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# Medicinal values of Garlic (*Allium sativum* L.) in Human Life: An Overview

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## ABSTRACT

Garlic is one of the important bulb crops grown and used as a spice or a condiment throughout India. According to the Unani and Ayurvedic systems as practised in India, garlic is carminative and is a gastric stimulant and thus help in digestion and absorption of food. Allicin present in aqueous extract of garlic reduces cholesterol concentration in human blood. Garlic extract has antimicrobial activity against many genera of bacteria, fungi and viruses. Garlic contains a higher concentration of sulfur compounds which are responsible for its medicinal effects. The chemical constituents of garlic have also been investigated for treatment of cardiovascular disease, cancer, diabetes, blood pressure, atherosclerosis and hyperlipidaemia and highly praised by several authors. Therefore, this paper is reviewed to inspire and impress the young researchers about the medicinal values of garlic. The inhalation of garlic oil or garlic juice has generally been recommended by doctors in case of pulmonary tuberculosis, rheumatism, sterility, impotency, cough and red eyes. Garlic possesses insecticidal action. About 1% garlic extract gives protection against mosquitoes for 8 hours. Extract of garlic along with chilli and ginger has beneficial action against soil nematodes. Beneficial use of garlic extract has been found against many fungi. Garlic is probably one of the earliest known medicinal plants, which used from ancient time to cure different disease conditions in human. Garlic's principal medicinal uses are to lower blood pressure and cholesterol, fight infections, and prevent cancer. The main interest of researchers in the medicinal values of garlic is its broad-spectrum therapeutic effect with minimal toxicity. Garlic extract has antimicrobial activity against many genera of bacteria, fungi and viruses. Garlic contains a higher concentration of sulphur compounds which are responsible for its medicinal effects. The active constituents are avoura-containing compounds that are rapidly absorbed and metabolized. Numerous studies suggest that garlic lowers total cholesterol concentrations by approximately 10%, favorably altering HDL/LDL ratios. Literature survey support garlic's effectiveness as a mild antihypertensive, lowering blood pressure by 5-7%. Garlic inhibits platelet aggregation and enhances fibrinolytic activity, reducing clots on damaged endothelium. Another important use of garlic is as antidiabetic. Garlic controls the blood sugar level by different types of mechanisms. In vitro studies and animal data suggest that garlic may help to prevent some solid tumors. Therefore garlic is also effective in the cancer prevention. There are no studies evaluating its effectiveness in treating children or pregnant or nursing women. The other proposed uses of garlic include the hepatoprotective, antihelmentics, anti-inflammatory, antioxidant, antifungal and wound healing. Garlic, from crushed to capsules, is consumed throughout the world. The active chemical in garlic is allicin, which is produced when raw garlic is crushed, allowing the enzyme alliinase to act on the stable precursor allin. Garlic's antidiabetic, antibiotic and perhaps anticancer effects are well accepted in the world over, because of the many scientific literature supporting these effects. Garlic also has hepatoprotective, antioxidant, and antihelmentic effect. This review paper demonstrated some of the benefits of garlic for its potential uses in preventing and curing different diseases, and acting as antioxidant for many radicals. Fresh and powdered garlic are popular for food flavor and should continue to be used. Today, with the ever-growing resistant organisms, taking of garlic extract remains a powerful antimicrobial agent. Clearly more studies are needed to refine the use and improvement of the efficacy of this important medicinal plant. It is corresponding that substitute medicines practices with plant extracts including garlic as a means of decreasing the burden of diseases would be of public health importance.

## INTRODUCTION

Garlic, *Allium sativum* L. is plant member of the Liliaceae family, has been widely recognized as a valuable spice and a popular remedy for various ailments and physiological disorders. Garlic is one of the important bulb crops grown and used as a spice or a condiment throughout India. According to the Unani and Ayurvedic systems as practised in India, garlic is carminative and is a gastric stimulant and thus help in digestion and absorption of food. Allicin present in aqueous extract of garlic reduces cholesterol concentration in human blood. Garlic extract has antimicrobial activity against many genera of bacteria, fungi and viruses. Garlic contains a higher concentration of sulfur compounds which are responsible for its medicinal effects. The chemical constituents of garlic have also been investigated for treatment of cardiovascular disease, cancer, diabetes, blood pressure, atherosclerosis and hyperlipidaemia and highly praised by several authors. Therefore, this paper is reviewed to inspire and impress the young researchers about the medicinal values of garlic. The inhalation of garlic oil or garlic juice has generally been recommended by doctors in case of pulmonary tuberculosis, rheumatism, sterility, impotency, cough and red eyes. Garlic possesses insecticidal action. About 1% garlic extract gives protection against mosquitoes for 8 hours. Extract of garlic along with chilli and ginger has beneficial action against soil nematodes. Beneficial use of garlic extract has been found against many fungi. Garlic is probably one of the earliest known medicinal plants, which used from ancient time to cure different disease conditions in human. Garlic's principal medicinal uses are to lower blood pressure and cholesterol, fight infections, and prevent cancer. The main interest of researchers in the medicinal values of garlic is its broad-spectrum therapeutic effect with minimal toxicity. Garlic extract has antimicrobial activity against many genera of bacteria, fungi and viruses. Garlic contains a higher concentration of lavoura compounds which are responsible for its medicinal effects. Natural products of animals, plants and microbial sources have been used by man for thousands of years either in the pure forms or crude extracts to treat many diseases (Parekh and Chanda, 2007). Garlic (*Allium sativum* L.) is one of those plants that were seriously investigated over several years and used for centuries to fight infectious diseases (Onyeagba *et al.*, 2004). The taxonomic position of garlic and related genera had been a matter of controversy for long period of time. The most recent classification scheme of garlic was class Liliopsida, subclass Liliidae, superorder Liliianae, order Amaryllidales, family Liliaceae, subfamily Allioideae, tribe Allieae and genus *Allium* which is mainly based on the sequences of nuclear ribosomal DNA (Friesen *et al.*, 2006). The name garlic may have originated from the Celtic word 'all' meaning pungent. Cultivated practically throughout the world, garlic appears to have originated in central Asia and then spread to China, the Near East, and the Mediterranean region before moving west to Central and Southern Europe, Northern Africa

