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GARLIC (Allium Sativum): A Cure for Most Disease Present in Every Household

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Abstract **Original Research Article**

Garlic is a worldwide cultivated crop species which is used in culinary as condiment or as flavoring agent and its antioxidant and immunomodulatory property are well-known for human health and beneficial effects. Many different cultures have recognized the potential use of garlic for prevention and treatment of different diseases and it was noticed that among herbs garlic is on top in regard to its use in household. It contains sulfur compounds such as allicin, diallyl disulfide, S-allylcysteine, and diallyl trisulfide which can be extracted by distillation, soxhlation, aqueous extraction. Garlic oil is extracted by steam distillation. Recent studies support that garlic is as an antibacterial, antifungal, antiviral, and anti-parasite due to the presence of sulphur compound namely thio-2-propene-1-sulfinic-acid S-allyl ester (Allicin). It shows antioxidant property due to its two pivotal organosulfur compounds: S-allylcysteine and S-allylmercaptocysteine. Garlic and its extract acts as cardioprotective and lowers serum cholesterol, inhibits different type of carcinogen (DMBA, DEN, NMBA, BP), antidiabetic. In this paper the traditional use of garlic and how these are still relevant in the modern science and medicine is depicted, an overview is given on a number of important plant and health aspects of garlic. However, the exact mechanism of all ingredients and their long-term effects are not fully understood, still the organosulfur compounds allicin, di allyl sulfide, di allyl trisulfide, ajoene etc have a huge margin of health bestowing properties.

Key words: Garlic, Anticancer, Antimicrobial, Antidiabetic, Cardiovuscular.

INTRODUCTION

Garlic is present in every house's kitchen all around the world which is used in culinary as condiment or as flavoring agent. Its use can be traced dating back in the time of first human civilization and is also mentioned in the old Hindu texts. In history it can be found that in Ancient Egypt as well as Rome, it was used as condiment or seasoning and for medicinal purposes [1]. As early as 1858, Louis Pasteur reported the antibacterial properties of garlic [2]. Garlic is also known as Rocambole, ajo, Allium, stinking rose, rustic treacle, nectar of the gods, camphor of the poor, poor man's treacle, and clove garlic. In contemporary times, China is the world producer of garlic reins the throne and supplies 80% all around the globe and India produces 5% claiming the 2nd seat on ranking list [3]. Our ancestors were far more advanced than we can even imagine. They were medically so sound that they used herbs to cure most diseases unlike in the present time where we pop a pill to cure our fluctuating temperature. Needless to say, all the methods of modern medicine and surgery are a gift to us by our ancestors. The modern science is nothing but the understanding of the knowledge given to us by the sages in a very forcible language. Garlic scientifically, called as *Allium sativum* belonging to the family *Liliaceae*. It has many other species such as *Allium ursinum*, *Allium vineale*, and *Allium oleraceum* etc [4]. The chemical constituents of garlic as studied are organosulfur compounds such as allicin, diallyl disulphide, S-allylcysteine, and diallyl trisulfide. The characteristics odor of garlic is due to the presence of diallyl sulphide [5]. Garlic is one of the herbs which possess multiple qualities and properties. It can be called as the wholesome herb which has the ability to cure most of the modern day disease if used properly. More than 1000 research articles have been published claiming the

traditional use and medicinal virtue of garlic [6]. No doubt, our great grandfathers were the wisest. Now, I understood why my grandfather used to take one garlic bud every morning with a glass of water on empty stomach. Garlic claims to cure diabetes, ulcers, has antioxidant, antimicrobial properties against (*Campylobacter jejun*, *Pseudomonas aeruginosa*, *Klebsiella pneumonia*, MSRA, *Candida* spp., *Aspergillus* spp. Etc) [7]. Many research enthusiast have found that garlic directly inhibit proliferation of a variety of cancer cell lines derived from colon, lung, leukemia, skin, breast, and prostate cancers [8]. Garlic may not be directly affecting the cancerous cells but the plethora of other affect it possesses helps to prevent cancer. Free oxygen radicals are also one of the reasons for cancer which can be effectively scavenged by the garlic active constituents. The antioxidant property of garlic is widely known and helps keep the age intact [9]. Due this antioxidant property it also act as anti-platelet and hypolipidemic which can be the reason for diabetes and studies suggest that consumption of garlic extract or powder can hinder the occurrence of diabetes and maintain the serum glucose level [10]. Garlic have a number of positive effects on cardio vascular system such as coronary artery disease, reduce myocardial infarction, stroke, anti-thrombic, anti-arthrosclerosis, hypolipidemic, hypercholesterolemia, hypotriacylglyceride, and hypoglycemic. It is such that consumption of garlic daily can surely keep one healthy due to the infinite health benefits it possesses. Modern medicine must put attention to more natural medicine to search cure for modern day diseases and find new moieties which are available in nature and understand them. Nature has the cure for everything, even the heinous of diseases but all we need to do is understand her and protect her for our own good.

