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## Medicinal plant *Allium sativum* = A Review

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### Abstract

Garlic *Allium sativum* the Liliaceae family, is among the oldest of all cultivated plants. It has been used as a medicinal agent for thousands of years. Garlic is one of the most important bulb vegetables, which is used as spice and flavoring agent for foods. Garlic adds to taste of foods as well as it helps to make them digestible. Garlic contains different useful minerals, vitamins and many other substances used for health of human beings. It is rich in sugar, protein, fat, calcium, potassium, phosphorous, sulfur, iodine fiber and silicon in addition to vitamins. It possesses high nutritive value. Furthermore, garlic has pharmaceutical effects and used to cure a vast conditions including blood pressure and cholesterol, cancer, hepatoprotective, anthelmintics, anti-inflammatory, antioxidant, antifungal and wound healing, asthma, arthritis, sciatica, lumbago, backache, bronchitis, chronic fever, tuberculosis, rhinitis, malaria, obstinate skin disease including leprosy, leucoderma, discoloration of the skin and itches, indigestion, colic pain, enlargement of spleen, piles, fistula, fracture of bone, gout, urinary diseases, diabetes, kidney stone, anemia, jaundice, epilepsy, cataract and night blindness. Garlic products are used as sources of medicine in many ways in human beings in their day today life. As a result, researchers from various disciplines are now directing their efforts towards discovering the medicinal values of garlic on human health. The main interest of researchers in the medicinal values of garlic is its broad-spectrum therapeutic effect with minimal toxicity.

**Keywords:** Garlic, medicinal plant, allicin, antihypertensive, antidiabetic, antiatherosclerosis

### 1. Introduction

Garlic (*Allium sativum*) is among the oldest of all cultivated plants. It has been used as a spice, food and folklore medicine for over 4000 years, and is the most widely researched medicinal plant (Milner 1996) [35]. Codex Ebers, an Egyptian medical papyrus dating to about 1550 B.C., includes 22 therapeutic formulations that mention garlic as an effective remedy for a variety of ailments including heart problems, headache, bites, worms and tumors (Block 1985) [8]. According to the Bible, the Jewish slaves in Egypt were fed garlic and other allium vegetables, apparently to give them strength and to increase their productivity (Rivlin 2001) [48]. In ancient Greece, garlic was consumed to treat intestinal and lung disorders (Farbman *et al.* 1993) [21]. In India, garlic has been used for centuries as an antiseptic lotion for washing wounds and ulcers. During World War II, garlic was used to treat the wounds of soldiers (Essman 1984) [18]. Many workers have researched on garlic's insecticidal, antimicrobial, antiprotozoal and antitumor activities (Bolton *et al.*; 1982) [9]. In traditional Chinese medicine, Islamic medicine, folklore medicine and the Ayurvedic system of medicine, several spices and herbs including garlic are described to possess medicinal properties e.g. anti-thrombotic, hypolipidemic and anti-hypertensive (Makheja 1990 and Moyers 1996) [36, 37]. In the homeopathic system, garlic is also an effective remedy for many ailments. In China, garlic tea has long been recommended for fever, headache, cholera and dysentery. In rural Japan, miso-soup containing garlic is used as a remedy for the common cold with headache, fever and sore throat (Sato *et al.* 2000) [53]. More recently, garlic has been reported to be effective in various ailments such as cardiovascular diseases because of its ability to lower serum cholesterol (Bordia *et al.* 1977) [10]. A component of garlic, S-methylcysteine sulfoxide (SMCS), has been shown to reduce both blood cholesterol and the severity of atherosclerosis (Sainani *et al.* 1979) [54]. Garlic has protective effects against stroke, coronary thrombosis, atherosclerosis, platelet aggregation, as well as infections and vascular disorders. However, we must note that there is considerable controversy concerning the cholesterol lowering effects of garlic and a number of studies have reported that some garlic preparations do not lower serum cholesterol. The fibrinolytic activity of garlic in both man and experimental animals has been reported.

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Many claims of an antibiotic action, a hypoglycemic effect, antitumor, antioxidant and antithrombotic properties have also been attributed to the garlic extracts (Alnaqeeb *et al.* 1992) [2].