(Egypt) and Mexico (Singh VK, Singh DK *et al.*, 2008)). Garlic has been used for thousands of years for medicinal purposes. Sanskrit records show its medicinal use about 5,000 years ago, and it has been used for at least 3,000 years in Chinese medicine. The Egyptians, Babylonians, Greeks, and Romans used garlic for healing purposes. In 1858, Pasteur noted garlic's antibacterial activity, and it was used as an antiseptic to prevent gangrene during World War I and World War II. Garlic's current principal medicinal uses are to prevent and treat cardiovascular disease by lowering blood pressure and cholesterol, as an antimicrobial, and as a preventive agent for cancer. The early Egyptians used garlic to treat diarrhea and its medical power was described on the walls of ancient temples and on papyrus dating to 1500 BC (Bradley, 1992). It was used by Greek physicians Hippocrates and Galen to treat intestinal and extra-intestinal diseases; ancient Japanese and Chinese used it to treat headache, flu, sore throat and fever. In Africa, particularly in Nigeria, it is used to treat abdominal discomfort, diarrhea, otitis media and respiratory tract infections (Jaber and Al-Mossawi, 2007). In Europe and India, it was used to treat common colds, hay fever and asthma. Garlic is nicknamed as Russian penicillin for its widespread use as a topical and systemic antimicrobial agent; it is commonly used in many cultures as an excitement and reputation of healing power (Timbo *et al.*, 2006). The natural products are found to be more effective with least side effects as compared to commercial antibiotics so that reason they are used an alternated remedy for treatment of various infections. (Tepe *et al.*, 2004). Spices are defined as plant substances used to enhance flavour, they include leaves (mint and coriander), flower (clover), bulbs (garlic, turmeric), fruits (black pepper), stem (cinnamon), rhizomes (ginger and turmeric) (Shelf, 1983). Medicinal plants produce certain bioactive molecules which show both antibacterial and antifungal activities. Many medicinal plants produce antioxidant and antimicrobial properties which protect the host from cellular oxidation reactions and other pathogens highlighting the importance of starch for natural antimicrobial drugs. (Mothana and Lindequist, 2004, Bajpai *et al.*, 2005; Wojdylo *et al.*, 2007). Most of the foods borne bacterial pathogens are sensitive to extracts from plants such as garlic, mustard, onion and oregano. Gram positive bacteria are more sensitive to antimicrobial compounds in spices than G-negative bacteria (Lawson, 1996). Herbs are God nature's gifts to use. Garlic is therapeutically effective because of its oil and water soluble organosulfur compounds, thiosulfinates is mainly responsible for its antibiotic activity as (Hughes and Lawson, 1991) reported that if extract is free from thiosulfinates the antimicrobial capacity will be lost. Garlic has antibacterial and antifungal activity and contains powerful sulphur and numerous phenolic compounds.

## CHEMISTRY OF GARLIC

Garlic contains at least 33 sulfur compounds, several enzymes, 17 amino acids, and minerals such as selenium. It contains a higher concentration of sulfur compounds than any other *Allium* species. The sulfur compounds are responsible both for garlic's pungent odor and many of its medicinal effects. Dried, powdered garlic contains approximately 1% *alliin* (S-allyl cysteine sulfoxide). One of the most biologically active compounds, *allicin* (diallyl thiosulfinate or diallyl disulfide) does not exist in garlic until it is crushed or cut; injury to the garlic bulb activates the enzyme allinase, which metabolizes alliin to allicin. Allicin is further metabolized to vinylthiines. This breakdown occurs within hours at room temperature and within minutes during cooking. Allicin, which was first chemically isolated in the 1940's, has antimicrobial effects against many viruses, bacteria, fungi and parasites. Garlic oil, aged garlic and steam-distilled garlic do not contain significant amounts of alliin or allicin, while instead contain various products of allicin transformation; none appears to have as much physiologic activity as fresh garlic or garlic powder (Kemper KJ *et al.*, 2000). Various workers have studied the flavour of garlic. In 1844, German chemist Wertheim isolated strong smelling volatile substances from steam distilled garlic oil and proposed the name allyl (from *Allium*) for the hydrocarbon group in the oil, and allyl sulphur for the volatiles. Allyl refers to group of structure  $\text{CH}_2 = \text{CHCH}_2$  or  $\text{C}_3\text{H}_5$ . German chemist

F.W. Semmler, isolated diallyl disulphide ( $\text{C}_6\text{H}_{10}\text{S}_2$  or  $\text{CH}_2 = \text{CHCH}_2\text{SSCH}_2\text{CH} = \text{CH}_2$ ), diallyl trisulphide and diallyl tetrasulphide from steam distilled garlic oil in the year 1892. In 1944, Cavallito and co-workers isolated allicin from crushed garlic by aqueous ethanolic extraction followed by steam distillation. The chemical formula of allicin was found to be  $\text{CH}_2 = \text{CHCH}_2\text{S}(\text{O})\text{SCH}_2\text{CH} = \text{CH}_2$ . In 1948, Stoll and Seebeck showed that allicin develops when an enzyme initiate its formation from an odourless precursor molecule, (+)S-allyl-L-cysteine sulfoxide ( $\text{CH}_2 = \text{CHCH}_2\text{S}(\text{O})\text{CH}_2\text{-CH}(\text{NH}_2)\text{COOH}$ ). Stoll and Seebeck named the precursor alliin. It accounts for about 0.24 per cent of the weight of a typical garlic bulb. It can be formed by attaching an allyl group and an oxygen atom to the sulphur atom in the amino acid cysteine. Alliin is a colour less, odour less, water-soluble amino acid present in the intact cells of garlic. Within the cell there are vacuoles that contain an enzyme known as allinase (EC 4.4.1.4). when the cell is crushed/ injured/sliced, the enzyme allinase comes in contact with alliin and causes its breakdown into the sulphur containing product allicin. Allicin is the antibacterial substance of garlic and has the typical odour of fresh garlic. It is a chemically unstable, colour less liquid, which accounts for the odour of garlic. It breaks down into the strong smelling constituents of garlic oil (Block, 1985).