MATERIALS AND METHOD

The entire literature search was done on different search engines and on sites such as googlescholar, researchgate, sci hub, pubmed etc. key words such as garlic, garlic extraction, diallylsulphide, and uses of garlic, medicinal properties or combination of all these words were used for the search. Further, googlescholar was searched using author's initials and the related articles link for key publications. Moreover, additional articles were traced from the reference list of the papers and brainstorm of the articles and publications. The structures were drawn by the aid of chemsketch.

The entire study explains the use of garlic in different ailments and its positivity. This article deciphers the medicinal properties of garlic and it effect on major contemporary diseases.

The paper will discuss the use of garlic and its constituents as nutritive, antibacterial, antifungal, antiviral, anti-parasite, anticancer, anti-diabetic, antioxidant and scavenging, and use in cardiovascular ailments such as hypertension, arthrosclerosis etc.

Chemical constituents of garlic and their extraction

Allium sativum contains sulphur compounds such as allicin, diallyl disulphide, S-allylcysteine, and diallyl trisulfide which can be extracted by distillation, soxhletion, aqueous extraction. Garlic oil is extracted by steam distillation [11, 14]. The major compounds present in aged garlic buds are S-allylcysteine (SAC) and S-allylmercaptocysteine (SAMC). Few grams of garlic powder are made to undergo steam distillation where n-hexane is employed as solvent to yield garlic oil which is yellowish in color with a characteristic pungent smell. This oil contains organosulphur compounds for instance diallyl sulphide and triallyl sulphide. Ultrasonic assisted extraction (USE) and microwave assisted hydro distillation (MWHD) are way better method of extraction in comparison to the traditional method of extraction via simultaneous distillation extraction (SDE). These techniques help yield better without the possibilities of thermal degradation and moreover these techniques use different solvents such as diethyl ether [12]. These techniques help penetrate the solvent into the cells and aid in more yield of the constituents. The Allicin has been found to be the compound most responsible for the spiciness of the raw garlic and being a powerful antibiotic and antifungal compound, it believe to be the agent responsible for the speed recovery from strep throat or other mild ailments when garlic is used [13]. Diallyl sulphide is majorly used as antimicrobials.

