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Medicinal Properties of Garlic – A Concise Review

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ABSTRACT

The objective of this review is to update and assess the medicinal properties of garlic includes immune functions, antibacterial activities, antifungal activities, antiviral activities, detoxification, anti-oxidant agent, prevent platelet aggregation, reduction in blood pressure, lowering of cholesterol- and triglyceride, prevention of arteriosclerosis, antithrombotic, anticancer effects. The scientific research shows that the wide variety of dietary and medicinal functions of garlic can be attributed to the sulfur compounds present in or produced from garlic. Chemical analysis of garlic cloves have revealed a concentration of sulfur-containing compounds (1–3%). Although garlic produces large number of sulfide compounds from a few sulfur containing amino acids, their functions are different from one another like allicin, diallyl, mono, di, tri, tetra, hexa and hepta sulfides, vinyldithiols and ajoenes. Allyl, propyl disulfide and other organic sulphide or sulphur compounds diallyl disulphide, alliinase, alliin(S-allyl cysteine sulphoxide).

Keywords: Garlic, Allicin, Antioxidant, Hypertension, Antimicrobial.

1. INTRODUCTION

Hippocrates the “Father of Medicine” perhaps the greatest healer that ever lived, wrote 2500 years ago “Let your food be your medicine, let your medicine be your food.” Garlic, more than any other food fits into Hippocrates’ description of an ideal food, that which is both a super-nutritious food and a miracle medicine. Dietary Supplement Health and Education Act in 1994 made herbal dietary supplements readily available to U.S. consumers. A study has shown that 42% of the U.S. population uses complementary and alternative medicine, with 13% reporting the use of herbal products¹. Herbal therapies are widely used worldwide². More recently, 50% of patients with breast or gynecologic malignancies use complementary and alternative medicine, and as much as 5% of this population takes the herbal supplement, garlic³. Health properties of garlic (*Allium sativum* L.) depend on its bioactive compounds⁴. Raw garlic is widely used, but this vegetable is also an obligatory part in many cooked dishes⁵. Garlic has played an important dietary and medicinal role throughout the history of mankind. Garlic is a nature’s boon to mankind. Garlic has been used since time immemorial as a culinary spice and medicinal herb. Its use in China was first mentioned in A.D. 510, and Louis Pasteur first studied the antibacterial action of garlic in 1858. Whereas earlier trials suggest it may mildly lower cholesterol and triglyceride levels in the blood⁶. More than 5000 years garlic has been consumed both as food and used for medicine by ancient scholars. Garlic, *Allium sativum* L. is a member of the Alliaceae family⁷, has been widely recognized as a valuable spice and a popular remedy for various ailments and physiological disorders. The name garlic may have originated from the Celtic word ‘all’ meaning pungent⁸.

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2. HISTORY OF THE GARLIC

Medicinal plants from ancient time were considered as the God's gift to human beings as they are having profound use in the treatment of various dreadful diseases and disorders. Garlic has been known has one of the oldest known horticultural crops in the Old World. Egyptian and Indian cultures referred to garlic 5000 years ago and there is clear historical evidence for its use by the Babylonians 4500 years ago. The earliest indication of the use of garlic is in clay models in Egyptian cemeteries, dated to as early as 3,750 B.C.⁹. Not only during the time of the Babylonians and the Chinese but during the time of the Pharaohs, when Egypt was at the peak of its power, garlic was given to the laborers and slaves who were building the great pyramids in order to increase their stamina and strength as well as to protect them from disease. During the first Olympic games in Greece in 776 B.C, athletes ingested garlic as stimulant¹⁰. Herodotus a Greek historian back in the fifth century A.D., wrote about Egyptian pyramids having inscriptions of Egyptian characters describing the amount of garlic consumed by the workers and slaves who were building the great pyramid of King Khufu (Cheops). Not only did workers and slaves consume garlic, but also it has been written that even the Egyptian soldiers would consume garlic to increase their courage during battle. In Bible clearly stated that for 400 years the Israelites were slaves in Egypt sometime around 1730 to 1330 B.C. Aristotle attributed garlic as a cure for rabies, and the Prophet Mohammad recommended it for treating scorpion stings. While and no doubt being forced to help build pyramids, garlic was a part of their diet. Shortly after they had been delivered from slavery by Moses, and were traveling through the desert country of the Sinai Peninsula, they began to miss some of the food they had been eating while in slavery, one of the food missed was that of garlic. French priests of the Middle Ages used garlic to protect themselves against bubonic plague.

