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Garlic and its health benefits

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Abstract
Garlic (*Allium sativum* L.) belongs to Liliaceae family, and is on the best herbal remedies, and is used as a food and a spice Garlic has long been considered an herbal "wonder drug", with a traditional reputation of being able to prevent everything from the common cold and flu. *Allium sativum* is highly recognized throughout the world for both its medicinal and culinary purpose. Garlic is highly nutritious contains different minerals, vitamins and many other health improving substances used for f human beings. It is rich in sugar, protein, fat, calcium, phosphorous, sulfur, iodine fiber and vitamins. It has been scientifically studied and proven as an efficient remedy for different ailments. These studies raised the possibility of revitalization of therapeutic values of garlic and its compounds in different diseases. Garlic is rich in sulphur-containing compounds, including alliin, produced by enzyme alliinase which are responsible for its medicinal effects. Research conducted on garlic has proved that garlic possesses antibacterial, cardiovascular benefits, cholesterol lowering, anticarcinogenic, immunostimulant and hypoglycemic properties. Different compounds present in garlic have the tendency to reduce the risk of cardiovascular diseases, even possess anti-tumor, anticancer and anti-microbial effects, and ability to control high blood glucose levels. Wide spread research has been carried on the medicinal properties of garlic. Garlic and its different products are effective against health risks and used as dietary supplements mainly used as aged garlic extract and garlic oil and garlic tablets Further studies are required for revealing mechanisms of action of garlic in reducing different ailments as well as its efficiency and safety.

Keywords: allium, allicin, antioxidant, cardiovascular, anticancer

Introduction
Garlic is an underground bulb crop it is known as *Allium sativum* and is member of Alliaceae or Liliaceae family [1] It is also known by stinking rose due to abhorrent odour of its constituents. Garlic is the ancient cultivated herb. It is believed to be originated from central Asia [2] Its scientific name is "*Allium sativum*". The English name," garlic" has been obtained from the Anglo-Saxon "gar-leac", which refers to the flowering stalk of garlic [3]. Garlic-based remedies have been functional in India since 5,000 years ago and in Chinese medicine 3,000 years ago. During the period of 1550 B.C garlic was fed by Egyptians to workers involved in the construction of pyramids for the purpose of providing them extra strength (Rivlin, 2001) [4]. Garlic tea has been used in ailments like fever, headache, cholera, diarrhea, in china and in India, it has been used as a remedial measure for ailments like hemorrhoids, Rheumatoid Arthritis, skin diseases, abdominal discomfort, cough and even as an antiseptic and antibiotic liniment for cleaning and rinsing wounds and ulcers (Srivastava *et al.* 1995) [5] During the World War I, European soldiers treated their wounds by putting garlic directly on the injured tissues to prevent sepsis and infection. Garlic has been used for common health issues and durability by ancient Egyptians, Israelites, Greeks, Romans, and Chinese and even by the colonial Americans. At present, garlic is one of the best and most demanded preventive medicines in Europe, where it has been accepted as secure and effectual by both medical authorities and government officials. Most of the garlic consumed at present arrives from China, South Korea, India, Spain, and the United States. Single bulb of garlic was used as only source of medicine and was recognized as pharmaceutical industry due to its broad spectrum effects at the time when antibiotics and other pharmacy products were not available. The garlic was recognized by several other names which are even used such as "Russian penicillin", "antibiotic", "vegetable viagra", "plant talisman", "rustic's theriac", "snake grass", etc. (Petrovska BB, Cekovska S, 2010) [6] Many experimental and clinical studies conducted indicated the medicinal and healing effects of garlic and its preparations which include lessening of risk factors responsible for cardiovascular diseases, cancer, antioxidant and antimicrobial effect, and improvement in detoxification of harmful compounds and hepato-protective effects (Colín González., *et al*. 2012; Aviello, *et al*. 2009) [19, 8]. Garlic has numerous health benefits due the compounds present in it such as volatile oil in garlic is 0.1 % which is rich in sulphur, but is devoid of oxygen its main constituents are diallyl disulfide 60 percent, diallyl trisulfide 20 percent, allyl propyl disulfide (5-6 %), a small amount of diethyl disulfide and diallyl polysulfide[8]. These sulfur compounds are responsible for pungent smell as well as flavour of garlic. Garlic has many functional and medicinal properties due to presence of this volatile oil rich in sulphur compounds. It consists of 33 (Newal, *et al.* 1996) sulfur compounds of about twenty types mostly allicin, methyl allyl trisulfide, and diallyl trisulfide reported. Other organosulfur compounds like Alliin, isoalliin, methiin, cycloalliin, and gamma-l-glutamyl-S-methyl-l-cysteine have also been identified [4]. Allicin is the most important

