REVIEW ARTICLE

Exploring the Therapeutic Potential of *Allium sativum*: Recent Advances and Applications

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ABSTRACT

This review dives into the multidimensional character of *Allium sativum*, generally known as garlic, exploring its botanical aspects, chemical elements, and varied pharmacological effects. With a complex array of sulfur compounds, amino acids, enzymes, and minerals, garlic has long been renowned for its strong flavor and therapeutic potential. Allicin and its derivatives are the focus of this research as it investigates the medical uses of garlic's numerous sulfur compounds. Garlic has a wide variety of biomolecules, and this article investigates their potential synergistic effects on health to highlight the need for additional study in this field. Garlic's pharmacological actions are also described in detail, providing insight into its prospective therapeutic applications. These activities range from its antiatherosclerotic and antihypertensive qualities to its anticancer, immunomodulatory, antifungal, and digestive effects.

Keywords: *Allium sativum,* Biomolecules, Sulfur compounds, Immunomodulatory.

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INTRODUCTION

Allium sativum, the scientific name for garlic, belongs to the *A.* genus, which also contains onion and leek. It has a bulbous shape and many cloves all wrapped up in one papery covering.[1] True, the word "garlic" is supposed to have been derived from the Celtic word "all," which signifies "pungent" or "burning".[2] The pungent flavor and perfume of garlic are perfectly reflected in the name.[3] Although the precise place of garlic's first appearance is unknown, it was likely in the central Asian region that includes present-day Iran, Turkmenistan, and Uzbekistan. It is believed that garlic was first domesticated in this region. Both softneck garlic and hardneck garlic belong to genus *Allium*. One type of garlic uses an underground root made up of cloves, which are prophylls covered in a dry membrane and held together by a plate at the base. On the other hand, hard-neck garlic has a bulb made up of 6–11 cloves that are crowded together around a central woody stem. The "scape" on top of this type of garlic is bent once or twice before it is cut off. This is because there will be insufficient energy to power the light bulb if it continues to grow. Bulbils, which are essentially young cloves, would develop on the scape. Along with the bulbils, infertile white or pale purple flowers may also develop.[4] The softneck variety of garlic has no flowering top and can contain up to twenty-four cloves per bulb. The larger cloves are located on the outside of the stack, while the more malleable stem is located in the middle. Many studies using garlic don't specify which species is used, but since the more common *A. sativum* is always used, we can assume that the chemical and biological effect is the same regardless of which species are used.[5] Raw garlic has a very strong odor and taste because of these chemicals, which also serve as defensive mechanisms against predators.[6]

Chemical Constituents

There are at least 33 sulfur compounds in garlic, along with enzymes, seventeen amino acids, and minerals.[7] It has more sulfur compounds than any other *Allium* species. Both the pungent odor and the medicinal properties of garlic can be attributed to the presence of sulfur compounds.[8] Alliin (S-allyl cysteine sulfoxide) makes up around 1% of dried, powdered garlic.[9] Allicin (diallyl thiosulfinate or diallyl disulfide), one of the most physiologically active chemicals, does not exist in garlic until the bulb is injured, at which point the enzyme allinase is activated and alliin is metabolized to allicin.[10] Vinyldithiines are the next metabolic step after allicin.[11] Garlic oil, aged garlic, and steam-distilled garlic, as opposed to fresh garlic or garlic powder, do not contain significant quantities of aliin or allicin. However, they do contain a variety of by products resulting from the transformation of allicin.[12]

Not a single garlic preparation tested showed the same level of physiologic action as fresh garlic or garlic powder,

