

GARLIC (*Allium sativum* L.) AS FUNCTIONAL AND MEDICINAL FOOD

Asma HARB¹, Banu Yeşim BÜYÜKAKINCI^{2*}

¹ Istanbul Aydın University, Faculty of Engineering, Department of Food Engineering, 34295, Istanbul, Türkiye

² Haliç University, Faculty of Fine Arts, Department of Textile and Fashion Design, 34060, Istanbul, Türkiye

*Corresponding Author: bamyeyesimbuyukakinci@halic.edu.tr
ORCID number: 0000-0001-7597-4406

ABSTRACT

Garlic (*Allium sativum* L.), a bulb herbal plant had a history of several thousand years of human consumption and use, starting as a seasoning, traditional treatment, and functional food. Nowadays, scientific studies considered this food an excellent health-promoting element. All that is because of the existence of active organosulfur compounds (OSCs) in garlic, which are disease-preventing for many common diseases, from cancer, heart, and blood vessel disorders, metabolic disturbances, and blood pressure to diabetes mellitus through its antioxidant or inflammation treatment. Garlic as well fights several viral infections (e.g., coronavirus) and has fat-reducing properties, as proven in several in vitro, in vivo, and clinical studies. In this article, the importance of garlic & its active sulfur compounds was investigated, according to previous studies. Also, the health benefits of garlic were discussed as well.

Keywords: *Garlic (Allium sativum L.), sulfur-containing compounds, bio-active components, health benefits, anticancer mechanism.*

INTRODUCTION

Garlic (*Allium sativum* L.) is a bulb flowering plant with a history of several thousand years of human consumption and use, starting as a seasoning, traditional treatment, and a portion of functional food [1]. The Codex Ebers, one of the oldest information sources for medical texts mentioned garlic as therapy and included it in a lot of medication recipes. In old traditional Asian medicine, garlic has been prescribed to help patients with

¹Geliş Tarihi: 19.07.2021 Kabul Tarihi: 22.08.2021
DOI: 10.17932/IAU.IJFER.2015.003/ijfer_v07i2003

breathing and digestive problems. Several documents highlight garlic as a medicine with magnificent healing effectiveness [1]. The consuming part can be the root, leaves, or bulb itself. It can also be fresh green, dried, or in the form of a powdered spice or its extract oil. All examined parts contain different types of active ingredients such as sulfur moieties such as γ -glutamyl-S-alkenyl-L-cysteine, S- alkenyl-L-cysteine sulphoxides, alliin, and ajoene [2]. The main sulfur compound is alliin. On average, during the consumption of garlic alliinase is released and converted into allicin which is unstable and rapidly deconstructs into other products, including dithi-ins, ajoene, allyl methyl trisulfide, diallyl disulfide (DADS), diallyl sulfide (DAS), diallyl trisulfide (DATS) & oil-soluble organosulfur compounds (OSCs) [3]. These OSCs are generally considered the main bioactive component in cancer prevention. S-Allylcysteine (SAC) is a stable compound known because of its antioxidant and cholesterol-reducing effects via clinical research & pharmacological action of allicin or diallyl disulfide [1, 2].

The mechanism of action of garlic is wide branched. The therapeutic results of garlic are remarkable. The presence of some biologically active compounds, for example, organic sulfides, saponins, and phenolic compounds [4]. Several in vitro and in vivo experiments have shown that these compounds can modulate various signaling pathways, improving the network shape of biological activities: anti-inflammatory, antioxidant properties, chemo-preventive, antiproliferative, anti-angiogenic, antidiabetic, immunomodulatory, anti-obesity, antibacterial properties and cardioprotective effects [2]. In Egypt, garlic's abilities as a chemotherapeutic agent against tumors have been 3500 years ago [5]. A lot of food processing approaches were working on manufacturing techniques to decrease the loss of the functionality of garlic's major compounds [6]. Various manufacturing techniques (during dehydration, chopping, and packaging) were discussed in related articles to play an important role in garlic preservation. However, their only object is not to decrease garlic quality. The findings of this review can provide a scientific basis to help improve the methods of handling garlic & its multiform products [7].

This article represents a summary of studies that investigated the roles of garlic as a functional and medicinal food. Also, discusses the promise of using garlic's bioactive compounds can lead to improvement between natural food therapy and pharmacological drugs.