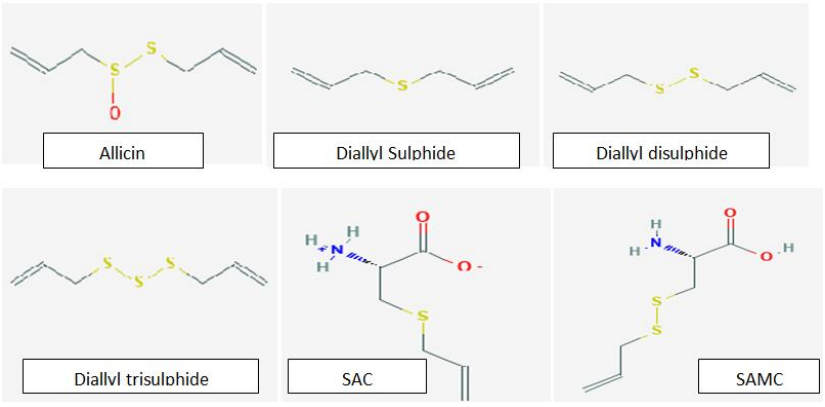

Fig-1: Structure of constituents of *Allium sativum [15]*

Nutritive effects

There are a plethora of health benefits of garlic and garlic supplements which are being used since the times of first human civilization. The supplements available in the market are the garlic extract, dry powder and oil. It was noticed that among herbs garlic is on top in regard to its use in household. These supplements help in intestinal disorders, flatulence, worms, respiratory infections, skin diseases, wounds, symptoms of aging and many other ailments [16]. The complex chemistry of garlic active components needs a wider understanding. It's not only allicin that provides health benefits but it is a synergistic effect of other sulphur and non sulphur constituents Because of the complex chemistry in Allium plants, variations in processing yield quite different preparations. Highly reactive thiosulonates such as allicin disappear during processing and are quickly transformed to other types of organosulphur compounds. Efficacy and safety are also compromised upon processing methods [17]. Garlic supplements have good effect on cardiovascular system, hypolipidemic, anti-platelet properties. It prevents cold and flu symptoms through immune enhancement and exhibits anticancer and chemo-preventive properties. Many research enthusiast found that the aged garlic have humongous health benefits out of which is immunomodulatory effect [18]. Any kind of suppression on immunity or immune system will result in ill health and a door way to many diseases and disorders. Thus, a strong immunity is desired which can be easily maintained by consumption of aged garlic extract and create a protective sheet against diseases.

Antimicrobials

Garlic have been used since ages as an antibacterial, antifungal, antiviral, and anti-parasite due to the presence of sulphur compound thio-2-propene-1-sulfinic-acid S-allyl ester commonly known as allicin [19]. The issue of resistance is very common in bacteria which need to be addressed and new antibacterial must be made so that negligible resistance occurs. The issue of resistance can be addressed by using garlic extract or other components of garlic. This active compound is believed to readily react with the free thiol group via the thiol-disulphide exchange. This interaction is responsible for the mechanism of antimicrobial action, which also interact with thiol containing enzymes namely protease, cysteine, alcohol dehydrogenase [20]. These enzymes are responsible for the nutrition and metabolism of bacteria and allicin interacts with these and cease their growth and destroys them. Garlic extract has proven to inhibit the growth of oral bacteria, *Porphyromonos gingivalis* [21].

Garlic extract has shown to act against fungus growth which was first studied by the Schmidt and Marquardt in 1936. The extract acts against fungus by inhibit the synthesis of lipids, proteins and nucleic acids and also reduces oxygen uptake. Garlic acts against a wide variety of fungus such as *Candida, Aspergillus, Torulopsis, Trichophyton, Cryptococcus, Trichosporon and Rhodotorula* [24]. A bit less work has been done on the antiviral properties of the garlic or its extract in comparison to antifungal or antibacterial. Many studies have reported the antiviral activity of garlic extract same way as it is seen for bacterial antagonism. Extract of garlic has shown positive effect against influenza A and B, rhinovirus, herpes simplex virus 1, viral pneumonia and rotavirus [23]. It's not only this virus's garlic is effective against HIV too. The active components allicin, diallyl tri-sulfide and ajoene are believed to act against the retrovirus by inhibiting the integrin-dependent processes.

Table-1: Effect of *Allium sativum* on different microorganism

Antibacterial			
Sl.No	**Organism**	**Garlic preparations**	**References**
1.	*Staphylococcus aureus*	Ethanolic extract (Diallyl sulphide)	Tsao *et al*, [25], Tsao *et al*, [26]
2.	*Porphyromonos gingivalis*	Garlic extract	Bakri and Douglas, [21]
3.	*Campylobacter jejuni*	Garlic extract (Diallyl sulphide)	Lu *et al*. [27]
4.	*Klebsiella pneumonia*	Garlic oil	Tsao and Yin [28]
5.	*Pseudomonas aeruginosa*	Garlic oil	Tsao and Yin [28]
6.	*Escherichia coli*	Aqueous and ethanolic extract	Ankri and Mirelman [23]
7.	*Salmonella typhi*	Garlic extract	Harris *et al*. [24]
8.	*Helicobacter pylori*	Garlic extract	Cellini *et al.* [29]
Antifungal			
1.	*Candidia albicans*	Aqueous extract (ajoene)	Yoshida *et al.* [30]
2.	*Aspergillus niger*	Aqueous garlic extract and concentrated garlic oil	Pai and Platt. [31]
3.	*Ascosphaera apis*	Essential oil vapours	Kloucek *et al*. [32]
4.	*Cryptococcus*	Alcoholic extract	Khan and Katiyar, [33]
5.	*Trichophyton mentagrophytes,*	Aqueous extract (ajoene)	Yoshida *et al.*[30, 34]
Antiviral			
1.	*Influenza A and B*	-	Ankri and Mirelman [23]
2.	*Herpes simplex virus type 1*	Garlic extract	Harris *et al*. [24]
3.	*Human rhino virus*	Garlic extract	Harris *et al*. [24]
4.	*Viral pneumonia*	-	Ankri and Mirelman. [23]
Antiparasite			
1.	*Hymenolepiasis nana and giardiasis*	Aqueous garlic extract	Soffar and Mokhtar. [35]
2.	*Entamoeba histolytica, Trypanosoma SP, Giardia lamblia*	Aqueous extract (diallyl trisulphide)	Lun, *et al*. [36]
3.	*Ichthyophthirius multifiliis Theronts and Tomocysts*	Garlic extract with Sodium Percarbonate	Buchmann. [37]
4.	*Leishmania spp, Cochlospermum planchomi*	Aqueous garlic extract	Anthony *et al.* [38]