## 2. Botanical Description

Other members of the onion genus, *Allium*, include *A. cepa* (onion), *A. schoenoprasum* (chives), *A. ascalonicum* (shallots), and *A. porrum* (leeks). *Allium sativum* is further divided into two subspecies, *A. sativum var. sativum*, also known as softneck garlic, and *Allium sativum var. ophioscorodon*, also known as hardneck garlic. Both varieties are composed of an underground bulb made up of cloves, which are prophylls enclosed by dry membranous skins and held together by a basal plate. The variations differ in that hard neck garlic's bulb is composed of six to eleven cloves, circled around a centralized woody stalk. This variety of garlic has a scape that curls at the top, but it is generally removed after it curls one to three times. This is because if it continues to grow, less energy can be utilized towards the bulb. Eventually, the scape would give rise to bulbils, containing miniature cloves. The bulbils are occasionally accompanied by white or light purple flowers, although these are sterile. Softneck garlic does not have a flowering top and contains up to twenty-four cloves per bulb. The stem is central and soft, hence the name, and the cloves are layered with larger ones on the outside. *Allium sativum* is the more common variation, many studies involving garlic do not specify which subspecies is used, but chemical and biological action are assumed to be similar. *Allium sativum* is sterile and hence is grown asexually from cloves, not requiring a pollinator. It grows best in mild climates, through hardneck varieties are better adapted to colder environments. *Allium sativum* is a perennial species, as are most members of the genus. Garlic is composed of very strong organosulfur compounds that serve as secondary metabolites as described in the section entitled chemistry and pharmacology. These compounds are responsible for the very pungent smell and taste of raw garlic and act as defenses against predators (Block 2010) [11].

### 2.1 Bulb

Rounded, composed of up to about 15 smaller bulblets known as cloves. Cloves and bulbs are covered by a whitish or pinkish tunic (papery coat).

### 2.2 Leaves

Four to twelve long, sword-shaped leaves attached to an underground stem.

### 2.3 Flowers

Borne in a dense, spherical cluster on a spike (flower stalk) up to 25 cm long. The young flower head is enclosed in a long-beaked pair of enclosing bracts, which become papery and split to reveal the flowers. Individual flower stalks arise from a common point. Flowers are greenish-white or pinkish with six perianth segments (sepals and petals) about 3 mm long. Bulbils (asexual propagules), which resemble tiny cloves, are often interspersed among the flowers.

### 2.4 Fruits

Flowers usually abort before developing to a stage at which fertilisation could take place.

### 2.5 Seeds

Not usually produced in the wild but have been produced under laboratory conditions. With a black coat, similar to onion seeds, but approximately half the size.

## 3. Vernacular Names

Synonyms	: <i>Allium sativum L.</i>
Sanskrit	: Lasuna, Rosona, Yovanesta
English	: Garlic, poorman's treacle
Bangali	: Rosun
Hindi	: Lashan, lahsun
Arabic	: Saun Taum
German	: Knoblauch, Lauch
Greek	: Allidion, Skorodon
Italian	: Aglio
Chinese	: Syun tauh
Urdu	: Lehsun
Malayalam	: Veluthulli.

## 4. Unani description:

Unani name	: Lehsun, Fum, Thoum, Thum
Botanical name	: <i>Allium sativum L.</i>
Synonyms	: <i>Allium sativum</i> , Garlic, Saun Taum, Lehsun, Lashan, lahsun.
Properties	: Mizaj 3rd Order Warm and Dry
Maza	: Bitter and acrid
Boo	: Radio-active and acrid
Muzir	: Mehrooreen (for persons with hot temperament)
Mukhrij	: Expels Balgham (Phlegm)
Nafa-e-Khas	: Phlegmatic and stomach related diseases.

## 5. Important formulations

Important Unani formulations containing *Allium sativum* are as follows:

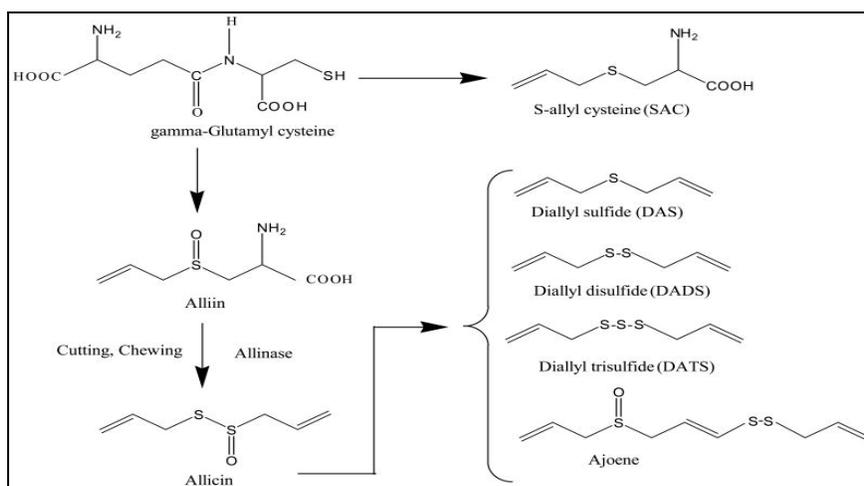
- Garlic parl
- Qurch Ziabetis
- Sarbat Lahsun (B.N.U.F 2010)