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but they did contain diverse products of allicin transformation such as aged garlic, garlic oil, and steam-distilled garlic.[13] Germanium and selenium are two of the trace elements present in appreciable amounts. Alliin, an odorless sulfur-containing amino acid, is present in the bulbs. The process of grinding the bulb induces the release of the enzyme alliinase, which catalyzes the conversion of alliin to 2-propenesulforic acid, subsequently causing allicin to dimerize. The predominant sulfur compounds identified in whole or pulverized garlic are γ-glutamylcysteines, including γ-glutamyl-S-allylcysteine and γ-glutamyl-S-trans-1-propenylcysteine.[14] Garlic has many different types of biomolecules that aren't sulfur, such as oil of garlic, steroidal glycosides, flavonoids, lectins, prostaglandins, anthocyanins, fructan, vitamins B1, B2, B6, C, and E, pectin, adenosine, biotin, nicotinic acid, glycolipids, phospholipids, fatty acids, and essential amino acids.[15] The true role of these components in amplification health advantages of garlic has yet to be addressed, despite the fact that they combine synergistically to produce a variety of benefits. Our study shows that there is a dearth of information on *A. sativum* (Figure 1).

Pharmacological Activity

Antiatherosclerotic

Atherosclerosis, the major cause of death in developed countries, is a complicated interaction of serum cholesterol with artery wall components. Recent advances in prevention and therapy have been made, however, the cause and progression of atherosclerotic lesions remain a mystery. High serum cholesterol, being male, becoming older, having high blood pressure, smoking cigarettes, and having diabetes are all risk factors for atherosclerotic illnesses. In the context of experimental atherosclerosis, garlic offers both therapeutic and preventative benefits. Its antiatherosclerotic effect is independent of blood cholesterol levels and is instead caused by a direct effect on vascular wall processes. Suppressing lipid production and decreasing enzyme activities, garlic reduces free cholesterol and cholesteryl ester concentrations in lipid-overloaded arterial cells. It not only lowers and normalizes the most noticeable signs of atherosclerosis, but it also stops the production and buildup of collagen in the artery and stops atherosclerotic cells from multiplying. High-dose garlic powder cut the size of arteriosclerotic plaque by 5–18% or even went back to normal after 48 months. Between 50 and 80 years old, the plaque amount grows, but garlic treatment cuts it by 6 to 13% in 4 years.[16,17]

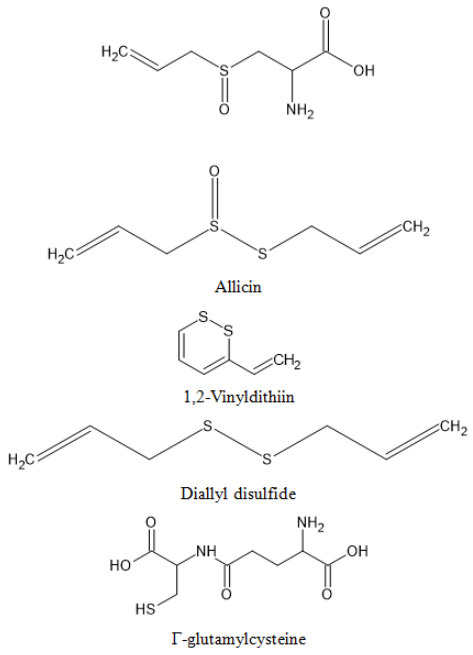

Figure 1: Active chemical constituents of *A. sativum*

Antihypertension

An estimated 1 billion people around the world have hypertension, making it a major threataspect for cardiovascular morbidity and mortality. A combination of garlic's hydrogen sulfide generation and allicin levels has been related to blood pressure lowering qualities. Studies on garlic's influence on blood pressure are few, although conflicting results exist. Patients with hypercholesterolemia, moderate hypertension, and normotensive subjects saw reductions in diastolic blood pressure after consuming 900 mg of garlic powder daily. However, research on possessions of garlic on blood pressure in healthy persons came up empty. Studies in animals, including the Goldblatt model, have demonstrated garlic's antihypertensive properties and its capacity to inhibit hypoxic pulmonary hypertension, suggesting garlic may have a blood pressure-lowering effect in humans. Allicin is a systemic vasodilator that also works as a pulmonary vasodilator in rats with lungs that are separated from their chests and cats that are not paralyzed.[18-20]