Anticancer

Cancer is one of the most prevalent and the heinous disease in the world which is claiming life. Garlic which is daily used as condiment in every kitchen can cure cancer who would have ever thought it. Many research enthusiast have found that garlic directly inhibit proliferation of a variety of cancer cell lines derived from colon, lung, leukemia, skin, breast, and prostate cancers. Garlic together with vitamins E and C reduced the incidence of precancerous gastric lesions in a large population in China [39]. A study from China indicated an inverse relationship in mortality between stomach cancer and garlic consumption, providing the first evidence of garlic's anticancer potential. Similarly, other studies like a lower risk of colon cancer for American consumers of garlic were reported in the Iowa Woman's Health Study [40]. The modes of action of garlic is by inhibiting of tumor growth, exhibit radical scavenging, induction of apoptosis, stimulation of the immune response which is the virtue of organosulphur compounds [41]. Fresh garlic extract inhibits the carcinogen DMBA (7,12-dimethylbenz(a)anthracene); garlic oil inhibits the carcinogen DMBA, PMA (phorbol-myristate-acetate); fresh garlic powder inhibits the carcinogen DEN (diethylnitrosamine) and diallyl sulfide (DAS) inhibits the carcinogens DMH (1,2-dimethylhydrazine), NMBA (N-nitrosomethylbenzylamine), BP (benzo[a]pyrene) and DMBA (7,12-dimethylbenz(a)anthracene). It is studied that garlic loses its health properties on heating and therefore, it is advice to take garlic raw or consume its extract or essential oil or garlic macerate [42]. Garlic may not be directly affecting the cancerous cells but the plethora of other affect it possesses helps to prevent cancer and cure cancer. Consumption of garlic daily and include it in diet may help reduce the opportunities of cancer.

Antioxidant

Garlic and aged garlic extract have promiscuously proved to be effective antioxidants due to presence of antioxidant phytochemicals as they provide protection against free radicals which damage the body. Oxidative modification of biomolecules such as proteins, lipids etc by reactive oxygen species (ROS) lead to aging and introduction of disease, even cancer is a possibility [43]. The aged garlic extract contains water-soluble and lipid-soluble organosulfur

compounds, and flavanoids. Flavanoids are very good antioxidant agent and help prevent floating of free oxygen species. Aged garlic species acts by scavenging ROS, inhibits lipid peroxidation, inhibiting oxidative modification of LDL, therefore providing a shield for endothelial cells [44]. Aged garlic extract and other active constituents of the garlic showed scavenging effect on Chain-breaking effect induced by hydrophilic radical initiator and scavenging assay of superoxide anion radical. The two pivotal organosulphur compounds S-allylcysteine and S-allylmercaptocysteine in aged garlic showed scavenging activity in both chemiluminescence and 1-1-diphenyl-2-picrylhydrazyl [45]. Study done by Chung *et al*. [46] clearly showed that the garlic compounds tested have different patterns of antioxidant activity in terms of scavenging of superoxide and hydroxyl radical and preventing peroxidation of microsomal membranes. For example, alliin scavenges superoxide as generated by the xanthine/xanthine oxidase system, while allyl cysteine, allicin, and allyl disulfide did not react with superoxide.

