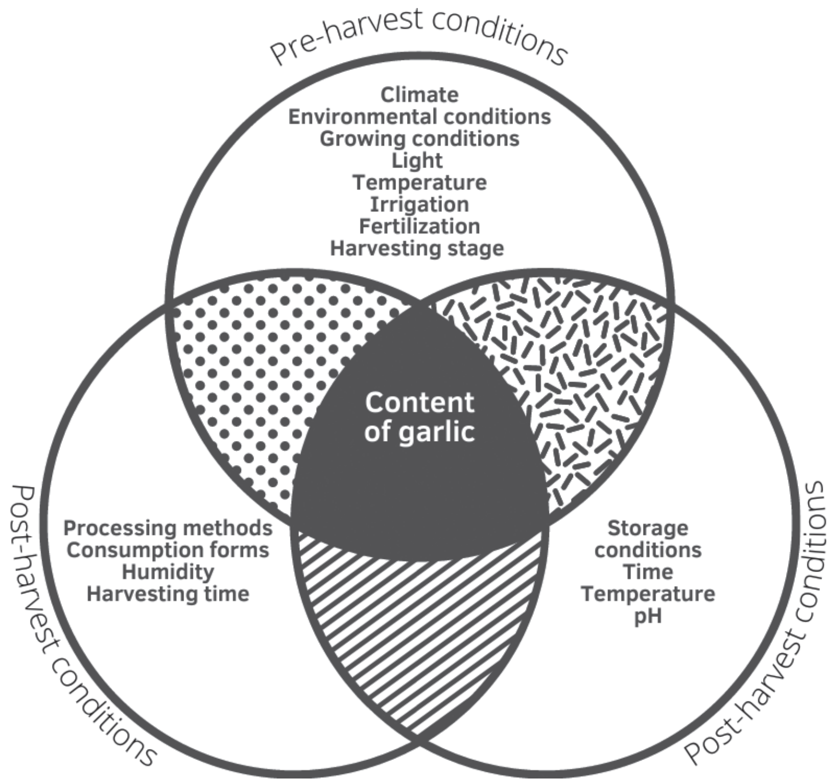



**Figure 2.** Pre-harvest and post-harvest conditions affecting the content of garlic.

**Table 4.** Garlic products and their content.

| Product material | Method of preparation | Content of main organosulfur compounds | Other characteristics | References: |
|---|---|---|---|---|
| Raw fresh garlic clove | Slice of fresh raw garlic | 4–12 mg per gramm of alliin γ-Glutamyl-L-cysteine peptides different percentage of allicin and its derivatives | Up to 65% is water | (Majewski 2014; Higdon 2016) |
| Dried garlic\dried garlic in special capsules | Garlic cloves are sliced and dried at a low temperature to prevent alliinase inactivation | 3 times more alliin than fresh garlic γ-Glutamyl-L-cysteine peptides different percentage of allicin and its derivatives | | (Staba et al. 2001; Majewski 2014) |
| Garlic essential oil | Steam distillation of crushed garlic cloves | Garlicin, allitridin, Allyl methyl trisulde and allicin | 99% vegetable oil | (Staba et al. 2001; Majewski 2014) |
| Garlic oil macerate | Incubation of crushed garlic cloves in oil at room temperature | Vinyldithiins, (E/Z)-ajoene, allitridin and allicin | | (Brace 2002) |
| AGE (Aged garlic extract) | water-alcohol garlic extract | Low level of sulfur compounds | Contain water soluble compounds | (Majewski 2014) |
| Garlic powder | Garlic cloves are sliced and dried at a low temperature and then pulverized to make garlic powder | Alliin and γ-Glutamyl-L-cysteine peptides and different percentage of allicin and its derivatives | | (Staba et al. 2001) |
| Garlic juice | Blending of peeled garlic cloves with distilled water | Allicin, Vinyldithiins, garlicin and allitridin | | (Yu and Wu 1989) |
| Garlic tincture | Maceration of chopped garlic with vinegar/alcohol for 3 weeks | Alliin, allicin and ajone | | (Santos and Carvalho 2014) |

## Antioxidant effect

In comparison to fresh and other commercial garlic supplements, products produced from garlic, such as aged garlic extract, have stronger antioxidant activity. This might be owing to the extraction method used, which tends to enhance the concentration of stable and highly accessible water-soluble organosulfur compounds such as SAC and S-allyl mercapto cysteine, both of which have significant antioxidant activity. Other antioxidant chemicals found in garlic include DAS, DATS, DADS, and diallyl polysulfides, which are stable lipid-soluble allyl sulfides (Amagase et al. 2001).