**Table 1: Nutritive Value of Garlic**

Particular	Fresh peeled garlic cloves	Dehydrated garlic powder
Moisture (%)	62.80	5.20
Protein (%)	6.30	17.50
Fat (%)	0.10	0.60
Mineral matter (%)	1.00	3.20
Fibre (%)	0.80	1.90
Carbohydrates (%)	29.00	71.40
Energy k.Cal	145.00	--
Calcium (%)	0.03	0.10
Phosphorus (%)	0.30	0.42
Potassium (%)	--	0.70
Magnesium (mg/100g)	71.00	--
Iron (%)	0.001	0.004
Niacin (%)	--	0.70
Sodium (%)	--	0.01
Copper (mg/100g)	0.63	--
Manganese (mg/100g)	0.86	--
Zink (mg/100g)	1.93	--
Chromium (mg/100g)	0.02	--
Vitamin A (IU)	0.40	175.00
Nicotinic acid (mg/100g)	0.40	--
Vitamin C (mg/100g)	13.00	12.00
Vitamin B (mg/100g)	16.00	0.68
Riboflavin B <sub>2</sub> (mg/100g)	0.23	0.08
Thiamine (mg/100g)	0.06	--

**Source:** *Vegetable crops in India* T.K. Bose & M.G. Som (Ed.) & NIN, Hyderabad

## ROLE OF GARLIC IN MEDITIONAL VALUES:

**Antibacterial Potential:** (Singh VK, Singh DK *et al.*, 2009). According to the tested antimicrobial activity of constituents and their chemical characteristics, a new formulation of oral antiseptic was made based on garlic bulb powder and its active principles with strong antimicrobial activity against a wide range of bacteria and fungi. The antimicrobial activity of garlic bulb powder, allicin and the lozenge with 15% of garlic powder was tested using broth microdilution method. The tested garlic powder, as well the lozenge, have shown very high antimicrobial activity with MIC 1.25–5.00 mg/ml, and 1.87–7.50 mg/ml, respectively. The major compound, allicin, was highly active at a very low concentration. The minimal inhibitory concentration of allicin was from 6.25–12.50 µg/ml for antibacterial activity and 0.4 µg/ml for antifungal activity. Those concentrations are comparable with concentrations of commercially available antibiotics and fungicides. The formulation of an antiseptic with herbal constituents, high antibacterial and antifungal activity and pleasant taste could be an alternative to classic

### Medicinal Uses

According to the (Dr. Lisa Waltz, Herbal Encyclopaedia, 1999-2000. In herbal Medicine, garlic has been atherosclerosis traditionally used for asthma, deafness leprosy, bronchial congestion, arteriosclerosis i.e. hardening of arteries, fevers, worms and liver gall bladder trouble. Garlic is good for the heart, a food for the hair and a stimulant to appetite. In recent times, experiments have confirmed several ancient beliefs about the healing value of this herb. These experiments have in fact proven much greater power of garlic than known previously. The unpleasant odour in garlic is due to its sulphur content. This mineral is content to a greater degree in its volatile oil, which has remarkable medicinal values, some of the medicinal uses are:

**Chest diseases:** Garlic has proved effective in certain diseases of the chest. It reduces stinking of the breath in pulmonary gangrene. Garlic is also useful in the treatment of tuberculosis. In Ayurveda a decoction of garlic boiled in milk is considered a wonderful drug for tuberculosis. One gram of garlic, 250ml of milk and a liter of water are boiled together till it reduces to one fourth of the decoction. It should be taken thrice a day. Taken in sufficient quantities, it is marvelous remedy for pneumonia; (Breithaupt-Grogler, K., *et al.*, 1997).

**Asthma:** Three cloves of garlic boiled in milk can be used every night with excellent results in asthma. A pod of garlic is peeled, crushed and boiled in 120ml pure malt vinegar. It is strained after cooling and an equal quantity of honey is mixed and preserve in a

clean bottle. One or two teaspoon of this syrup can be taken with fenugreek decoction in the evening and before retiring. This has been found effective in reducing the severity of asthmatic attacks.

**Digestive disorders:** Garlic is one of the most important herbs for the digestive systems. It stimulates peristalsis or movement of the intestines and the secretion of the digestive juices; Prescription for Nutritional Healing, Third Edition. James F. (2000).

**High Blood Pressure:** Garlic is one of the most effective remedies for lowering blood pressure; Pressure and tension are reduced because it has the power to ease the spasm of the small arteries. It also modifies the pulse and modifies the heart rhythm. Rheumatism: In Russia garlic is used extensively in the treatment of rheumatism and associated diseases. Even in Britain, garlic is recommended for Rheumatic afflictions; The Green Pharmacy-James A. (1997).

**Heart attack:** Garlic helps to break up cholesterol in the blood vessels, thereby preventing any hardening of arteries which leads to high blood pressure and heart attack. If a patient takes garlic after a heart attack, the cholesterol level comes down. Though the earlier damage may not be repaired, the chances of new attacks are reduced; Herbs of the Bible: (2000).