compound present in the garlic responsible for its chemical and therapeutic functionality. Allicin is not released naturally by garlic itself it requires either crushing or chewing raw garlic and cant be obtained even from processed garlic (Ross SA, *et al.*, 2006) [9] allicin is colorless, odorless and water soluble component and is responsible for triggering the thermo transient receptor potential channel (TRPA1) and TRPV1 (Transient receptor potential vanilliod 1) (parle. M *et al.*, 2012) [10] which is liable for the burning sensation of heat in raw garlic while consuming it When garlic is crushed cut, chewed, dehydrated, minced or exposed to water or microbial attack the enzyme alliinase present in the inside of garlic vacuoles quickly lyses the cytosolic cysteine sulfoxides (alliin) which gets transformed to compound, allicin, which comprises of about 70–80% of the thiosulfinates. The alliin compound gets converted to allicin by alliinase and quickly decomposes to other compounds which include diallyl sulfide (DAS), diallyl disulfide (DADS), dithiins and ajoene. At the same time, g-glutamyl cysteine gets converted to S-allylcysteine (SAC), by a different pathway than the alliin–allicin pathway (S.V. Rana., *et al.* 2011) [11]**.** These compounds are digested in the body to produce sulfenic acid, which has the tendency to react with harmful and toxic free radicals in a more rapid manner than any other compound. The sulfur compounds of garlic get metabolized in the body to form allyl methyl sulfide. Which directly passes to blood and is expelled out in lungs and skin. this is this reason that the pungent odor of garlic persists for longer duration. Non-sulfur compound present in the garlic is phytoalexin (allixin), which might be effective in cancer prevention. Other healthy compounds present in garlic are enzymes, vitamins (Vit-B1, B2, B3, B5, B6, B9 and C) arginine-rich proteins, minerals like calcium, iron magnesium, manganese, phosphorus, potassium, sodium, zinc, selenium, saponin s, oligosaccharides, dietary fibers and flavonoids several enzymes such as Allinase, peroxidase, myrosinase, catalases, dismutases, arginases, lipases. Amino acids like arginine, glutamic acid, asparagic acid, methionine, threonine Se, Ge, Te and other trace minerals Biotin, nicotinic acid, elements, lipids, prostaglandins, fructan, pectin, adenosine (Fenwick GR and Hanley A.B., 1985) [2]

Health benefits of black garlic

Prevents cardiovascular diseases

Cardiovascular disease claim more lives than any other ailments and occur mainly due to clogging of the coronary arteries which leads to narrowing of arteries due to plaque buildup in them which restricts the blood supply, as a result of which a portion of the heart does not receive required amount of oxygen and leads to heart attack. The role of garlic in coronary heart disease has been studied on rabbits and it was found that the atherosclerotic deposits and lesions that block the arteries could actually be reversed by consistent consumption of garlic (Bordia, 1981) [5] one of the study conducted in India indicated that 432 coronary artery patients grouped into two groups and half of the population was fed with garlic juice in milk, whereas the remaining patients not fed with garlic juice died (Yeh *et al.*, 2006) [15]. Garlic and garlic extracts, because of their antioxidant activities, have successfully been studied and resulted in providing protection against free radical changes in the body. Another study indicated positive results for antioxidant properties due to presence of alliin, allyl cysteine, allyl disulfide and allicin, obtained from garlic by chemical synthesis or purification (clung L.Y,2006) similar results were obtained from a study conducted in Japan which indicated the anti oxidative mechanism of allicin. (Okada Y., *et al.*; Sato. E., *et al.* 2006) [17, 18] Garlic has been used for prevention and treatment of hypertension. Castro *et al.*, 2010 confirmed that the compounds allyl methyl sulphide (AMS) and diallyl sulphide (DAS) present in garlic prevented aortic muscle angiotensin II-stimulated cell-cycle progression and movement their studies suggest that AMS and DAS, compounds derived from garlic, are effective antioxidants and prevent hypertension. Several studies conducted on humans indicated that garlic consumption increased fibrinolytic activity in healthy as well as in acute myocardial infarction suffering patients (Bordia *et al.*, 1998) [20]**.** It has also studied that garlic decreases the risk of arterial occlusive diseases, plasma viscosity, and unstable angina and enhances elasticity of blood vessels and capillaries. (Sumiyoshi and Wargovich, 1990) [21].