In china, garlic tea has long been recommended for fever, headache, cholera, dysentery, and prolonging longevity and in India, garlic has been used for centuries for the treatment of hemorrhoids, rheumatism, dermatitis, abdominal pain, cough and as an antiseptic lotion for washing wounds and ulcers, due to its antibacterial properties¹¹. During World War I, European soldiers prevented infection by putting garlic directly on their wounds. Nearly every culture has used garlic for general health and longevity, from ancient Egyptians, Israelites, Greeks, Babylonians, Romans, and Chinese down to the colonial Americans. Today, garlic is one of the best selling preventive medicines in Europe, where it is accepted as safe and effective by both medical authorities and government officials. Most of the garlic eaten today comes from China, South Korea, India, Spain, and the United States.

3. CHEMISTRY AND CHEMICAL CHANGES IN GARLIC

When garlic is crushed or otherwise damaged attacked by microbes, crushed, cut, chewed, dehydrated, pulverised or exposed to water, the vacuolar enzyme alliinase rapidly lyses the cytosolic cysteine sulfoxides (alliin). The transiently formed compound, allicin, comprises 70–80% of the thiosulfates. Typically, alliin is converted to allicin by alliinase. Allicin instantly decomposes to other compounds, such as diallyl sulfide (DAS), diallyl disulfide (DADS), dithiins and ajoene. At the same time, g-glutamyl cysteine is converted to S-allylcysteine (SAC), via a pathway other than the alliin–allicin pathway¹².

1. Garlic contains at least 33 sulfur compounds¹³, Sulfur compounds: alliin, allicin, ajoene, allylpropyl disulfide, diallyl trisulfide (DATS), S-allylcysteine (SAC), vinyl dithiins, S-allylmercaptocysteine and others.
2. several enzymes (Allinase, peroxidase, myrosinase, catalases, superoxide dismutases, arginases, lipases),
3. Amino acids (arginine, glutamic acid, asparagic acid, methionine, threonine)
4. proteins (glutamyl peptides)
5. vitamins (B1, B2, B6, C and E),
6. Se, Ge, Te and other trace minerals
7. Biotin, nicotinic acid, elements, lipids, prostaglandins, fructan, pectin, adenosine¹⁴.

4. ROLE OF GARLIC IN VARIOUS DISEASES

4.1 Antioxidant

Plant based diets rich in vegetable and fruits provide a great amount of antioxidant photochemicals like vitamins C and E, phenolic compounds (Flavonoids), vegetable pigments (anthocyanins and carotenoids), thiols (sulphur compounds)^{15,16}. Antioxidants are able to slow down, stop or reverse oxidation of nucleic acids, proteins and lipids by scavenging oxidizing agents such as reactive oxygen species¹⁷. Oxidizing agents or free radicals attack our bodies constantly and have the potential to damage our cells, which compresses human tissue. Oxidation process plays an important role in aging and in a wide range of common diseases including cancer and cardiovascular, atherosclerosis, liver disease, inflammatory and neurodegenerative diseases, such as Alzheimer's disease and other age related degenerative conditions¹⁸. Defending ourselves against from chemicals, heavy metals, pollutants, radiation and poor nutrition has become a vital area of scientific focus and research. Substances which have been found to help protect us from the cellular damage caused by free radicals include vitamin C, bioflavonoids, vitamin E, vitamin A, beta carotene and selenium. Garlic has an abundance of sulfhydryl which is an excellent antioxidant. The ability of garlic to protect against free radical damage may have another important benefit to cancer

victims. Garlic constituents inhibit the formation of free radicals, support endogenous radical scavenging mechanisms, enhance cellular antioxidant enzymes (e.g. superoxide dismutase, catalase, glutathione peroxidase), protect low-density lipoprotein from oxidation by free radicals, and inhibit the activation of the oxidant-induced transcription factor nuclear factor kappa B^{19,20}. Garlic was able to reduce the radicals present in cigarette smoke²¹.

4.2 Antihypertensive

Garlic has probably been most popularized as a complementary therapy for blood pressure control²². Hypertension (systolic blood pressure 140 mm Hg; diastolic pressure 90 mm Hg) the most important risk factor for chronic circulatory disease and is one of the major risk factors of atherosclerosis¹¹, affecting an estimated 1 billion individuals worldwide²³. The mechanism of antihypertensive activity of garlic is due to its prostaglandin-like effects, which decrease peripheral vascular resistance²⁴. The gamma-glutamylcysteines are the compounds in garlic that may lower blood pressure, as indicated by their ability to inhibit angiotensin-converting enzyme in *in vitro*. Garlic modulates the production and function of both endothelium derived relaxing and constricting factors and this may contribute to its protective effect against hypoxic pulmonary vasoconstriction. Garlic elicits nitric-oxide-dependent relaxation in pulmonary arteries. Garlic pearls at a dose of 250mg/d for 2 months of supplementation; there was also a significant decline in both systolic and diastolic blood pressures. It could be suggested that dietary supplementation of garlic may be beneficial in reducing blood pressure and oxidative stress in hypertensive individuals²⁵. Garlic also activated the synthesis of nitric oxide, which is a potent endogenous vasodilator²⁶.