**Blood Disorders:** The herb is regarded as a rejuvenator. It has been found to help remove toxins revitalise the blood, stimulate circulation and promote intestinal flora, or colony of bacteria that prevent infection by harmful bacteria; Herbs of the Bible: (2000).

**Skin Disorder:** Garlic has been used successfully for a variety of skin disorders. Pimples disappear without a scar when rubbed with raw garlic several times a day. Even very persistence forms of acne in some adults, have been healed with garlic. Garlic rubbed over ringworm, gives quick relief. The area is burnt by the strong garlic and later the skin peels off and the ring worm is cured; Herbs of the Bible: (2000).

**Other uses:** Garlic has a pronounced aphrodisiac effect. It is a tonic for the loss of sexual power from any causes. It also treats sexual debility and impotency caused by overindulgence in sex and nervous exhaustion from dissipating habit .It is said to be especially useful to old men with nervous tension and falling libido; Herbs of the Bible: (2000).

### Uses and Benefits

Garlic is one of the oldest herbal remedies; it was a favored food in the Old Testament and has been accorded almost magical properties in various cultures. It was considered a cure all and aphrodisiac. Garlic has been employed to treat infections, wounds, respiratory conditions, diarrhea, rheumatism, heart disease, diabetes, and many other disorders. Currently, it is most often used as an antithrombotic and antioxidant herb to help prevent heart disease, atherosclerosis, and cancer. It is widely promoted to reduce abnormal cholesterol and blood pressure levels; Herbs of the Bible: (2000).

## HEALTH BENEFITS OF GARLIC

### Garlic the broad-spectrum natural antibiotic

As these enzymes are found in a large variety of different infectious organisms, including bacteria, viruses and fungi, it becomes clear why allicin is such a broad-spectrum microbial agent which is capable of treating so many kinds of infections. Harmful and infectious organisms do not become resistant or immune to garlic. The study also found that allicin blocks the two groups of enzymes by reacting with sulfhydryl (SH) groups, or thiols, which is an important component of these enzymes. And, because the organisms are unlikely to change or modify the enzymes which play a critical part in their activity, it is thus very unlikely that they would become resistant to allicin; this is totally in contrast to pharmaceutical drugs and antibiotics. Increasingly, there is a big problem with harmful and infectious organisms adapting and mutating to become drug-resistant, dangerous strains which do even more damage to us and animals; Herbs of the Bible: (2000).

### Healing Properties

Garlic has many healing properties, but the most research has been done on its potential to help reduce heart disease. Garlic has been intensively studied, and numerous large studies have shown that taking supplements that mimic fresh garlic can significantly lower LDL cholesterol levels without hurting beneficial HDL cholesterol levels. Garlic appears to act by blocking the liver from making too much LDL cholesterol. There is also some evidence that garlic supplements can mildly lower blood pressure by dilating or expanding blood vessels. And garlic helps prevent; Herbs of the Bible: (2000)

**Blood clots:** and therefore reduces the risk of heart attack and stroke by decreasing the stickiness of platelets, which are tiny disk-shaped bodies in the blood that are necessary for blood clotting. When platelets are too sticky, they form clumps that can

adhere to artery walls and contribute to clogged arteries. Garlic has also been shown to reduce pain and other symptoms in people with rheumatoid arthritis. And it reduces the size of some cancerous tumors and helps prevent some cancers, particularly those in the intestines. However, the research on this is not nearly as far advanced as that for garlic and heart disease, so do not use garlic supplements without consulting with a natural health care professional. One of the oldest uses of garlic, however, is as an antibiotic. Garlic kills a range of microbes, including viruses, bacteria, fungi, and parasites, and can be effective against such conditions as athlete's foot, thrush (a fungal infection of the mouth), viral diarrhea, and the ulcer-causing bacteria *Helicobacter pylori*. Only fresh garlic or supplements that mimic it have these effects; Herbs of the Bible: (2000).

### Garlic for Health

Today, we know garlic is an excellent herb for creating and maintaining overall health, but it also has many lesser known, but powerful qualities. For example, many people don't know that it's a naturally powerful antibiotic. This natural antibiotic is effective against toxic bacteria, viruses, and fungus. Available in pills, capsules, liquid and actual raw cloves, garlic is one of the most popular healthy herbs around today. Garlic helps platelet stickiness or aggregation to help reduce blood coagulation, and promote heart health. The antioxidant properties of garlic help scavenge harmful free radicals, which can damage LDL (bad) cholesterol in the blood stream. Garlic also promotes increased bile production to help reduce levels of fat in the liver. Garlic pills also help ward off coughs and colds; Herbs of the Bible: (2000; Herbs of the Bible: 2000).

### Garlic and Heart

The positive effect of garlic on your circulatory system is extremely well documented and it has been proved to: lower blood pressure decrease platelet aggregation lower serum triglycerides and LDL-cholesterol (the bad type) levels increase serum HDL-cholesterol (the good type) and fibrinolysis (the process through which the body breaks up blood clots.) Plus it stimulates the production of nitric oxide in the lining of blood vessel walls, a substance that helps them to relax. As a result of these beneficial actions garlic helps to prevent arteriosclerosis and thereby reduces the risk of heart attack or stroke. Two or three cloves a day have cut the risk of subsequent heart attacks in half in heart patients. One reason for these beneficial effects may be garlic's ability to reduce the amount of free radicals in the bloodstream. According to a study published in Life Sciences, a daily dose of 1 ml/kg body weight of garlic extract for a period of 6 months resulted in a significant reduction in oxidant (free radical) stress in the blood of arteriosclerosis patients. It's positive effect

on the circulatory system improves blood flow throughout the body so has even been hailed as a cure for impotence; Herbs of the Bible: (2000).