Antibacterial activity

Pasteur was the first scientist to discover the antimicrobial properties of garlic (1958), studies conducted so far have proved its effectiveness and broad spectrum antimicrobial activity against several species of bacteria, viruses, parasites, protozoan and fungi (Jaber and AlM ossawi, 2007) [20] Garlic is safe highly effective without side effects when compared to commercial antibiotics as a result, garlic is preferred as a substitute for treatment of various infectious disease and wounds (Tepe. *et al.*, 2004) [23]. Garlic powder has been examined and is found to be highly effective against Bacillus anthracis. (Sasaki J, Kita J, 2003) [24] it is also effective against Streptococcus pneumoniae and Klebsiella pneumoniae responsible for pneumonia (Dikasso D *et al.*, 2002) [25] Microorganism responsible for chronic lung infections in cystic fibrosis patients is Pseudomonas Aeruginosa it colonizes the lungs by its biofilm forming capability throughout the lung. Garlic has been highly effective when used in combination with an antibiotic, tobramycin. It was observed that garlic compounds make P. aeruginosa sensitive to tobramycin, leading to an improved effect of antibiotic in case of pulmonary infections. (Bjarnsholt T *et al.*, 2005) [26] Extract prepared from garlic hampers the growth of Gram+ and Gram - bacteria, some of them are as Staphylococcus, Streptococcus, Micrococcus, Enterobacter, Escherichia, Klebsiella, Lactobacillus, Pseudomonas, Shigella, Salmonella, and Helicobacter pylori (Tsao and Yin, 2001) [27]. Better satisfaction was observed by the use of garlic rather than nystatin in the patients suffering with denture stomatitis (Bakhshi *et al.*, 2012) [41].

Anti fungal activity

Ajoene is an active compound found in garlic responsible for antifungal activities (Ledezma and Apitz-Castro, 2006) [64]. Garlic inhibits fungal diseases as equally as the drug ketoconazole, it has been tested on the fungi Malassezia furfur, Candida albicans, Aspergillus, Cryptococcus and other Candida species (Shams-Ghahfarokhi *et al.*, 2006) [28]. Chinese medical journal described the use of intravenous garlic to treat a potentially fatal and rare infection of the brain caused by fungi called Cryptococcus meningitis effectiveness of the garlic was compared with standard medical treatment by toxic antibiotic called Amphotericin

B. The study indicated that intravenous administration of garlic was much effective than the drug non toxic despite of its dosage (Lemar *et al.*, 2007) [30] Oil extracted from garlic is highly effective against ringworms, skin parasites and warts when externally applied as a medicine. It can even be used to treat Lesions caused by fungi in rabbits and guinea pigs by external applications of garlic extract and healing effect was seen within seven days (Sabitha *et al.*, 2005) [29]. Many fungi species are garlic sensitive species which include Candida (Yousuf, 2011) [32], Torulopsis, Cryptococcus (Fromtling and Bulmer, 1978) [33], Aspergillus (Hitokoto *et al.*, 1980) [34], Trichosporon, and Rhodotorula (Tansey and Appleton, 1975) [35]. The Garlic extracts have the capability to decline the oxygen uptake (Szymona, 1952) [36], which leads to improper growth and inhibition of lipids, proteins, and nucleic acids synthesis (Adetumbi *et al.*, 1986) [37], and injures membranes (Ghannoum, 1988) [38]. allicin compound is responsible for antifungal activities if allicin is removed from the extract by solvent extraction the antifungal activity of the extract decreases (Nervi, 2006; Hughes and Lawson, 1991) [39, 40]. A study indicated that Addition of ajoene to fungal growth mixtures consisting of Aspergillus niger, Candida albicans, and Paracoccidiodes, resulted in inhibition at a concentration minor than that of allicin. garlic also showed antifungal effects on two airborne pathogens Botrytis cinerea and Trichoderma harzianum (Lanzotti *et al.*, 2012) [42].