4.3 Cardiovascular Diseases

Disorders of the heart and the circulatory system claim more lives than any other diseases. Cardiovascular diseases include elevated blood cholesterol, and triglycerides levels; increased platelet activity, which can give rise to arteriosclerotic plaques formation; elevated blood homocysteine; alteration on glucose metabolism; hypertension and obesity. Garlic and its preparations have been widely recognized as agents for prevention and treatment of cardiovascular diseases. The wealth of scientific literature supports the proposal that garlic consumption have significant effects on lowering blood pressure, prevention of atherosclerosis, reduction of serum cholesterol and triglyceride, inhibition of platelet aggregation, and increasing fibrinolytic activity²⁷. A research was conducted with 432 coronary artery patients were randomly grouped into two groups and half of them were supplied with garlic juice in milk, whereas the other group patients were not supplied with garlic juice. The report showed that within the three years of the study time, nearly twice as many patients had died in the group not supplied with garlic juice²⁸. It is

well reported to scavenge oxidants, increase superoxide dismutase, catalase, glutathione peroxidase, glutathione levels, inhibit lipid peroxidation as well as it reduces cholesterol synthesis by inhibiting 3-hydroxy-3-methylglutaryl-CoA. It has been shown to reduce platelet aggregation, arterial plaque formation, decrease homocysteine, lower blood pressure, and increase microcirculation. It may also help prevent cognitive decline by protecting neurons from neurotoxicity and apoptosis, thereby preventing ischaemia or reperfusion-related neuronal death and by improving learning and memory retention²⁹. Garlic administration in rats suffering from hypercholesterolemia, induced by a high-cholesterol diet, significantly reduced serum cholesterol, triglyceride, and LDL, but there was no effect on serum HDL³⁰. Long term application of garlic and its preparations on experimental atherosclerosis induced by a high cholesterol diet, showed 50% reduction in atheromatous lesions, particularly in the aorta³¹. Most of human studies on lipid lowering effects of garlic and garlic preparations described significant decrease in serum cholesterol and triglyceride³². A Fresh garlic extract and the constituents S-allylcysteine, diallyl trisulfide and diallyl disulfide were shown to inhibit human squalene monooxygenase, an enzyme catalyzing a step in cholesterol biosynthesis³³. Another *in vitro* study reported that S-allylcysteine, S-propylcysteine and S-ethylcysteine inhibit triglyceride biosynthesis in part by decreasing *de novo* fatty acid synthesis via inhibition of fatty acid synthase³⁴. The anti-atherogenic, anti-atherosclerotic and cholesterol- and lipid-lowering effects of garlic and its constituents have been documented in several animal models (e.g. rabbits, rats, chickens, pigs) of atherosclerosis, hypercholesterolaemia and hyperlipidaemia³⁵.

4.4 Anticancer Effect

According to Hikino H *et al* in 1986, animal studies have reported protective effects of garlic against hepatotoxins, cyclophosphamide, adriamycin, methylcholanthrene, gentamicin, 4-nitroquinoline 1-oxide, and bromobenzene³⁶. Garlic has demonstrated strong inhibition of cancer development in the presence of known tumor promoters including 12-O. More recent studies seem to relate the consumption of garlic with cancer inhibition. Sulphurous components are believed to be responsible to avoid the developing of cancerous cells in stomach, liver. The exact mode of action was not fully understood, but several modes of action have been proposed. These include its effect on drug metabolizing enzymes, antioxidant properties and tumor growth inhibition. Recently, it has been observed that aged garlic extract, but not the fresh garlic extract, exhibited radical scavenging activity. The two major compounds in aged garlic, S-allylcysteine and S-allylmercapto-L-cysteine, had the highest radical scavenging activity. In addition, some organosulfur compounds derived from garlic, including S-allylcysteine, have been found to retard the