### Garlic and Cancer

Current research has shown that a number of readily available foods such as garlic and onions that make up a healthy diet, actually have a major impact on cancer prevention. The protective effect of garlic seems to be greater than that of onions, even though onion consumption has been shown to reduce the risk of stomach cancer. These cancer fighting foods seem to have the ability to interfere with the development of cancerous tumors. The October 2000 issue of the American Journal of Nutrition had a summary of a number epidemiologic studies which showed that people who consumed cooked or raw garlic on a regular basis compared to those that ate little or none had about half the risk of stomach cancer and one-third less risk of colorectal cancer. This remarkable little bulb now tops the American National Cancer Institute's 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 alliin have also been shown to retard cancer cells as a type of natural chemotherapy. The Iowa Women's Health Study discovered that women who included garlic in their daily diet had lower risks for colon cancer. Meat cooked at high temperatures (well done to burnt) can produce carcinogenic (cancer producing) chemicals and research has recently discovered that when meat is cooked with garlic this effect is limited. The ten best groups of anti-cancer foods include: berries and citrus fruits, cruciferous vegetables, garlic and onions, green tea, omega 3 essential fatty acids, olive oil, tomatoes, soy products, red wine and dark chocolate; Herbs of the Bible: (2000).

### Garlic and the Brain

Studies conducted on animals have shown improvement in brain function after eating garlic. It is possible that antioxidants in garlic neutralize and destroy the free radicals which have accumulated in the body. If so, this will make garlic useful in treating persons who suffer from Alzheimer's disease which is caused by free radical accumulation. Researchers in China have also shown that the sulfur compound sallylcystein found in garlic prevents the degeneration of the brain's frontal lobes. Thus, eating garlic may even make one more intelligent; Herbs of the Bible: (2000).

### Antibacterial activity of alliin

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*.

### Antifungal activity of alliin

Garlic extracts also have a strong antifungal effect and inhibit the formation of mycotoxins like the aflatoxin of *Aspergillus parasiticus* (Lawson L.D., 1996). Alliin was assumed to be the main component responsible for the inhibition of fungal growth. A concentrated garlic extract containing 34% alliin, 44% total thiosulfinates, and 20% vinyldithiins possessed potent in vitro fungistatic and fungicidal activity against three different isolates of *Cryptococcus neoformans*. The minimum inhibitory concentration of the concentrated garlic extract against  $1 \times 10^5$  organisms of *C. neoformans* ranged from 6 to 12  $\mu\text{g/mL}$ . In addition, in vitro synergistic fungistatic activity with amphotericin B was demonstrated against all isolates of *C. neoformans* (Davis L.E., Shen J., Royer R.E., 1994). Pure alliin was found to have a high anticandidal activity with a minimum inhibitory concentration of 7  $\mu\text{g/mL}$  (Hugges B.G., Lawson L.D., 1991). (Yamada and Azuma (Yamada Y., Azuma K., 1997) report that pure alliin was effective in vitro against species of *Candida*, *Cryptococcus*, *Trichophyton*, *Epidermophyton*, and *Microsporum* at low concentration (minimal inhibitory concentrations of alliin was between 1.57 and 6.25  $\mu\text{g/mL}$ ). Alliin inhibits both germination of spores and growth of hyphae (Yamada Y., Azuma K., 1997). The sensitivities of various clinically important yeasts to a pure preparation of alliin were determined and found to be very significant (Mirelman et al., unpublished results). The mode of action of alliin on the fungal cell has not yet been elucidated but it is assumed to function on thiol enzymes as in other microorganisms (see below).

### Antiparasitic prope Antiparasitic properties of alliin

The antiparasitic effects of freshly crushed garlic were to treat people suffering from dysentery or intestinal worms with freshly crushed garlic. One of the traditional Chinese medical treatments for intestinal diseases is an alcoholic extract of crushed garlic cloves. Several years ago we found out that *Entamoeba histolytica*, the human intestinal protozoan parasite, is very sensitive to alliin, as only 30  $\mu\text{g/mL}$  of alliin totally inhibits the growth of amoeba cultures (Mirelman D., Monheit D., Varon S., 1987). More

recently we have found that at lower concentrations (5 µg/mL), allicin inhibited by 90% the virulence of trophozoites of *E. histolytica* as determined by their inability to destroy monolayers of tissue-cultured mammalian cells in vitro (Ankri S., Miron T., Rabinkov A., Wilchek M., Mirelman D., 1997). Allicin (30 µg/mL) also very efficiently inhibited the growth of other protozoan parasites such as *Giardia lamblia*, *Leishmania major*, *Leptomonas colosoma*, and *Crithidia fasciculata* (Mirelman *et al.*, unpublished results). Some allicin toxicity towards tissue-cultured mammalian cells was observed at concentrations above 100 µM (Ankri S., Miron T., Rabinkov A., Wilchek M., Mirelman D., 1997). Interestingly however, at these high allicin concentrations no damage to the mammalian cells was seen if the incubations were done in the presence of amoebic trophozoites, suggesting that the affinity of the allicin molecules is towards the parasite targets. The reason for microbial cells' higher sensitivity to allicin than that of mammalian cells is that most of the microbial cells do not have, or have very small amounts of, glutathione (or its equivalent thiol molecules such as trypanothione) and thus lack the ability to reactivate the essential SH-enzymes that are thiolated by allicin (see below).