Table 1. The chemical combination of garlic bulbs [8,9].

Chemical composition	Percent %
H ₂ O	65%
Carbohydrate	28%
Protein	2%
Amino acid	1.2%
Fiber, fatty acid, phenols, trace elements	1.5%
Sulfur-containing compounds	2.3%
Vitamins (C, B) & minerals (K, Ca, Se).	

Chemistry of garlic

The chemical combination of garlic bulbs contains different materials shown in Table 1. While the active main organosulfur components of garlic (Figure 1) like diallyl thiosulfonate (allicin), diallyl sulfide (DAS), diallyl disulfide (DADS), diallyl trisulfide (DATS), E/Z-ajoene, S-allyl-cysteine (SAC) and S-allyl-cysteine sulfoxide (alliin). Alliin or S-allyl-cysteine sulfoxide is the responsible compound for flavor and taste [4, 9]. During the consumption of garlic, alliinase is released and converted into allicin when it enters the body to form bi-products [3]. Earlier studies confirmed the health-promoting properties of garlic for the human body. The health benefits are reportedly due to the presence of mentioned bioactive compounds [9, 10].

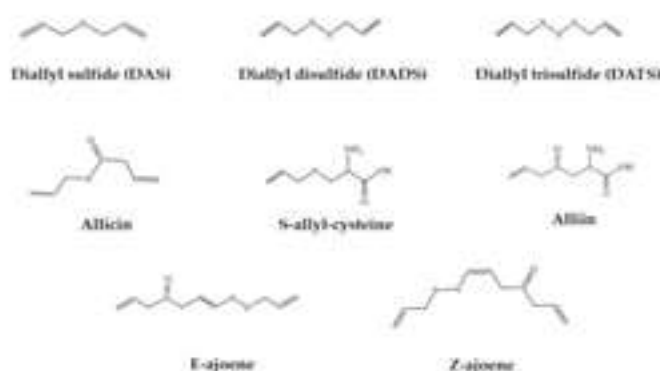


Figure 1. The chemical structural form of the main organosulfur compounds in garlic [10].

In general, these bioactive compounds vary in their bioavailability and digestibility and their levels can vary depending on whether the garlic is fresh, cooked, dried, or chopped [4]. In a randomized controlled study aims to determine the residues of garlic components in the body, after oral consuming 1-3 grams of fresh garlic, organosulfur compound (diallyl disulfide - DADS and diallyl sulfide - DAS) was not detected in urine samples after 6-24 hours. while compound like allyl methyl sulfide which can be detected in Breath undergoes extensive metabolism produced from allyl thiosulfate [11]. The effects of different processing methods and storage conditions (humidity, temperature, pH) along with the efficiency of bioactive components have been also included [12]. In the botany field, the defense mechanisms of garlic against plant pests, and pathogens have also been shown in laboratory experiments to prevent cell damage and plant tissue lesions [13].

Biological Activities of Garlic

Antioxidant activity

On the cellular level, the last effect of active ingredients such as phenols and saponins appear as major antioxidant compounds [4, 14, 15]. While the intensity of this effect and the mechanism of action appear as a network full of branches (pathway regulation) and side products (minor products) [9].

Anti-inflammatory activity

The bioactivity of garlic has been shown to exhibit anti-inflammatory properties [10]. Moreover, allicin could be included in therapy as an anti-inflammatory against arthritis disease, due to its low presence of toxicity. [16]. A study by Martina et al focused on the mechanism of the ethyl linoleate which controlled the number of oxidative chemicals (nitric oxide -NO and prostaglandin E-2) by decreasing regulation & expression through their pathway either by inhibiting the transcription factor or enhancing the macrophage's effectiveness [4, 14]. Also, garlic supplements consider to stopping inflammatory agents, which can be nitric oxide (NO), tumor necrosis factor α (TNF- α), or interleukin-1 (IL-1) according to pharmacological research [16].

Antimicrobial activity

During the research on the antibacterial and antifungal properties of garlic in Italy, it was found that garlic significantly suppresses the growth of *Aspergillus Versicolor*, *Penicillium citrinum*, and *Penicillium expansum*. Also, the oil extracted from the fresh plant got the ability to prevent the production of toxins from bacteria and may limit the growth of *Staphylococcus aureus*, *Escherichia coli*, and *Bacillus subtilis* by destroying the formation and the metabolic pathway of bacterial cells [9, 14]. Furthermore, in a clinical trial, the treatment of raw garlic inhibited *Helicobacter pylori* in the stomach of patients with *H. pylori* infection [13].