Anticancer

Garlic's presence of organosulfur compounds has been linked to its chemopreventive action. These chemicals have been considered for their anti-cancer, anti-oxidant, and tumor-suppressing activities. Animals were used in the majority of the research. A recent study has focused on the antimutagenic potential of garlic, with aged garlic extract demonstrating radical scavenging action. Two main parts of aged garlic, S-allylcysteine and S-allylmercapto-L-cysteine, are the best at getting rid of free radicals. Organosulfur chemicals found in garlic have been shown to stop tumors from growing both in the lab and in living things.[21,22]

Immunomodulatory action

The immunomodulatory actions of *A. sativum* make it a valuable therapeutic herb. QSepharose chromatography of a 30 kD filtration of raw garlic extract was used to purify three proteins with immunomodulatory properties. Human murine splenocytes, peripheral blood lymphocytes, and mouse thymocytes are all susceptible to mitogenic action of these proteins. The present investigation revealed lectins or agglutinins ASA II and ASA I, abundantly present in garlic, as having significant mitogenic action with potential

clinical value for immunomodulation. Evidence suggests that garlic may be able to alter biological responses. Garlic's ability to boost immunity against tumors was the first of its immunostimulatory actions to receive media attention. Since immunological dysfunction can be a contributing factor in the development of several diseases, garlic's ability to modulate immune processes could have implications for both treatment and prevention. Therefore, immune modification may serve as a mediator for some of garlic's pharmacological actions.[23]

Antifungal

Fungicide qualities of garlic extracts were shown by their ability to kill *Candida, Torulopsis, Trichophyton, Cryptococcus, Aspergillus, Trichosporon,* and *Rhodotorula species*. Recently, garlic extract stopped the growth and development of *Meyerozyma guilliermondii* and *Rhodotorula mucilaginosa*. In a different study, it was discovered that *A. sativum* extracts in water, ethanol, methanol, and petroleum ether could stop human harmful fungi like *Trichophyton verrucosum* from growing. The garlic extract changed the fungi cell wall in a way that could not be undone, which made it less likely for the fungus to germinate. These changes in the cytoplasm hurt the nucleus and other parts of the cell, which leads to cell death. Allicin and garlic oil killed *C. albicans*, *Ascosphaera apisin*, and *A. niger* by getting into their cell membranes and mitochondrial membranes. DADS and DATS from garlic essential oil stopped *C. albicans*, *C. tropicalis*, and *Blastoschizomyces capitatus* from growing. *Botrytis cinerea* and *Trichoderma harzianum* were stopped by saponins from *A. sativum*.[24]

Effect on digestive system

Black garlic extract boosts gastrointestinal peristalsis, empties the stomach, and aids defecation, treating gastric tissue injury. *In vitro*, black garlic water improves gastrointestinal functions more than n-butanol and ethyl acetate. Garlic and cabbage extract decrease stomach ulcer length, acid, juice volume, bacteria count, and histology. AGE oral treatment healed indomethacin-induced gastric mucosal damage in male rats and reduced stomach bacteria levels. Garlic bioactive chemicals protect the digestive system, including allicin suppressing STAT-1 activation, lowering ulcerative colitis in mice, and reducing stomach inflammation and *Helicobacter pylori*. Garlic and its bioactive compounds can treat colitis, stomach ulcers, and other gastrointestinal issues.[25]

CONCLUSION

A. sativum is a remarkable plant because it has a wide variety of chemicals that work together to make it a powerful medicine. Many of garlic's therapeutic properties can be traced back to its sulfur components, most notably allicin. The specific mechanisms and synergistic interactions among garlic's components are not fully understood, despite advances in our understanding of its chemical makeup and pharmacological activity. Further study is needed to fully understand its therapeutic potential, but existing evidence suggests it helps with anything from cardiovascular disease to cancer prevention to immune system regulation. The wide range of pharmacological effects and chemical complexity of garlic keeps researchers interested and encourage them to learn more about its potential benefits to human health.

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