Organosulphur compounds in garlic oil reduce the toxicity of tributyltin (Liu and Xu 2007). Glycation final products and glycation-derived free radicals are both inhibited by aged garlic extract (Ahmad and Ahmed 2006). Also, low-density lipoprotein (LDL) oxidation and lipid peroxidation are both inhibited by aged garlic extract (Lau 2006).

In aqueous garlic extract, the tissue is protected against oxidative damage caused by nicotine (Augusti 1996). Carbontetra chloride causes liver damage, however, diallyl trisulphide helps to alleviate it (Fukao et al. 2004). Hydroxyl radicals are scavenged by allicin (Prasad et al. 1995). Protection against lipid-related oxidations by S-ethyl cysteine (SEC) and N-acetyl cysteine (NAC) (Tsai et al. 2005).

Garlic oil enhances glutathione peroxidase activity and prevents the reduction in the intracellular ratio of reduced to oxidized glutathione caused by 12-O-tetradecanoylphorbol-13-acetate (TPA) in epidermal cells, according to Perchellet and colleagues (Perchellet et al. 1986). Garlic oil was also discovered to block lipoxygenase (LOX), an enzyme essential for TPA-stimulated arachidonic acid metabolism (Belman 1985). The antioxidant activities of three garlic preparations and organosulfur components in garlic were investigated by Imai and colleagues. They discovered that old garlic extract demonstrated radical scavenging activity, but not fresh garlic extract. The two primary components in old garlic extract, SAC and S-allylmercapto-L cysteine showed the greatest radical scavenging activity of the organosulfur compounds examined. In addition, Naito et al. reported on SAC's anti-oxygenic properties (Naito et al. 1981).

Balasenthil and colleagues have been studying the effects of garlic on lipid peroxidation and antioxidant levels during 7,12-dimethylbenz[a]anthracene (DMBA) – induced hamster buccal pouch carcinogenesis in male Syrian hamsters for the past few years. They discovered that giving hamsters treated with DMBA an aqueous extract of garlic (250 mg/kg) reduced lipid peroxidation in oral tumor tissue to cause apoptosis in the human promyelocytic leukemia cell line HL-60 was examined by Dirsch and colleagues. Ajoene causes apoptosis in human leukemia cells but not in healthy donors' peripheral mononuclear blood cells, according to the researchers. Both dosage and timing were factors in the outcome. Pretreatment of human leukemic cells with the antioxidant N-acetylcysteine reduced the generation of intracellular peroxide in a dose- and time-dependent way (Agarwal 1996; Balasenthil et al. 1999; Dirsch and Vollmar 2001).

Garlic preparations have been shown in tests to have radical scavenging action and to reduce lipid peroxidation. It is tough to put a finger on a common cause for these phenomena. The presence of sulfur-containing molecules in all garlic preparations, on the other hand, shows that sulfur is the key to these biological benefits.

## Cardioprotective properties

Atherosclerosis, hyperlipidemia, thrombosis, hypertension, and diabetes are just a few of the metabolic illnesses that garlic and its derivatives have been shown to prevent and treat. Experimental investigations on the effectiveness of garlic in cardiovascular disorders were more encouraging, which led to the initiation of multiple clinical trials (Sanjay and Subir 2002).

Enhanced plasma fibrinogen and coagulation factors, as well as increased platelet activation, are all contributors to cardiovascular disease. The oxidative alteration of LDL occurs as a result of reactive oxygen species, which is currently thought to be the primary cause of atherosclerosis development. There is also a lot of evidence that platelets have a role in atherosclerosis development (Dhawan and Jain 2004).

Cardiovascular disease has a high morbidity and death rate, but it may be avoided by eating a nutritious diet and exercising regularly. Because hypercholesterolemia plays a key role in the development of atherosclerosis, controlling plasma cholesterol levels is critical in preventing cardiovascular disease (Singh et al. 2007).

Garlic supplements help lower LDL cholesterol, blood pressure, and oxidative stress in hypertensive people. Garlic has the capacity to decrease lipid peroxides due to its lipid-lowering action. Daily eating of the half to one clove of garlic can decrease cholesterol by up to 9% (Sangeetha and Darlin-quine 2006; Tapsell et al. 2006).