### Antiviral activity of allicin

Fresh garlic extracts in which allicin is known to be the main active component have been shown to have in vitro and in vivo antiviral activity. Among the viruses which are sensitive to garlic extracts are the human cytomegalovirus, influenza B, herpes simplex virus type 1, herpes simplex virus type 2, parainfluenza virus type 3, vaccinia virus, vesicular stomatitis virus, and human rhinovirus type 2 (Tsai Y., Cole L.L., Davis I.E., Lockwood S.J., Simmons V., Wild G.C., 1985). The allicin condensation product, ajoene, seems to have in general more antiviral activity than allicin. Ajoene was found to block the integrin-dependent processes in a human immunodeficiency virus-infected cell system (Tarantsev A.V., Vrzhetz P.V., Ershov D.E., Turgiev A.S., Karamov E.V., Kornilaeva G.V., Makarova T.V., Fedorov N.A., Varfolomeev S.D., 1992). Interestingly, there are some viruses like the garlic plant virus X which are resistant to the antiviral effects of garlic extracts (Song S.I., Song J.T., Chang M.U., Lee J.S., Choi Y.D., 1997).

### Mechanism of action of allicin

Inhibition of certain thiol-containing enzymes in the microorganisms by the rapid reaction of thiosulfonates with thiol groups was assumed to be the main mechanism involved in the antibiotic effect (Cavallito C., Bailey J.H., 1944). Recently, we have studied the mechanism of action of pure allicin molecules with thiol groups in more detail (Rabinkov A., Miron T.,

Konstantinovski L., Wilchek M., Mirelman D., Weiner L., 1998). This study confirmed the ability of allicin to react with a model thiol compound (L-cysteine) to form the S-thiolation product, S-allylmercaptocysteine. The identification of the thiolation product was proven by nuclear magnetic resonance as well as by mass spectroscopy. The main antimicrobial effect of allicin is due to its interaction with important thiol-containing enzymes. In the amoeba parasite, allicin was found to strongly inhibit the cysteine proteinases, alcohol dehydrogenases (Ankri S., Miron T., Rabinkov A., Wilchek M., Mirelman D., 1997), as well as the thioredoxin reductases (Ankri *et al.*, unpublished results) which are critical for maintaining the correct redox state within the parasite. Inhibition of these enzymes was observed at rather low concentrations (< 10 µg/mL). Allicin also irreversibly inhibited the well known thiol-protease papain, the NADP<sup>+</sup>-dependent alcohol dehydrogenase from *Thermoanaerobium brockii*, and the NAD<sup>+</sup>-dependent alcohol dehydrogenase from horse liver. Interestingly, all three enzymes could be reactivated with thiol-containing compounds such as DTT, mercaptoethanol, and glutathione. At (Rabinkov A., Miron T., Konstantinovski L., Wilchek M., Mirelman D., Weiner L., 1998) concentrations that are at least a log higher (> 100 µg/mL), allicin was also found to be toxic to tissue-cultured mammalian cells (Ankri S., Miron T., Rabinkov A., Wilchek M., Mirelman D., 1997). As mentioned above, the significant difference in sensitivity between the microbial and mammalian cells may be explained by the much higher concentrations of glutathione that the mammalian cells possess. Allicin also specifically inhibits other bacterial enzymes such as the acetyl-CoA-forming system, consisting of acetate kinase and phosphotransacetyl-CoA synthetase (Focke M., Feld A., Lichrenthaler K., 1990). The inhibition is noncovalent and reversible. (14C) acetate incorporation into fatty acids of isolated plastids was inhibited by allicin with a 50% inhibitory concentration (I<sub>50</sub> value) lower than 10 mM. Furthermore, allicin at bacteriostatic concentrations (0.2 to 0.5 mM) was found to partially inhibit, in *Salmonella typhimurium*, the DNA and protein synthesis, but the effect on RNA synthesis was immediate, suggesting that this could be a primary target of allicin action (Feldberg R.S., Chang S.C., Kotik A.N., Nsdler M., Neuwirt Z., Sundstom D.C., Thompson N.H., 1988). *E. coli* RNA polymerase, in its alpha-subunit, contains a single sulfhydryl group which was shown to react with the monomeric derivative of fluorescein, a specific reagent for thiol groups (fluorescein monomercuroacetate) (Ozolin O.N., Uteshev T.A., Kim I.A., Deev A.A., Kamzolova S.G., 1990). This suggests that RNA polymerase could also be a target for allicin. The condensation product of allicin, ajoene, which has a similar oxygenated sulfur group, has been shown to inhibit the proliferation of *Trypanosoma cruzi*, possibly by inhibition of phosphatidylcholine biosynthesis (Urbina J.A., Marchan E., Lazard K., Visbal G., Apitz Castro R., Gil F., Aguirre T., Piras M.M., Piras R., 1993). Ajoene was also recently shown to inhibit phosphatidylcholine

biosynthesis in the human pathogenic fungus *Paracoccidioides brasiliensis*. The inhibition capacities shown for ajoene clearly suggest that additional microbe-specific enzymes may also be targets for allicin. It is reasonable to conclude, therefore, that the widespectrum antimicrobial effects of allicin (and ajoene) are due to the multiple inhibitory effects they may have on various thiol-dependent enzymatic systems. It is difficult at this stage to state which are the more lethal targets. It could very well be that the effect of allicin may be at different levels. Some enzymes such as the thiol proteases, which cause severe damage to the host tissues, may be inhibited at the lowest concentrations. At low concentrations the inhibition of these enzymes may not be lethal, but sufficient to block the microbe's virulence. At slightly higher concentrations other enzymes such as the dehydrogenases or thioredoxin reductases may be affected, and even partial inhibition of these enzymes could be lethal for the microorganism. All the above descriptions on the wide range of biological activities that allicin has been found to have should have propelled this molecule into becoming a prime candidate for therapeutical use. Unfortunately, until now pharmaceutical companies have not become interested in investing in the development of this antimicrobial molecule as a drug and in performing the necessary preclinical and clinical efficacy trials. The reasons for this unfortunate situation are that no patents can be submitted on allicin due to its long-standing presence in the public domain. This is not the first time that economic considerations will prevent a natural compound with superb medicinal properties to reach those patients that could most benefit from it.