Garlic protective effect

During eating products containing garlic, organosulfur compounds (e.g., allicin and alliin) and flavonoid (e.g., quercetin) will be responsible for most immunomodulatory effects. Treatment with garlic oil for 30 minutes can normalize several immunological factors from serum total immunoglobulin concentration to T-cell subtype CD4+. Moreover, consuming AGE reduces the severity of influenza by improving body defense responses [14, 17, 18].

In another study, dried garlic can effectively reduce blood total fat, and inhibit platelet aggregation and any risk factors along with heart diseases. All by increasing the production of NO and hydrogen sulfide (H₂S) and inhibiting the angiotensin-converting enzyme, thereby lowering hypertension and oxidative stress [10, 16]. The anti-hypertension mechanisms of garlic are shown in (Figure 2). The findings of randomized controlled research, have suggested that garlic supplementation can reduce atherosclerosis or prevent cardiovascular events, such as myocardial infarction or stroke but the exact technique is still not fully understood [9, 19]

In the elderly category, ingredients such as S-allyl mercaptocysteine stood out. Where they help activate the role of antioxidants in the body. Which was used in the composition of medicines given to Alzheimer's patients because of its association with nerve impulses and brain function [17, 20]. The sector of garlic as a hypoglycemic agent is based either on stimulation of the pancreas that increases the secretion of insulin from β -cells and increases insulin sensitivity or the release of bound insulin which controls the glucose content in the blood. Vitamin B6 and Vitamin C are present in garlic extract. Vit B is engaged in the metabolism of carbohydrates, while

Vit. C plays an important role in controlling and maintaining the sugar level in the blood [21]. Garlic oil, obtained from steam distillation of *Allium sativum* enhances insulin and glucose tolerance. It also enhances skeletal muscle glycogenesis [15, 22]. Allicin in combination with sulfur-containing amino acid, will create a pathway involved in the regulation and increase the blood insulin concentration by preventing the inactivation of insulin by the liver. Garlic functions as an insulin secretagogue or insulinotropic in diabetic rats [2, 3, 21]. A study by Sudhakar et al., (2021) demonstrated in Table 2 used supplements containing garlic in the management of type 2 diabetes mellitus and reducing diabetic complications [21].

Anticancer mechanisms of garlic

The anticancer-related study has shown that allylsulfide derivatives have significant and clear biological effects on mechanisms in carcinogenesis [19]. The anticancer actions have been divided into the following categories depending on the cancer phase, which are summarized in Figure 3.

Table 2. Summary of clinical trials of herbal medicine in diabetic patients [21].

TYPE OF FOOD	MECHANISM	CLINICAL TRIALS	AGE GROUP (YEARS)	OUT-COMES	COM-PLI-CAT-ION
<i>Allium sativum</i> (Garlic tablet)	Allicin combines with cysteine and enhances serum insulin. Inhibiting the forming of advanced glycation final products (AGEs) It increases the pancreatic secretion of insulin from the beta cells.	Type 2 Diabetes Mellitus patients	25-70 years	Improve the glyce-mic control by improv-ing the glycemic index and maintaining a glucose level	Gastric irritation
	Direct hypogly-cemic action, fasting blood glucose level and serum fructosamine are decreased significantly.	Type 2 di-abetes ath-erosclerosis patients	34-62 years	Fast blood glucose level was decreas-ing, and serum fruc-tosamine was declin-ing.	Not stated

In the initiation phase of cancer progression, it inhibits vital phytochemicals and carcinogens with antioxidants, mutagenicity, and detoxification. In the second phase (promotion), it cuts the reproduction cycle of phytochemicals that lead to stopping the propagation of cells by folding protein and DNA repairing. In the third phase (progression), the inhibition of phytochemicals causes changing cell pathways, including antiproliferation, apoptosis, and immunocompetence [19].