Garlic and garlic extract have been widely explored for their pharmacological effects on heart diseases. Garlic and its chemical contents have been studied for their potential benefits in cardiovascular disease, including hyperlipidemia, hypertension, platelet aggregation, and blood fibrinolytic activity (Mantawy and Mahmoud 2002; Gardner et al. 2003; Siegel et al. 2004).

In an animal experiment, the cardioprotective efficiency of freshly crushed garlic was compared to that of processed garlic. In comparison to the untreated control group, garlic skin and meat extracts exhibited a dose-dependent effect on the norepinephrine (NE) – induced increase in cardiomyocyte surface area.

## Anticancer effects

Despite the fact that garlic's anticancer qualities have been known for centuries, most contemporary research on the herb has concentrated on numerous elements, including chemoprevention. Various garlic preparations, including fresh garlic extract, aged garlic, garlic oil, and several organosulfur compounds generated from garlic, have been studied for their chemopreventive effects.

A number of studies have lately concentrated on the antimutagenic action of garlic, in addition to the anticarcinogenic effect of garlic components.

The chemopreventive effect of garlic is clearly linked to the organosulfur compounds (OSCs) generated from it, according to this research. As a result, research in the last five years has concentrated on elucidating the mechanism of action of OSCs in vivo and in culture. Although the exact mechanism by which garlic achieves chemoprevention is unknown, numerous mechanisms have been hypothesized based on this research (Thomson et al. 2003).

## Antidiabetic effects

Diabetes affects a large portion of the global population and is arguably the fastest-growing metabolic illness. Garlic, *Allium sativum* L., *Liliaceae*, is a popular cooking spice with a long history as traditional medicine, and it has been shown to have anti-diabetic effects. Garlic is a rich natural source of bioactive sulfur-containing chemicals that may have anti-diabetic effects.

Diabetes mellitus is a condition defined by hyperglycemia, which eventually impairs the functionality of numerous organs and tissues in individuals. In diabetes, hyperglycemia is caused by inadequate insulin secretion from pancreatic b-cells in response to glucose stimulation, as well as insulin's ineffectiveness in regulating the metabolism of its peripheral target tissues. Type 1 diabetes is caused by the autoimmune destruction of the pancreatic b-cells, which leads to a complete lack of insulin production and, as a result, insulin resistance (Ginsberg 1977; Yki-jarvinen et al. 1986; Leslie 1997; Greenbaum 2002).

## Antibacterial effects

The antibacterial effects of garlic are related to its varieties and processing methods. Garlic oil was demonstrated to be the main antibacterial ingredient. Allicin is the main antibacterial and antimicrobial ingredient up to 100 °C.

Consequently, garlic contains two antibacterial enzymes: heat-resistant allicin and heat-resistant sulfur compounds, which act against bacteria (Duka and Ardelean 2010).

Garlic's antimicrobial qualities have been extensively researched in the scientific community, demonstrating a wide range of garlic uses in medicine. Antibacterial capabilities have been shown by scientific study in these areas: antibacterial activity and inhibitory properties on *Staphylococcus aureus*, *E. coli*, and *Bacillus subtilis*, fungus *Penicillium funiculus*, *Candida albicans* and *Helicobacter pylori* (Shang et al. 2019).

## Antiviral effects

Compared to the anti-bacterial effects, the antiviral effects of garlic have been less studied. A few studies have reported that garlic extract shows in vitro activity against influenza A and B, cytomegalovirus, rhinovirus, HIV, herpes simplex virus 1 and 2, viral pneumonia, and rotavirus. Allicin, diallyl tri-sulfide, and ajoene have all been shown to be active. In the case of HIV, it is thought that ajoene acts by inhibiting the integrin-dependent processes. Allyl alcohol and diallyl disulfide have also proven effective against HIV-infected cells. No activity has been observed with alliin or S-allyl cysteine; it ap- pears that only allicin and allicin-derived substances are active.

Garlic's antiviral activities have received less attention than its antibacterial benefits. Garlic extract has been shown to have in vitro action against influenza A and B, Cryptococcus, rhinovirus, HIV, herpes simplex virus 1 and 2, viral pneumonia, and rotavirus in a few investigations. Ajoene, allicin, and diallyl trisulfide have all been proven to be active. It's suspected that ajoene works against HIV by blocking integrin-dependent activities. Diallyl disulfide and allyl alcohol have also been shown to be effective against HIV-infected cells. Alliin and S-allyl cysteine have shown no action; it appears that only allicin and allicin-derived compounds are active (Harris et al. 2001).