## ROLE OF GARLIC IN HEALTH

Garlic can rightfully be called one of nature's wonderful plants with healing power. It can inhibit and kill bacteria, fungi, lower (blood pressure, blood cholesterol and blood sugar), prevent blood clotting, and contains anti-tumor properties. It can also boost the immune system to fight off potential disease and maintain health (Abdullah *et al.*, 1988). It has the ability to stimulate the lymphatic system which expedites the removal of waste products from the body. It is also considered an effective antioxidant to protect cells against free radical damage. It can help to prevent some forms of cancer, heart disease, strokes and viral infections. Garlic alone can provide us with over two hundred unusual chemicals that have the capability of protecting the human body from a wide variety of diseases. The sulfur containing compounds found in garlic afford the human body with protection by stimulating the production of certain beneficial enzymes (Mansell and Reckless, 1991).

### Treat cardiovascular disease

Disorders of the heart and the circulatory system claim more lives than any other diseases. It is the obstruction or clogging of the coronary arteries which causes more deaths than any other factors. The arteries, which supply the heart with blood and oxygen, become increasingly narrower as plaque builds up over time. When blood supply becomes restricted, a certain portion of the heart is deprived of oxygen and leads to heart attack. The two greatest means of heart disease are high blood pressure and high blood serum cholesterol levels; which are directly impacted by the therapeutic action of garlic. The relevant role of garlic in coronary heart disease was done on rabbits and found that even pre-existing athero-sclerotic deposits and lesions could actually be reversed if garlic was consistently consumed (Bordia, 1981). From a study conducted in India, 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 result showed that within the three years of the study time, nearly twice as many patients had died in the group not supplied with garlic juice (Yeh *et al.*, 2006). 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 retention (Borek, 2006).

### Reduces high blood pressure/hypertension

Garlic has probably been most popularized as a complementary therapy for blood pressure control (Capraz *et al.*, 2006). A recent *in vitro* study has confirmed that, the vasoactive ability of garlic sulfur compounds whereby red blood cells convert garlic organic polysulfides into hydrogen sulfide, a known endogenous cardio-protective vascular cell signaling molecule (Benavides *et al.*, 2007). Using 2400mg garlic tablet containing 31.2mg allicin has high dose reduced diastolic pressure by 16 mm Hg after 5 h of administration (McMahon and Vargas, 1993). A meta-analysis made on pooled data from 415 patients showed also reduction of 7.7 mm Hg diastolic pressure (Silagy and Neil, 1994).

### As natural blood thinner

Platelets and fibrin play great role in blood clotting and higher amount of fibrin in blood can cause heart attack. Garlic constituents can reduce fibrin formation and also help reduce the fibrin existing in the blood even



better than aspirin (Fukao *et al.*, 2007). Ajoene, a sulfur compound found in garlic seems to be responsible for its anti-clotting effect; but ajoene is only viable at room temperature or above, it is not present in raw or freeze-dried garlic. It is believed that the addition of garlic to a diet can help to increase the breakdown of fibrin from 24 to 30% in people (Ernst, 1994).

### As natural immunity booster

With the arrival of frightening viral diseases like HIV/AIDS, boosting immunity system is receiving a new attention. Because these types of diseases have no effective cures or treatments, strengthening the body's ability to fight off infection has become even more important. Garlic has abundant sulfur containing amino acids and other compounds that seem to initiate increased activity in the immune system (Lau *et al.*, 1991). It is one of the impressive conductors of the body's immune system; which stimulates immune function by making macrophages or killer cells more active. We are constantly beaten by inadequate nutrition, cigarette smoke, physical injury, mental tension and chemical pollution. In light of the enormous pressures, which our immune systems sustain, supplemental nutrients like garlic are clearly needed (Salman *et al.*, 1999). Its remarkable content of germanium alone offers excellent immune stimulation. In addition to germanium, garlic contains thiamine, sulfur, niacin, phosphorous, and selenium (Morioka *et al.*, 1993).

Preliminary studies in humans, using an alliin standardized garlic powder preparation, have demonstrated positive effects on immunoreactions and phagocytosis. In aged subjects, the administration of 600mg garlic powder per day for 3 months induced significant ( $p < 0.01$ ) increases in the percentage of phagocytosing peripheral granulocytes and monocytes when tested *ex vivo* for their ability to engulf *Escherichia coli* bacteria. Another human study was conducted with an unrefined garlic extract (5 to 10 g/day) which was given to HIV/AIDS patients. For the seven patients who completed the 12 weeks study, there was a major increase in the natural killer cells activity from a seriously low mean value (Abdullah *et al.*, 1988).

In USA, trials in HIV/AIDS patients have demonstrated the enhancement of natural killer cells activity using garlic extracts; and Chinese studies with viral infections in bone marrow transplant patients have demonstrated a "potent antiviral activity". A double blind placebo controlled survey using a 100% allicin yielding supplement has reported that allicin can reduce the occurrence of the common cold and recovered from symptoms (Josling, 2001).

### Atherosclerosis and hyperlipidaemia

Health claims advertizing garlic's universal ability to lower cholesterol level and decrease lipid peroxidation in order to inhibit plaque formation. *In vitro* studies clearly have shown that, it has an ability to suppress low density lipoprotein (LDL) and an increased resistance of LDL to oxidation (Lau, 2006). Results from controlled human studies are mixed with studies performed in the early 1990's and was showing effective results. As more researches were conducted newer processes to extract garlic, recent study of 15 hypercholesterolemia patients evaluated a material produced from garlic fermented with the mold *Monascus pilosus*. This preparation significantly reduced serum total cholesterol and low density lipoprotein cholesterol levels when checked at 2 and 4 weeks after treatment beginning. The level of triglycerides had a tendency towards reduction in hyper-triglyceridemic patients as well, whereas high density lipoprotein cholesterol was unchanged (Sumioka *et al.*, 2006). After 60 days of supplementation, low-density lipoprotein, serum triglyceride and very low density lipoprotein, were reduced by 21, 37, and 36.7%, respectively (Jeyaraj *et al.*, 2006).