Anti diabetic activity

The effect of garlic on blood glucose levels in humans is still contentious Although studies conducted indicated that garlic can result in lower blood glucose level in diabetic animals. Interim benefits of garlic on dyslipidemia in diabetic patients have also been studied (Ashraf *et al.*, 2005) [43]. Garlic consumption has resulted in reduction of total serum cholesterol and LDL cholesterol and moderately increased HDL cholesterol in comparision with placebo in diabetic patients (Ashraf *et al.*, 2005) [43]. Diabetic Patients treated with Metformin and Garlic for 12 weeks resulted in lower fasting blood glucose (FBG) levels, but the results were better in patients that consumed garlic with metformin than those patients which consumed metformin alone (Kumar *et al.*, 2013) [1]. Volatile sulfur compounds, such as alliin, allicin, diallyl disulfide, diallyl trisulfide, diallyl sulfide, S-allyl cysteine, ajoene, and allyl mercaptan are responsible for favorable effect of garlic on diabetes mellitus. Garlic extracts have been found to be effective in decreasing insulin resistance (Padiya and Banerjee, 2013) [45]. Garlic has the ability to lower blood sugar, which makes it a very useful in the treatment of diabetes. Garlic has been found to be effective in blood glucose level reduction in streptocin-induced (Ohaeri, 2001; Patumraj *et al.*, 2000) [46, 47] as well as alloxan-induced diabetes mellitis in rats and mice models (Swanston-Flatt *et al.*, 1990; Farva, *et al.*, 1986; Sheelaetal., 1995; Augusti and Sheela, 1996; Kumar and Reddy, 1999) [48, 51, 50, 11]. A study indicated that diabetic rats fed with with garlic oil showed a considerable reduction in levels of activities of serum acid and alkaline phosphatase, serum alanine and aspartate transferases and even in serum amylase activity (Ohaeri, 2001) [46]. Allicin administered at the rate of 250 mg/Kg body weight was as effective as tolbutamide against alloxan-induced diabetes (Mathew and Augusti, 1973; Banerjee *et al.*, 2002) [54, 45].

Effect of garlic on lipid metabolism

Garlic has significant role in lipid metabolism. Clinical investigation on the blood lipid profiles of 23 humans suffering with high blood cholesterol (>5.98 mmol/L) was conducted they were fed with garlic extract supplementation for 4 months and the change in their blood lipid profiles were examined before and after being treated with garlic The results obtained indicated that there was a significant decrease in serum total cholesterol, low-density lipoprotein (LDL), VLDL cholesterols and triglyceride levels with an increase in the level of high-density lipoprotein cholesterol (HDL). The effect of allicin was also was investigated using male ICR mice for its effectiveness in preventing atherosclerosis and hypercholesterolemia, mice were orally administrated with allicin doses of 5, 10, & 20 mg/kg body weight, regularly for 12 weeks. Significant decrease in daily food consumption was observed in most of the animals treated with allicin. In the mean time allicin showed a positive effect in reduction of blood cholesterol, triglycerides, and was responsible for a significant decrease in the hepatic cholesterol storage (Lu.Y.2012). A significant decrease was observed in hyperlipidaemia in animal administered with garlic and its compounds (Augusti KT, 1996) [49] Chickens showed reductions of plasma and tissue cholesterol TAG when fed with diets supplements of garlic powder (chowdary *et al.*, 2002)

Anti cancer

Inhibition of the growth of cancer cells is the most notable function of garlic. It can be used in different forms which include fresh garlic extract, aged garlic, garlic oil and a numerous other organ Sulphur compounds, offer protection against some cancers. The chemo preventive activity of garlic has been ascribed to its ability to alter the activity of several enzymes that activate (cytochrome P450s) or detoxify carcinogens and prevent the formation of DNA segment attached to cancer causing chemicals in target tissues (Hassan 2004) [59]. several, clinical and laboratory studies have been conducted so far which have sucessfully demonstrated the role of garlic in cancer prevention (Milner 2001, Flieischauer *et al.* 2001, Galeone *et al.* 2006, Setiawan *et al.* 2005) [60, 62, 63] especially digestive tract cancers, esophageal and stomach cancers (Gao *et al.* 1999, Berspalov *et al.* 2004) [67, 68]. Promising research has been conducted to evaluate the use of garlic in leukemic (Hassan), melanoma (Taylor *et al.* 2006) [64] and neuroblastoma (Karmakar *et al.* 2007) [65] cell lines. A study conducted indicated that S-allylcysteine, a potent compound present in garlic, suppressed the PC-3 cell proliferation and hampered the cell cycle at the G0/G1 phases, as well as induced cell death and by the decreased expression of Bcl-2 and enhanced expression of Bax and caspase 8. Which demonstrated the chemopreventive activity of SAC in vitro, and that SAC may be a promising method for prostate cancer treatment. (liu. *et al.*, 2012) Oral cancer which occurs widely due to increase in the osteopontin (OPN) plasma concentration.an investigation was conducted by pai.*et al.* to study the effect of SAC consumption in prevention of tumour growth and progression, including the EMT (epithelial-mesenchymal transition), in a mouse xenograft model for oral cancer study. The study conducted indicated that SAC inhibited the growth of oral cancer cells in tumour-bearing mice. Histopathological and immune histo-