## 6. Classification of *Allium sativum*

Kingdom	: Plantae
Subkingdom	: Tracheobionta
Superdivision	: Spermatophyta
Division	: Magnoliophyta
Class	: Equisetopsida
Subclass	: Magnoliidae
Superorder	: Lilianae
Order	: Asparagales
Family	: Amaryllidaceae
Genus	: <i>Allium</i>

## 7. Chemistry and Pharmacology

Sulfur compounds are the main chemical constituents responsible for *Allium sativum*'s taste, smell, and likely for its biological effects. When a garlic clove is intact, glutamyl cysteins are the primary sulfur components (Powolynny and Singh 2008) [47]. These are hydrolyzed to form alliin. When garlic is crushed by chewing, chopping, etc., the alliin promptly reacts with the enzyme alliinase to form allicin; after 30 seconds the reaction is 97% complete. Allicin is a diallyl thiosulfinate that accounts for 70-80% of the thiosulfates present in *Allium sativum* (Harunobu *et al.* 2001) [23]. Allicin is also highly unstable and quickly decomposes to yield sulfur compounds when oxidized such as diallyl sulfide (DAS), diallyl disulfide (DADS), diallyl trisulfide (DATS), ajoene, and hydrogen sulfide (Banerjee and Maulik 2002) [12]. The pathways of this reaction can be seen in Figure 1. DAS, DADS, DATS and ajoene are all oil soluble (Miroddi *et al.* 2011) [38].



**Fig 1:** Chemical structures of organ sulfur compounds involved in reactions with alliin. (Image source: Powolny and Singh 2008) [47].

## 8. Chemical Manipulation

When garlic is manipulated to produce alternate forms, the unstable sulfur compounds react and hence alter active chemical constituents. It is important to note that these changes in chemistry can alter the bioavailability of the compounds. Unfortunately, many studies do not specify the actions taken, which could possibly account for inconsistencies in reported data. Traditionally used in its raw form, garlic is now often heated, dehydrated, and aged. Only freshly crushed garlic has hydrogen sulfide, which is suspected to have significant cardioprotective effects as a vasodilator (Mukherjee *et al.* 2009) [39]. Garlic powder can be made through dehydrating the plant with heat, but when high temperatures are applied to garlic, alliinase is deactivated and hence cannot react with alliin to form allicin (Tsai *et al.* 2011) [59]. This explains why cooked garlic has a mellower flavor than raw garlic. Powder can retain some allicin content if the cloves are frozen before being pulverized; acetone removes the water and alliin and alliinase remain separate yet intact until water is added, at which point allicin is formed. While dehydration during the powdering process does not destroy alliinase like heat does, more than half of the alliin is lost. While levels are lower than with raw garlic, dried garlic does contain alliin and alliinase, as explained above. Alliinase is deactivated by the acidic environment of the stomach (Touloupakis and Ghanotakis 2011) [60]. Freeman and Kodera (1995) [22] also came to this conclusion by exposing dehydrated garlic powder to simulations of the gastrointestinal fluids; allicin production decreased by 99%, presumably due to the lack of alliinase. This suggests that it could be beneficial to further research the affects of dehydrated garlic powder when taken in a capsule with an enteric coating to protect it from stomach acid. These studies also show that manipulating garlic's form leads to changes in the active constituents and could lead to data inconsistencies in studies.

Garlic can also be aged by soaking it in aqueous ethanol and then extracting and concentrating essential compounds. When allicin is dissolved in oils, the major compound in the final product is S-Allylcystein (SAC) while ajoene, the most stable component of garlic, is also present (Rahman 2002) [49]. Kodera *et al.* (2002) [29] suggest that SAC could pass through the gastrointestinal tract without decomposing and successfully be absorbed. Kodera *et al.* (2002) [29] also suggest that SAC might be stable in blood, whereas allicin is unstable in blood and cannot reach target organs via circulation (Harunobu *et al.* 2001) [23].