Many people have recently been infected with a new coronavirus (SARS-CoV-2), and the death toll has risen to thousands and is continuing to rise, posing a serious global crisis. As a result, all experts throughout the world are concerned about the demand for natural and safe treatments to prevent coronavirus.

According to recent research, garlic essential oil is a powerful natural antiviral source that helps to prevent coronavirus from invading the human body. Allyl disulfide and allyl trisulfide, which make up the majority of garlic essential oil, have the strongest anti-coronavirus action (Bui et al. 2020).

Allicin has been identified as one of the key organosulfur compounds with antiviral, immunomodulatory, anti-inflammatory, antioxidant, and other pharmacological characteristics.

Allicin-derived organosulfur compounds such as ajoene, allitridin, garlicin, and DAS have been shown to have antiviral, immune-enhancing, and other therapeutic properties in preclinical research, both in vitro and in vivo (Rouf et al. 2020).

## Modulating immune system

Garlic contains many bioactive compounds that are beneficial for the immune system. Garlic polysaccharides have an immunomodulatory effect. Compared with black garlic, fresh garlic polysaccharides exhibit more potent immunomodulation activity. This is probably due to the degradation of fructan constituents during processing (Li et al. 2017).

Moreover, the consumption of AGE was found to reduce the occurrence and severity of the cold and flu and improve the immune system functions in humans. Overall, polysaccharides appear to be the main immune-modulating components in garlic (Percival 2016).

Cancer prevention agents and normal bioactive compounds from plants are for the most part phenolic compounds from the flavonoid bunch, tocopherol, coumarin, cinnamic corrosive subordinates, and polyphenolic natural acids. The flavonoid bunches that have antioxidant action incorporate catechins, isoflavones, flavonols, flavones, flavonoids, and chalcones (Kumar and Pandey 2013; Panche et al. 2016).

These compounds have a critical part in the well-being and can increment the safe system. Garlic has the potential to extend the safe framework when consumed either straightforwardly within the form of new and prepared garlic or within the shape of extricates of bioactive compounds. The resistant system is the foremost critical portion of the body's resistance framework. Endeavors to extend the resistant framework within the body are exceptionally critical to preserving it ideally. Expanding the body's guard framework can be conducted by giving immunostimulants. Immunostimulants are a way to extend the resistant framework by utilizing fixings that can fortify the resistant framework, which can come from different bioactive compounds from nourishment (Catanzaro et al. 2018; Rezaharsamto and Subroto 2019).

The bioactive compounds in garlic, particularly flavonoids, can play a part in expanding the body's resistance framework as immunostimulants (Tsai et al. 2011).

Related to the potential of garlic in expanding the safe framework within the body is that the substance of bioactive compounds found in garlic is demonstrated to extend the resistant framework, defense, or resistance, with its properties as an immunostimulant. Immunostimulants in garlic can be a potential elective in managing with the Covid-19 widespread, which is still continuous nowadays. In any case, it is vital to assist considers related contrasts in clinical adequacy and quality of the safe framework delivered by each person and how the part of each bioactive compound in garlic in acting as an immunostimulant to fortify the body's resistant framework.

## Conclusion

Garlic (*Allium sativum*) has been used as a raw material in medicine and pharmacy for several centuries. This raw material contains many biologically active substances that have a wide range of pharmacological effects and are confirmed by various methods of analysis. This review presents numerous phytochemical and pharmacological studies, and various methods for obtaining garlic extract, the following biologically active substances have been identified in these extracts: alliin, allicin, allyl sulfide, DAS, DADS, DATS, 1,2-vinyldithiin, ajeons, etc. These biologically active substances have the following pharmacological effects: antioxidant, anticancer, antimicrobial, antiviral, cardiovascular protection, antidiabetic, antibacterial, and immunomodulatory effects.

As a result of research and review of literature data, it was revealed that the chemical composition and pharmacological effects of local garlic have not been studied in Kazakhstan. This raw material can become a good raw material base for the production of medicines. A large number of analyses were studied to determine the chemical composition, bioactive substances, and conditions affecting the phytochemical profile of garlic to fully illustrate the content of plant raw materials and to identify prospects for further research. Analyzing various sources and studies by scientists, we have found that the organosulfur substances of garlic should be the main target for the development of medicines and for extraction in pharmacy.

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