chemical staining also gave positive results in inhibiting the tumour growth and progression of oral cancer in vivo by garlic consumption and carcinogenesis factors such as N-methylpurine DNA glycosylase and OPN were also suppressed Thus indicating that SAC has high potential against tumour growth and the succession of oral cancer in a mouse xenograft model used for this study. (Pai MH, *et al.* 2012) Ajoene one the important chemical present in garlic has the potency to inhibit proliferation and induce death of human leukaemia CD34-negative cells., ajoene when used in combination with chemotherapeutic drugs such ascytarabine and fludarabine, improved their apoptotic effect in human CD34-positive resistant myeloid leukaemia cells due enhancement in bcl-2 inhibitory and caspase-3 activation activities. The anti-cancer activity of ajoene is associated with blocking of the pathway for G2/M phase of cell cycle in human myeloid leukaemia cells. (Hassan HT. Ajoene, 2004) [59].

Effect on osteoporosis

Garlic has also bestowed us with phytoestrogenic effects to overcome bone loss. An intriguing animal study was conducted to examine the effects of garlic extracts on the intestinal absortion of calcium in rats as well as to investigate role of garlic the bone mineral content and bone tensile strength maintenance in an ovariectomized rat model ofor osteoporosis. The results obtained from the study indicated that, oil extract of garlic promoted intestinal absorption of calcium by adjustment of the activities of both intestinal alkaline phosphatase and Ca (2+) activated ATPase. As a result of which observed low bone mineral content and low bone tensile strength in the rats used for study were efficiently restored by garlic oil supplements. The garlic oil supplement also helped in recovery of serum estrogen titer in ovariectomized rat which resulted in better calcium transference, absorption and better conservation of bone mineral content (Mukherjee *et al.* 2006) [71]. Thus it can be useful as a treatment in post-menopausal women with higher osteoporotic propensity and also be used for pre-mature menopausal women having low estrogen levels.

Neuroprotective effect

High levels of cholesterol in blood hypertension and other inflammatory diserases, increase the risk of dementia, and Alzheimer's disease (AD). High cholesterol levels elevate the beta-amyloid the compound responsible for triggering of Alzheimers disease The antioxidant property of Aged Garlic Extract has the tendency to scavenge oxidants, resulting in increase of superoxide dismutase, catalase, glutathione peroxidase, levels, and suppressing lipid peroxidation and inflammatory prostaglandins. Garlic Inhibits the 3-hydroxy-3-methylglutaryl-CoA reductase by reduction in cholesterol synthesis which prevent arterial plaque formation. AGE results in lowers blood pressure and increases circulation, which is important for diabetes control and in reduction of dementia risks. AGE also may help in preventing cognitive decline by protecting neurons from beta-amyloid neurotoxicity and cell death. This prevents neuronal death, thus improves learning and helps in memory retention. However, additional studies are still required in case of humans. (Borek C. 2006) [79]

Conclusion

Garlic is a considered as GODs boon to humans. It is consumed throughout the world in different forms In the present review, antihypertensive, cardiovascular activity, antimicrobial and anticancer properties of garlic have been described Allicin present in garlic has been found to be a broad spectrum antibacterial and antifungal substance garlic is present in the market in different forms, such as powder, garlic tablets, oil, capsules, and aged garlic extracts have been incorporated into the global market of bioactive garlic products. Although there are ample scientifically proved results on the usefull effects of garlic as medicinal food under different clinical conditions in animal models, but still human clinical studies are limited and weak. Hence there is need to establish standard criteria to further investigate the nutritional and health-promoting properties of garlic. This review is aimed to provide useful knowledge about therapeutic effects of garlic and may help in improvement of future experimental and clinical studies. Even though garlic is considered as a safe substance, still realistic trials would provide the possible knowledge of side-effects of different garlic extracts. Methods to overcome the pungent smell, which is one of the major obstruction in consumption of garlic by patients must be studied to increase palatability of garlic

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