## 9. Pharmacological activities

Due to its biological active component allicin and its derivative, garlic has been used as a medicine to cure a wide range of diseases and conditions related the heart and blood system including high blood pressure, high cholesterol, coronary heart disease, heart attack, and "hardening of the arteries" (atherosclerosis) as pronounced (Mikaili *et al.* 2013) [40].

Amagase (2006) [3] noticed out garlic is used to prevent various types of cancer comprising colon cancer, rectal cancer, stomach cancer, breast cancer, prostate cancer, prostate cancer and bladder cancer, and lung cancer. It is also used to treat Cardiovascular disease including: Antihypertensive, antihypertensive, anti-atherosclerotic, an enlarged prostate (benign prostatic hyperplasia; BPH), diabetes, osteoarthritis, hayfever (allergic rhinitis), traveler's diarrhea, high blood pressure late in pregnancy (pre-eclampsia), cold and flu. It is also used for building the immune system, preventing tick bites, and preventing and treating bacterial and fungal infections.

Furthermore, Pendbhaje *et al.* (2000) [46] listed out the pharmaceutical activities of garlic. The plant is effective to treat fever, coughs, headache, stomach ache, sinus congestion, gout, rheumatism, hemorrhoids, asthma, bronchitis, shortness of breath, low blood pressure, low blood sugar, high blood sugar, and snakebites. It is also used for fighting stress and fatigue, and maintaining healthy liver function. In addition to this, Jung *et al.* (2000) [26] reported that garlic is also used to promising effect against to asthma, arthritis, sciatica, lumbago, backache, bronchitis, chronic fever, tuberculosis, rhinitis, malaria, obstinate skin disease including leprosy, leucoderma, discoloration of the skin and itches, indigestion, colic pain, enlargement of spleen, piles, fistula, fracture of bone, gout, urinary diseases, diabetes, kidney stone, anemia, jaundice, epilepsy, cataract and night blindness. Garlic paly crucial role in area of pharmaceutical and used for the treatment of cardiovascular and other demise causing ailments including:

### 9.1 Antibacterial activity

Garlic is a broad spectrum antibiotic, killing a wide variety of bacteria. Dr. Tariq Abdullah, a prominent garlic researcher stated in the August 1987 issue of Prevention: "Garlic has the broadest spectrum of any antimicrobial substance that we know of — it is antibacterial, antifungal, antiparasitic, antiprotozoan and antiviral." This property belongs to the garlic constituent allicin, which is released when you cut a

garlic clove. This is the chemical that gives fresh garlic its strong biting flavor, and you need to use fresh garlic to get a reliable antibiotic effect. Garlic appears to have antibiotic activity whether taken internally or applied topically. Researchers found that the urine and blood serum of human subjects taking garlic had activity against fungi (Caporaso *et al.* 1983) [16].

### 9.2 Antiviral activity

Garlic and its sulfur constituents verified antiviral activity against coxsackievirus species, herpes simplex virus types 1 and 2, influenza B, para-influenza virus type 3, vaccinia virus, vesicular stomatitis virus, human immunodeficiency virus type 1 and human rhinovirus type 2. The order of compounds found in garlic for virucidal activity was, ajoene > allicin > allyl methyl thiosulfinate > methyl allyl thiosulfinate; no activity was found for the polar fractions, alliin, deoxyalliin, diallyl disulfide, or diallyl trisulfide. Several laboratory tests have shown that garlic is an effectual treatment for both the influenza B virus and herpes simplex virus. Two independent researchers in Japan and Romania have found that garlic is able to protect living organisms from the influenza virus (Tsai *et al.*, 1985) [61]. Most recently, a double blind placebo controlled study has shown significant protection from the common cold virus. As conducted by The Garlic Centre, published in *Advances in Therapy*, this is the first serious work to show prevention, treatment and reduction of re-infection benefits from taking Allimax Powder capsules once daily (Josling, 2001) [27].