growth of chemically induced and transplantable tumors in several animal models. Therefore, the consumption of garlic may provide some kind of protection from cancer development³⁷⁻³⁹. Garlic can alter the carcinogen metabolism either increasing the detoxifying enzymatic systems activity that increase the carcinogen polarity facilitating its excretion from the body⁴⁰ or inhibiting the procarcinogen activation by cytochrome P450. Glutathione-S-transferase is a well known detoxifying enzyme in phase II metabolism. This remarkable little bulb now tops the list of potential cancer-preventative foods. It contains multiple anticancer compounds and antioxidants, more than 30 at the last count, which such powerful compounds as quercetin, diallyl sulphide, allin and ajoene. These have the ability to block cancer causing agents such as nitrosamine and Aflatoxins which have been specifically linked to stomach, lung and liver cancer. Garlic's ajoene and allicin have also been shown to retard cancer cells as a type of natural chemotherapy. Garlic reduces risk of patients with prostate cancer, especially those with localized disease. Men in the highest of three intake categories of total allium vegetables (>10.0 g/day) had a statistically significantly lower risk (odds ratio = 0.51, P<.001) of prostate cancer than those in the lowest category (<2.2 g/day)⁴¹. Additionally, garlic also contains a high concentration of selenium, which is responsible, in part, for garlic's antioxidant and cancer-preventive effects. Hence, some growers add selenium to the soil to increase garlic's selenium content⁴². Treatment of human melanoma cells with S-allylcysteine reduces expression of cell-surface gangliosides, the tumor associated markers of differentiation and transformation. S180 tumor cells when exposed to a garlic extract displayed delayed progression to S phase⁴³.

4.5 Antimicrobial Activity

Garlic is believed to possess antimicrobial properties that can control a variety of organisms. Louis Pasteur was the first to describe the antibacterial properties of garlic juice. Garlic is nicknamed 'Russian penicillin' for its widespread use as a topical and systemic antimicrobial agent⁴⁴, several studies recommend garlic as an alternative form of treatment or prophylaxis in cases of infections especially gastrointestinal infections⁴⁵. In folk medicine, garlic has been associated with the treatment of viral, bacterial, fungal, and parasitic infections. Recent chemical characterization of the sulphur compound that the therapeutic effects, particularly with regard to the antimicrobial properties, are due to the allicin derived compounds⁴⁶. The antimicrobial activity of allicin is due to the inhibition of thiol-containing enzymes in the microorganisms⁴⁷. The antibacterial properties of crushed garlic have been known for a long time. Various garlic preparations have been shown to exhibit a wide spectrum of antibacterial activity against Gram-negative and Gram-positive bacteria including species of *Escherichia*, *Salmonella*, *Staphylococcus*, *Streptococcus*, *Klebsiella*, *Proteus*, *Bacillus*, and *Clostridium*. Even acid-fast

bacteria such as *Mycobacterium tuberculosis* are sensitive to garlic⁴⁸. Crushed garlic cloves performed over a century ago showed a variety of allyl Sulfides isolated and identified the component responsible for the remarkable antibacterial activity of crushed garlic cloves. The compound turned out to be an oxygenated sulfur compound which they termed allicin from the Latin name of the garlic plant, *Allium sativum*^{49,50}.

Ajoene is an active compound in garlic that may also play a role as a topical fungal agent^{51,52}. Garlic has shown to inhibit growth of fungal elements equally along with the drug ketoconazole, when tested on the fungi *Malassezia furfur*, *Candida albicans*, other *Candida* sp. as well as 35 strains of various dermatophyte species⁵³. The extract of garlic is effective against a host of protozoa including *Opalina ranarum*, *O. dimidiata*, *Balantidium* entozoan, *Entamoeba histolytica*, Trypanosomes, *Leishmania*, *Leptomonas* and *Crithidia*⁵⁴. Garlic extracts have been shown to exert anthelmintic activity against common intestinal parasites, including *Ascaris lumbricoides* and hookworms⁵⁵.

Aqueous garlic extract at concentrations of 2–5 mg/mL inhibited the growth of clinical isolates of *Helicobacter pylori* from patients with chronic gastritis or duodenal ulcer⁵⁶.

5. CONCLUSION

In the present review, antioxidant, antihypertensive, cardiovascular activity, antimicrobial and antineoplastic actions of garlic have been shown. Garlic is a true super food when it comes to heart disease. Numerous studies have shown that regular consumption of garlic can lower our blood pressure. Allicin in garlic has been found to be a powerful antibacterial and antifungal. However, it has also been reported that higher concentrations of garlic powder cause considerable cell injury in the liver of rats, which is not observed at lower concentrations; additional evidence is needed to determine the quantity required by humans to minimize cancer. Garlic extracts have been shown to exert anthelmintic activity against common intestinal parasites.

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