Anti-diabetic

The prevalence of diabetes for all age-groups worldwide was estimated to be 2.8% in 2000 and 4.4% in 2030. The total number of people with diabetes is projected to rise from 171 million in 2000 to 366 million in 2030 [47]. These plummeting numbers are obvious enough that world needs to address the issue of diabetes and lead a healthy and efficient life. Use of natural diet and organic fruits and vegetable along with healthy life style can be a way to address this problem prevalent all around the globe. Garlic and aged garlic extract and the active constituents such as allicin, DAS, DADS have anti-diabetic properties. Consumption of a single garlic bud everyday helps maintain cholesterol level and improves immunity. Streptozotocin induce diabetic rats were studied and promising results were derived. On administration of garlic extract to diabetic rats' significant decline in serum glucose was noted along with total cholesterol and triglycerides [48]. These sulphide agents showed dose-dependent antioxidative protection against glucose- induced erythrocyte membrane oxidation. Hyperglycemia is a relative complication in diabetes in which glucose acts as a lipid pro-oxidant and is one of the reasons for the oxidative stress associated with diabetes. In flip side, platelet hyperactivity can also result in diabetes which is due to platelet aggregation due to hyperactivity which can lead to blockage of capillaries and lead to ischemia, hypoxia. Therefore, there are possibilities that garlic and it compounds act as antiplatelet and as antioxidant which can indirectly cure complications related to diabetes and cure diabetes [49]. Diallyl sulphide among the active agents is the most potent and effective and can be beneficial for diabetes and cardiovascular complications.

Cardiovascular

Cardiovascular disorders are one of the main culprits of suffering and demise of major population of the world. Name any cardiovascular disorder say it hypertension, arthrosclerosis, angina and myocardial infarction it is available and known to all in every household. Oxidation of cholesterol LDL in particular is the reason for arthrosclerosis, lipid peroxidation equally aids in formation of arthrosclerosis [50]. Many authors have penned the beneficial effect of garlic extract on cardiovascular system. Garlic has both antioxidant and immunomodulatory property which helps imparts health benefits and one healthy at cellular level. Garlic and its extract acts as cardioprotective and lower serum cholesterol which helps to prevent arthrosclerosis, and in hand to hand keeps the CVS healthy. Studies show that significant lower of cholesterol (LDL), triglycerides, and positive increase of HDL on consumption of garlic extract or powder [51].

Table-2: Effect of garlic preparation on cardiovascular system

Cardiovascular System			
Sl. No.	**Effect**	**Garlic Preparation**	**References**
1.	Hypoglycemic	Garlic extract	Jalal *et al*. [52]
2.	Hypolipidemia,	Garlic extract (organosulphurs)	Yeh and Liu [53]
3.	Hypocholesterolaemic,	Enteric-Coated Garlic Supplement	Kannar *et al*. [54]
4.	Hypotriacylglyceride	Aqueous extract	Oosthuizen *et al*. [51]
5.	Anti-atherosclerotic	Garlic powder extract	Orekhov *et al*. [55]
6.	Anti-thrombotic	Aqueous extract of garlic	Ali and Mohammad [56]
7.	Bradycardia	Aqueous extract	Nwokocha *et al.* [57]
8.	Reduce myocardial infarction	Not mentioned	Yang *et al*. [58]

CONCLUSION

The aim of this paper was to study the traditional use of garlic and how these are still relevant in the modern science and medicine. Garlic have been in each household and been giving us the shield against infinite number of diseases and disorder. The organosulphur compounds allicin, di allyl sulphide, di allyl trisulphide, ajoene etc have a huge margin of health bestowing properties. Many research enthusiasts have proven the various pharmacological benefits of garlic and its extracts, oil and macerate. As it is shown in this review that garlic bears the properties of antimicrobial, cardiovascular, anti-inflammatory, anticancer, immunomodulatory, antioxidant and, anti-diabetic which are among the hundred others. It is

proven that the chemical constituents of garlic are very good antimicrobials and have 1000 times less chance for resistance. Garlic has warm effect on consumption beyond threshold. The heat can be harmful for both digestive system and body as a whole. Raw garlic is more potent than the heated one as heat destroys the active ingredient of garlic. Further complex studies should be done on the plant for better quality and safety and discovery of newer health benefits.