### 9.3 Antifungal activity

Ajoene is an active compound found in garlic which plays a great role as topical antifungal agent (Ledezma and Apitz-Castro, 2006) [32]. Garlic has been shown to inhibit growth of fungal diseases as equally as the drug ketoconazole, when tested on the fungi *Malassezia furfur*, *Candida albicans*, *Aspergillus*, *Cryptococcus* and other *Candida* species (Shams-Ghahfarokhi *et al.*, 2006) [56]. A report from a Chinese medical journal delineates the use of intravenous garlic to treat a potentially fatal and rare fungal infection of the brain called *Cryptococcus meningitis*. In the report, the Chinese compared the effectiveness of the garlic with standard medical treatment which involved a very toxic antibiotic called Amphotericin-B. The study revealed that, intravenous garlic was more effective than the drug and was not toxic regardless of its dosage (Lemar *et al.*, 2007) [33].

A study found that *Candida* colonies were substantially reduced in mice that had been treated using liquid garlic extract. The study also revealed that garlic stimulated phagocytic activity. This implies that infections such as *Candida* may be controlled because garlic stimulates the body's own defenses. Garlic oil can be used to treat ringworm, skin parasites and warts if it is applied externally. Lesions that were caused by skin fungi in rabbits and guinea pigs were treated with external applications of garlic extract and began to heal after seven days (Sabitha *et al.*, 2005) [57].

### 9.4 Antiprotozoal activity

Garlic is effective in treating intestinal parasites has been known for a long time. An extract of garlic was effective against a host of protozoa such as *Opalina ranarum*, *Opalina dimidicita*, *Balantidium entozoon*, *Entamoeba histolytica*, *Trypanosoma*, *Leishmania*, *Leptomonas* and *Crithidia* (Reuter *et al.* 1996) [50]. In addition, it was efficacious at killing wild-type amoebae isolated from the diseased fish, slowing the

clinical signs of amoebic gill disease (AGD). However, it is necessary to study the toxicity and pathological effect of garlic on Atlantic salmon before using garlic to treat AGD in farmed Atlantic salmon.

### 9.5 Antiparasitic activity

Many herbalists worldwide recommend garlic as a treatment for intestinal parasites. In some cultures, children infested with helminthes are treated with enemas containing crushed garlic. One of the traditional Chinese medical treatments for intestinal diseases is an alcoholic extract of crushed garlic cloves. Allicin exhibits anti-parasitic activity against major human intestinal parasites such as *Entamoeba histolytica*, *Ascaris lumbricoides* and *Giardia lamblia* (Kalyesa *et al.*, 1975) [75]. *Entamoeba histolytica*, the human intestinal protozoan parasite, is very sensitive to allicin, as only 30 µg/ml of allicin totally inhibits the growth of amoeba cultures (Mirelman *et al.*, 1987) [41]. Moreover, researchers have found that at lower concentrations (5 µg/ml), allicin inhibited 90% the virulence of trophozoites of *E. histolytica* as determined by their inability to destroy mono-layers of tissue-cultured mammalian cells *in vitro* (Ankri *et al.*, 1997) [4].

### 9.6 Wound Healing activity

Successful wound healing depends upon angiogenesis, and impaired angiogenesis is a hallmark of the chronic wounds encountered with diabetes and venous or arterial insufficiency. To intervene and improve wound closure, it is essential to investigate the effects of different natural remedies in wound healing. Study was done on the chicken dorsum skin excision wound assay to investigate the influence of different concentrations of aged garlic solution (AGS) on wound healing. Gross, histopathology, scanning electron microscopy (SEM) and computer-based three-dimensional (3D) image-probing techniques were utilized to determine the effects of AGS on wound closure, re-epithelialization, dermal matrix regeneration and angiogenesis (Jalali *et al.* 2009) [24].

### 9.7 Anti- Diabetic activity

A number of animal studies support the effectiveness of garlic in reducing blood glucose in streptozotocin-induced as well as alloxan-induced diabetes mellitus in rats and mice. Most of the studies showed that garlic can reduce blood glucose level in diabetic mice rats and rabbits. One Iranian study evaluated oral administration of garlic extract for 14 days on the level of serum glucose, total cholesterol, triglycerides, urea, uric acid, creatinine, in normal and streptozotocin-induced diabetic rats. Administrations of the garlic extract significantly decreased serum glucose, total cholesterol, triglycerides, urea, uric acid, creatinine, aspartate amino transferase and alanine amino transferase levels, while increased serum insulin in diabetic rats but not in normal rats (p<0.05). Interestingly, a comparison was made between the action of garlic extract and glibenclamide, a well-known antidiabetic drug. The antidiabetic effect of the garlic was more effective than that observed with glibenclamide (Eidi *et al.* 2006) [19]. Unfortunately, the effect of garlic on humans with diabetes is not well studied as is fraught with conflicting results (Zhang *et al.* 2001) [65].