Previous in vitro studies have used the extraction material from garlic in inhibiting mutagenicity in bacteria, which came very effectively by SAC and SAMC the strong radical activities that block the extracellular mutagens [19]. On the other hand, the consumption of garlic increased circulatory antioxidants, vitamin E, and superoxide dismutase. While reducing glutathione, glutathione peroxidase, and peroxidation of lipids [23, 24]. Stimulating scavenging of reactive oxygen species (ROS) prevents oxidative damage to healthy tissue. The enzymatic activity of cytochrome P450 s (CYP2E1) was affected by the DAS oxidant derivative, leading to stop the production of carbon tetrachloride, acetaminophen, and N-nitroso dimethylamine which consider toxic carcinogen-forming elements [23, 24, 25]. Additionally, the ajoene component causes an accumulation and activation of misfolded protein aggregates in cancer cells [19, 23]. For all that, garlic's functional components consider blockers and regulators important in the first and second stages of oncogenesis. Prevent transportation of the tumor between organs by inhibiting toxic chemicals or interference between cellular macromolecules in DNA, RNA, and proteins [3, 24]. When cancer is invasive and metastatic, even immune evasion, growth, and proliferation can be happening. Garlic here is involved in the induction of apoptosis (death) of damaged cells by an increased splitting of genetic material and intracellular Ca, p53, Bax, and down-regulation Bcl-2.

A novel study has incubated One hundred and eighty cancer cells or what is known as Murphy-Sturm lymphosarcoma cells with diethyl thiosulfate. After that, it revealed that a complete prevention effect of cancer cells from developing tumors was noticed [2, 23, 24]. In vitro level, recent studies represent an idea that *Allium sativum* (garlic) has antiproliferative characteristics and apoptotic activities on carcinoma cell line A498 located in the kidney and carcinoma cell line A549 cell lines in the lung while no effect of a toxic level was detected [3, 9]. At the same level, the combination

of S-allyl cysteine from *Allium sativum* and lycopene from tomatoes can form suppress chemically induced gastric cancer progression [24, 19]. The functional components of garlic are not only effective in the chemopreventive stages of cancer but also contribute to enhancing the effectiveness of cancer treatment and reducing the side effects of treatment, whether chemo or radiotherapy, by suppressing symptoms after sessions. This result is quite surprising in the difference in the therapeutic effect of taking garlic extraction. Recent information indicated that the phytochemicals of raw garlic have a very high selectivity to kill exceptionally efficient cancer cells with no damage to normal cells [19].

Against coronavirus

Seventeen active organosulfur compounds are found in garlic essential oil, results show that 99.4% of contents have a strong effect on basic units of the ACE2 protein and PDB6LU7 protease of SARS-CoV-2. Also, it considers that these essential oils are a valuable natural antivirus source and can help prevent coronavirus invasion into the human body [26, 27]. Since the scientific research race against the coronavirus began, many drugs have been produced, either to fight the virus itself or the side effects and even some research has worked to produce drugs that help stimulate the human immune system [27].

Therapeutic Promises of Garlic

Medical importance garlic is an excellent source of therapeutic agents. A pharmaceutical drug from garlic was produced that contains allicin organosulfur compounds. For better results, garlic should be fresh and chemical-free. Pure allicin has been found effective against fungus and mold accumulation. The garlic was smashed to be used for sores in the mouth and throat, while these days it can be used in toothpaste to prevent related problems [2]. It is also good for hair growth (since it consists of vitamin B-6 and Vit C which are good for hair growth, nowadays a lot of shampoos and hair treatment products contain sulfur as an additive from garlic), for flu, anti-febrile and Anti-helminthic activity [3, 28].

Garlic also helps in removing the *Giardia lamblia* parasite from the intestinal tract. Antimicrobial activity: the allicin consists of organosulfur compounds which are the most important for antimicrobial properties [13, 28]. These findings, if used in the right ways, may give a new valuable method for treating cancer using traditional medicinal plants [2, 29, 30].

CONCLUSION

Garlic (*Allium sativum L.*) is a herbal plant used worldwide and considered a food, seasoning and old cultural (medicinal) treatment for the prevention of infectious diseases since antiquity. Through research, the food sciences and pharmaceutical industries have developed links between garlic's functional effect on cancer, heart disorders, blood pressure, and diabetes mellitus. Antioxidants and anti-inflammatories that fight many viral infections and have lipid-lowering properties have also been studied, as shown in numerous research and clinical studies. This article summarizes scientific investigations into the powerful effects of garlic and its wide use as a functional and medicinal food.

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