REFERENCES

1. Rivlin RS. Historical perspective on the use of garlic. The Journal of nutrition. 2001 Apr 1;131(3):951S-4S.
2. Lai PK, Roy J. Antimicrobial and chemopreventive properties of herbs and spices. Current medicinal chemistry. 2004 Jun 1;11(11):1451-60.
3. Agarwal KC. Therapeutic actions of garlic constituents. Medicinal research reviews. 1996 Jan;16(1):111-24.
4. Kokate CK, Purohit AP, Gokhale SB. Text book of Pharmacognosy. Pune: Nirali Prakashan. 2003.
5. Singh A, Arora A, Shukla Y. Modulation of altered hepatic foci induction by diallyl sulphide in Wistar rats. European journal of cancer prevention. 2004 Aug 1;13(4):263-9.
6. Rahman K. Historical perspective on garlic and cardiovascular disease. The journal of nutrition. 2001 Apr 1;131(3):977S-9S.
7. Chen C, Liu CH, Cai J, Zhang W, Qi WL, Wang Z, Liu ZB, Yang Y. Broad-spectrum antimicrobial activity, chemical composition and mechanism of action of garlic (Allium sativum) extracts. Food Control. 2018 Apr 1;86:117-25.
8. Hirsch K, Danilenko M, Giat J, Miron T, Rabinkov A, Wilchek M, Mirelman D, Levy J, Sharoni Y. Effect of purified allicin, the major ingredient offreshly crushed garlic, on cancer cell proliferation. Nutrition and cancer. 2000 Nov 1;38(2):245-54.
9. Benkeblia N. Free-radical scavenging capacity and antioxidant properties of some selected onions (Allium cepa L.) and garlic (Allium sativum L.) extracts. Brazilian archives of biology and technology. 2005 Sep;48(5):753-9.
10. Thomson M, Al-Qattan KK, Bordia T, Ali M. Including garlic in the diet may help lower blood glucose, cholesterol, and triglycerides. The Journal of nutrition. 2006 Mar 1;136(3):800S-2S.
11. Gafar MK, Itodo AU, Warra AA, Abdullahi L. Extraction and physicochemical determination of garlic (allium sativum L) oil. Int J Food Sci Nutr. 2012;1(2):4-7.
12. Kimbaris AC, Siatis NG, Daferera DJ, Tarantilis PA, Pappas CS, Polissiou MG. Comparison of distillation and ultrasound-assisted extraction methods for the isolation of sensitive aroma compounds from garlic (Allium sativum). Ultrasonics sonochemistry. 2006 Jan 1;13(1):54-60..
13. Lee HJ, Suh HJ, Han SH, Hong J, Choi HS. Optimization of extraction of cycloalliin from garlic (Allium sativum L.) by using principal components analysis. Preventive nutrition and food science. 2016 Jun;21(2):138.
14. Ueda Y, Sakaguchi M, Hirayama K, Miyajima R, Kimizuka A. Characteristic flavor constituents in water extract of garlic. Agricultural and Biological Chemistry. 1990 Jan 1;54(1):163-9.
15. https://pubchem.ncbi.nlm.nih.gov/compound/-
16. Amagase H, Petesch BL, Matsuura H, Kasuga S, Itakura Y. Intake of garlic and its bioactive components. The Journal of nutrition. 2001 Apr 1;131(3):955S-62S.
17. Amagase H. Clarifying the real bioactive constituents of garlic. The Journal of nutrition. 2006 Mar 1;136(3):716S-25S.
18. Kyo E, Uda N, Kasuga S, Itakura Y. Immunomodulatory effects of aged garlic extract. The Journal of nutrition. 2001 Apr 1;131(3):1075S-9S.
19. Lanzotti V, Scala F, Bonanomi G. Compounds from Allium species with cytotoxic and antimicrobial activity. Phytochemistry reviews. 2014 Dec 1;13(4):769-91.
20. Chen C, Liu CH, Cai J, Zhang W, Qi WL, Wang Z, Liu ZB, Yang Y. Broad-spectrum antimicrobial activity, chemical composition and mechanism of action of garlic (Allium sativum) extracts. Food Control. 2018 Apr 1;86:117-25.
21. Bakri IM, Douglas CW. Inhibitory effect of garlic extract on oral bacteria. Archives of oral biology. 2005 Jul 1;50(7):645-51.
22. Thomson M, ZM ZM, KK KK, LH LH. Anti-diabetic and hypolipidaemic properties of garlic (Allium sativum) in streptozotocin-induced diabetic rats. International Journal of Diabetes and Metabolism. 2007;15:108-15.
23. Ankri S, Mirelman D. Antimicrobial properties of allicin from garlic. Microbes and infection. 1999 Feb 1;1(2):125-9.
24. Harris JC, Cottrell S, Plummer S, Lloyd D. Antimicrobial properties of Allium sativum (garlic). Applied microbiology and biotechnology. 2001 Oct 1;57(3):282-6.
25. Tsao SM, Hsu CC, Yin MC. Garlic extract and two diallyl sulphides inhibit methicillin-resistant Staphylococcus aureus infection in BALB/cA mice. Journal of Antimicrobial Chemotherapy. 2003 Dec 1;52(6):974-80..
26. Tsao SM, Liu WH, Yin MC. Two diallyl sulphides derived from garlic inhibit meticillin-resistant Staphylococcus aureus infection in diabetic mice. Journal of medical microbiology. 2007 Jun 1;56(6):803-8.
27. Lu X, Samuelson DR, Rasco BA, Konkel ME. Antimicrobial effect of diallyl sulphide on Campylobacter jejuni biofilms. Journal of antimicrobial chemotherapy. 2012 May 1;67(8):1915-26.