### 9.8 Antihypertensive activity

Garlic powder is used to cure hypertensive. According to Silagy and Neil (1994) [55] garlic extracts has a significant reduction in systolic blood pressure (SBP) and in diastolic blood pressure (DBP) and act as anti-hypertensive.

### 9.9 Anti-tumor Effects

Garlic extracts used as inhibition of cancer development in the presence of known tumor promoters and Sulphurous components present in garlic are believed to be liable to evade the developing of cancerous cells in stomach, liver, and other organs of human as described by Pendbhaje *et al.* (2000) [46].

### 9.10 Liver Protective/Detoxification Effects

It has been reported that aged Garlic Extract have liver protective effects. It has demonstrated in vivo from the liver toxins: carbon tetrachloride, paracetamol (acetaminophen) and bromobenzene (Amagase 2000). It has been shown to inhibit both the formation and bioactivation of liver carcinogenic nitrosamines and has prevented the mutagenic effects of aflatoxin B1 as pronounced (Borek 1998) [14].

### 9.11 Antioxidative and Radioprotective Effects

Borek (2001) [13] reported that aged garlic extract and its various constituents have proven an array of antioxidant and radio-protective effects in studies. They have been shown to protect white blood cells from radiation damage, liver cells from lipid peroxidation and vascular endothelial cells from oxidant injury and enhance antioxidative enzyme systems in cells. They have been shown to scavenge hydrogen peroxide, to inhibit the formation of TBA-RS, to protect the heart from cardiotoxic, anticancer drug doxorubicin, to protect the kidneys from the antibiotic gentamicin as described by Oshiba *et al.* (1990) [43].

### 9.12 Diuretic and Digestive activity

IT has reported that garlic acts as a diuretic which helps to get rid of body liquids. It may act as a very useful resource in case of rheumatism, gout, arthritis, hidropesia, edemas. It eases digestion by stimulating the liver, the gall bladder and the pancreas although its use should be avoided when existing hyperchloridia (stomach acidity) and also when having frail stomachs (Eat it raw or crushed and mixed with butter) (Ali 1995) [5].

### 9.13 Anti-cancer Activity

In looking at multiple studies, Powolny and Singh (2008) [47] conclude that organosulfur compounds such as DAS, DADS, and DATS act by arresting the cell cycle of cancerous cells. Data from Miroddi *et al.* (2011) [28] and Omar and Al-Wabel (2009) [44] support this, showing that these allyl derivatives act as antioxidants and arrest the cell cycle. DATS was found to have the most significant role by Powolny and Singh (2008) [47], and is even a potential skin cancer fighting compound (Wang *et al.* 2010) [62]. More specifically, garlic acts as anti-inflammatory agent by altering cytokines and inhibiting NF- $\kappa$ B activity in surrounding tissues (Keiss *et al.* 2003) [30]. In a study using human promyeloleukemic cells, Dirsch *et al.* (1998) [17] found that ajoene prompted apoptosis in cancerous cells but not healthy ones; this might be due to peroxide production. In an in-vitro study involving rats, Jastrzebski *et al.* (2007) [25] found that raw garlic had the strongest antioxidant activity. Tsai *et al.* (2011) [59] reviewed animal and cell studies and found an inverse correlation between consumption of garlic and presence of cancerous cells, suggesting it has anticancer effects.

### 9.14 Cardio protective activity

Garlic is a popular supplement well-perceived as a healthy choice among people looking to increase cardiovascular wellness. Approximately 4% of all cardiovascular disease