28. Tsao SM, Yin MC. In-vitro antimicrobial activity of four diallyl sulphides occurring naturally in garlic and Chinese leek oils. Journal of medical microbiology. 2001 Jul 1;50(7):646-9.
29. Cellini L, Di Campli E, Masulli M, Di Bartolomeo S, Allocati N. Inhibition of Helicobacter pylori by garlic extract (Allium sativum). FEMS Immunology & Medical Microbiology. 1996 Apr 1;13(4):273-7.
30. Yoshida S, Kasuga S, Hayashi NO, Ushiroguchi T, Matsuura H, Nakagawa S. Antifungal activity of ajoene derived from garlic. Appl. Environ. Microbiol. 1987 Mar 1;53(3):615-7.
31. Pai ST, Platt MW. Antifungal effects of Allium sativum (garlic) extract against the Aspergillus species involved in otomycosis. Letters in applied microbiology. 1995 Jan;20(1):14-8.
32. Kloucek P, Smid J, Flesar J, Havlik J, Titera D, Rada V, Drabek O, Kokoska L. In vitro inhibitory activity of essential oil vapors against Ascosphaera apis. Natural product communications. 2012 Feb;7(2):1934578X1200700237.
33. Khan ZK, Katiyar R. Potent antifungal activity of garlic (allium sativum) against experimental murine dissemenated cryptococcosis. Pharmaceutical biology. 2000 Apr 1;38(2):87-100.
34. Shams Ghahfarokhi M, Razafsha M, Allameh A, Razzaghi Abyaneh M. Inhibitory effects of aqueous onion and garlic extracts on growth and keratinase activity in Trichophyton mentagrophytes. Iranian Biomedical Journal. 2003 Jul 15;7(3):113-8.
35. Soffar SA, Mokhtar GM. Evaluation of the antiparasitic effect of aqueous garlic (Allium sativum) extract in hymenolepiasis nana and giardiasis. Journal of the Egyptian Society of Parasitology. 1991 Aug;21(2):497-502..
36. Lun ZR, Burri C, Menzinger M, Kaminsky R. Antiparasitic activity of diallyl trisulfide (dasuansu) ou human and animal pathogenic protozoa (trypanosoma sp., entamoeba histolytica and giardia lamblia) in vitro. InAnnales-Societe Belge De Medecine Tropicale 1994 Mar 1 (Vol. 74, pp. 51-51). Institute of tropical medicine.
37. Buchmann K, Jensen PB, Kruse KD. Effects of sodium percarbonate and garlic extract on Ichthyophthirius multifiliis theronts and tomocysts: in vitro experiments. North American Journal of Aquaculture. 2003 Jan;65(1):21-4.
38. Anthony JP, Fyfe L, Smith H. Plant active components–a resource for antiparasitic agents?. Trends in parasitology. 2005 Oct 1;21(10):462-8.
39. Adaki S, Adaki R, Shah K, Karagir A. Garlic: Review of literature. Indian journal of cancer. 2014 Oct 1;51(4):577.
40. Song K, Milner JA. The influence of heating on the anticancer properties of garlic. The Journal of nutrition. 2001 Apr 1;131(3):1054S-7S..
41. Ariga T, Seki T. Antithrombotic and anticancer effects of garlic-derived sulfur compounds: A review. Biofactors. 2006;26(2):93-103.
42. Thomson M, Ali M. Garlic [Allium sativum]: a review of its potential use as an anti-cancer agent. Current cancer drug targets. 2003 Feb 1;3(1):67-81.
43. Borek C. Antioxidant health effects of aged garlic extract. The Journal of nutrition. 2001 Apr 1;131(3):1010S-5S.
44. Imai J, Ide N, Nagae S, Moriguchi T, Matsuura H, Itakura Y. Antioxidant and radical scavenging effects of aged garlic extract and its constituents. Planta medica. 1994 Oct;60(05):417-20.
45. Ide N, Matsuura H, Itakura Y. Scavenging effect of aged garlic extract and its constituents on active oxygen species. Phytotherapy Research. 1996 Jun;10(4):340-1.
46. Chung LY. The antioxidant properties of garlic compounds: allyl cysteine, alliin, allicin, and allyl disulfide. Journal of medicinal food. 2006 Jun 1;9(2):205-13.
47. Wild S, Roglic G, Green A, Sicree R, King H. Global prevalence of diabetes: estimates for the year 2000 and projections for 2030. Diabetes care. 2004 May 1;27(5):1047-53.
48. 48Eidi A, Eidi M, Esmaeili E. Antidiabetic effect of garlic (Allium sativum L.) in normal and streptozotocin-induced diabetic rats. Phytomedicine. 2006 Nov 24;13(9-10):624-9.
49. Chan KC, Hsu CC, Yin MC. Protective effect of three diallyl sulphides against glucose-induced erythrocyte and platelet oxidation, and ADP-induced platelet aggregation. Thrombosis research. 2002 Dec 15;108(5-6):317-22.
50. Durak I, Kavutcu M, Aytaç B, Avcı A, Devrim E, Özbek H, Öztürk HS. Effects of garlic extract consumption on blood lipid and oxidant/antioxidant parameters in humans with high blood cholesterol. The Journal of nutritional biochemistry. 2004 Jun 1;15(6):373-7.
51. Oosthuizen CB, Reid AM, Lall N. Garlic (Allium sativum) and Its Associated Molecules, as Medicine. InMedicinal Plants for Holistic Health and Well-Being 2018 Jan 1 (pp. 277-295). Academic Press.
52. Jalal R, Bagheri SM, Moghimi A, Rasuli MB. Hypoglycemic effect of aqueous shallot and garlic extracts in rats with fructose-induced insulin resistance. Journal of Clinical Biochemistry and Nutrition. 2007;41(3):218-23.
53. Yeh YY, Liu L. Cholesterol-lowering effect of garlic extracts and organosulfur compounds: human and animal studies. The journal of nutrition. 2001 Apr 1;131(3):989S-93S..
54. Kannar D, Wattanapenpaiboon N, Savige GS, Wahlqvist ML. Hypocholesterolemic effect of an enteric-coated garlic supplement. Journal of the American College of Nutrition. 2001 Jun 1;20(3):225-31.
55. Orekhov AN, Tertov VV, Sobenin IA, Pivovarova EM. Direct anti-atherosclerosis-related effects of garlic. Annals of medicine. 1995 Jan 1;27(1):63-5..

56. Ali M, Mohammed SY. Selective suppression of platelet thromboxane formation with sparing of vascular prostacyclin synthesis by aqueous extract of garlic in rabbits. Prostaglandins, Leukotrienes and Medicine. 1986 Dec 1;25(2-3):139-46.
57. Nwokocha CR, Ozolua RI, Owu DU, Nwokocha MI, Ugwu AC. Antihypertensive properties of Allium sativum (garlic) on normotensive and two kidney one clip hypertensive rats. Niger J Physiol Sci. 2011 Dec 26;26(2):213-8.
58. Yang Y, Chan SW, Hu M, Walden R, Tomlinson B. Effects of some common food constituents on cardiovascular disease. ISRN cardiology. 2011 Jun 16;2011.