patients and 30% of cardiovascular patients who use herbal supplements take garlic (Yeh *et al.* 2006) [64]. Known risk factors for cardiovascular disease include inflammation, high cholesterol, high homocysteine, high blood pressure, diabetes and dementia, including its most common form, Alzheimer's disease. Indeed, as early as the 1920's and 1930's (Schlesinger 1926) [52], numerous studies do bear the beneficial cardiovascular effects. Garlic is well reported to scavenge oxidants, increase superoxide dismutase, catalase, glutathione peroxidase, and glutathione levels, as well as inhibit lipid peroxidation and inflammatory prostaglandins. Garlic also reduces cholesterol synthesis by inhibiting 3-hydroxy-3-methylglutaryl-CoA. Garlic has been shown to inhibit LDL oxidation, platelet aggregation, arterial plaque formation, decrease homocysteine, lower blood pressure, and increase microcirculation, which is important in diabetes, where microvascular changes increase heart disease and dementia risks. Garlic may also help prevent cognitive decline by protecting neurons from neurotoxicity and apoptosis, thereby preventing ischemia- or reperfusion-related neuronal death and by improving learning and memory retention (Borek 2006) [7]. Garlic may also possess anti-inflammatory abilities to suppress the nuclear factor-kappa B activation pathway (Aggarwal *et al.* 2004) [1].

### 9.15 Alzheimer' Disease Protective activity

Known for its neuroprotective abilities in vitro (Peng *et al.* 2002) [45], aged garlic has been looked to for multiple benefits that some researchers believe may address a number of underlying mechanisms which contribute to the classic Alzheimer beta-amyloid plaque. According to one author, garlic: "is expected to produce cumulative benefits and exhibit enhanced neuroprotection by virtue of being "natural statin", "natural NSAID", "natural anti-oxidant", "natural anti-apoptotic agent" and "memory enhancer", a combination of many single-ingredient synthetic pharmaceutical drugs currently used for Alzheimer's therapy, only with least adverse effects (Chauhan 2006) [15]." Unfortunately, there is a dearth of clinical studies showing of aged garlic extract in relation to Alzheimer's pathology, except for reports showing improved behavior in senescence accelerated mice after garlic treatment (Nishiyama *et al.* 2001) [42]. Given the multiple-mechanistic possibilities and minimal risk associated with its use, garlic seems a prudent recommendation for prevention and treatment. Since aged garlic is best studied in relation to Alzheimer's it may be the best form to employ.

### 10. Dosage

A commercial garlic product should provide a daily dose equal to at least 4000mg (one to two cloves) of fresh garlic. The cloves may be diced and mixed with wildflower honey for palatability. This dosage translates to at least 10mg alliin or a total allicin potential of 4000ug (Murray *et al.* 2006) [34]. In dried form this would be 300-mg of garlic powder tablet (standardized to 1.3 percent alliin or 0.6 percent allicin yield) two to three times per day, or 7.2 g of aged garlic extract per day (Tattelman 2005) [58]. In tincture form from fresh bulb as a 1:2 in 95 % alcohol, the dosage can be 40 drops up to six times per day.

### 11. Adverse effects of garlic

The main adverse effect commonly associated with garlic intake is breath odor, especially when raw forms of the herb are used. Nausea and vomiting are other major adverse effects and care should be taken in consuming high quantities.

Although an entire bulb produces little juice, it is potent and can act as a strong emetic, even in small quantities. Although garlic generally poses little in terms of safety issues, there are isolated cases of topical garlic burns (Friedman *et al.*, 2006)<sup>[20]</sup> and anaphylaxis (Yin and Li, 2007)<sup>[63]</sup>. Rare garlic allergy has been attributed to the protein allinase, which has induced immunoglobulin E (IgE) mediated hypersensitivity responses from skin prick testing (Kao *et al.*, 2004)<sup>[28]</sup>. As a result, the literature has generally cautioned against using garlic while using anticoagulant therapy. There is a reported case of spontaneous spinal or epidural hematoma in an 87 years old man, with associated platelet dysfunction related to excessive garlic ingestion (Saw *et al.*, 2006)<sup>[51]</sup>.

## 12. Conclusion

Garlic, from crushed to capsules, is consumed throughout the world. This abstract demonstrates by documented studies the benefits of garlic for its anti-microbial, antioxidant and anti-inflammatory potential. It has been used to treat cardiovascular diseases, including atherosclerosis, strokes, hypertension, thrombosis and hyperlipidemias, as well as uses in Alzheimer's, diabetes, and cancer. Most impressive and unique are its use and safety in children. Although some studies show medicinal benefits of garlic, there are others which do not. Clearly more studies are needed. Fresh and powdered garlic are popular for food seasoning and should continue to be used. Today, with the ever-growing resistant organisms, garlic, taken alone or with other herbal antibiotics such as grape seed extract or ginger, remains a powerful antimicrobial agent. Clearly more studies are needed to refine the use and improve the efficacy of this important plant medicine.

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## 14. Conflicts of Interest

The authors declare no conflict of interests.

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