### Prevents diabetes

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 mice. Most of the studies showed that garlic can reduce blood glucose level in diabetic mice and rabbits (Ohaeri, 2001). A study was conducted to evaluate oral administration of garlic extract for 14 days on the level of serum glucose, total cholesterol, triglycerides, urea and uric acid, in normal and streptozotocin-induced diabetic mice. The result of the study showed significant decrease ( $p < 0.05$ ) in serum glucose, total cholesterol, triglycerides, urea, uric acid, aspartate amino transferase and alanine amino transferase levels, while increased serum insulin in diabetic mice, but not in normal mice. From a comparison study made between the action of garlic extract and glibenclamide, it was shown that the antidiabetic effect of the garlic was more effective than the glibenclamide (Eidi *et al.*, 2006).

### Anticancer

Of the many favorable actions of garlic, inhibition of the growth of cancer is perhaps the most prominent. It has several synergistic effects that either prevent or possibly may fight cancer. The action of garlic has been attributed to stimulate immune effector cells including T-cell and natural killer cells. Numerous epidemiological, clinical and laboratory studies have demonstrated that, garlic has a great role in cancer prevention especially in relation to digestive tract cancers. Human population studies have shown that,

regular intake of garlic reduces the risk of esophageal, stomach and colon cancer. This was thought to be due to the antioxidant effect of allicin in reducing the formation of carcinogenic compounds in the gastrointestinal tract (Galeone *et al.*, 2006).

Dutch research in the Netherlands cohort study found a significant decrease in the development of stomach cancer in those consuming garlic close relatives of onions (Dorant *et al.*, 1996). Garlic reduces the risk of patients with prostate cancer, especially those with localized disease. Men in the higher of two intake categories of total *Allium* vegetables (>10.0 g/day) had a statistically significant lower risk of prostate cancer than those in the lowest category (<2.2 g/day). Similar comparisons between categories showed reductions in risk for men in the highest intake categories for garlic specifically. The reduced risk of prostate cancer was independent of body size, intake of other foods and total calorie intake and was more pronounced for men with localized prostate cancer than with advanced prostate cancer (Hsing *et al.*, 2002). Prostate specific antigen serum markers had significant decreases during short term ingestion, but returned to baseline after 4 weeks (Moriyama *et al.*, 2006).

A very important epidemiological study for Americans has been published in which the intake of 127 foods (including 44 vegetables and fruits) was determined in 41,387 women (ages 55 to 69) followed by a five year monitoring of colon cancer incidence. The most striking result of this "Iowa Women's Health Study" was the finding that garlic was the only food which showed a statistically significant association with decreased colon cancer risk. For cancers anywhere in the colon, the modest consumption of one or more servings of garlic (fresh or powdered) per week resulted in a 35% lower risk, while a 50% lower risk was found for cancer of the distal colon (Steinmetz *et al.*, 1994).

### Dermatologic applications

A study examined 43 persons for their topical use of two different garlic extracts for wart and corn treatment. Of these persons, 15 volunteers utilized a water extract of garlic, while 23 volunteers applied lipid extract to appropriate areas twice a day. Five controls applied only a neutral solvent. All lipid extract volunteers experienced complete resolution of wart and 80% of corn within one to two weeks. The water extract seemed to be less potent, with complete dissolution of smaller warts and corns, and only partial dissolution of larger ones. Controls showed no improvement from baseline. The lipid extract did cause some burning, redness, blistering and skin darkening, which was resolved after conclusion of use (Dehghani *et al.*, 2005).

### Antimicrobial

The antimicrobial properties of garlic were first described by Pasteur (1958), and since then, many researches had demonstrated its effectiveness and broad spectrum antimicrobial activity against many species of bacteria, viruses, parasites, protozoan and fungi (Jaber and Al-Mossawi, 2007). Garlic is more effective with least side effects as compared to commercial antibiotics; as a result, they are used as an alternative remedy for treatment of various infections (Tepe *et al.*, 2004). Out of the many medicinal plants, garlic has an antimicrobial property which protects the host from other pathogens highlighting the importance of search for natural antimicrobial drugs (Bajpai *et al.*, 2005; Wojdylo *et al.*, 2007). Previously conducted researches confirmed that garlic is not only effective against Gram positive and Gram negative bacteria but also possess antiviral and antifungal activities (Tsao and Yin, 2001).

### Antiviral

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 thiosulfanate > methyl allyl thiosulfanate; no activity was found for the polar fractions, alliin, deoxyalliin, diallyl disulfide, or diallyl trisulfide. Several laboratory tests have shown that garlic is an effective 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). 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).

### Antibacterial

Garlic extract inhibits the growth of Gram positive and Gram negative bacteria, such as *Staphylococcus*, *Streptococcus*, *Micrococcus*, *Enterobacter*, *Escherichia*, *Klebsiella*, *Lactobacillus*, *Pseudomonas*, *Shigella*, *Salmonella*, *Proteus*, and *Helicobacter pylori* (Tsao and Yin, 2001). Its antibacterial activity is mainly due to the presence of allicin produced by the enzymatic activity of allinase on alliin. Allicin is considered to be the most potent antibacterial agent in crushed garlic extracts, but it can be unstable, breaking down within 16 h at 23°C (Hahn, 1996). However, the use of a water-based extract of allicin stabilizes the allicin molecule due to the hydrogen bonding of water to the reactive oxygen atom in allicin

or there may be water soluble components in crushed garlic that destabilize the molecule (Lawson, 1996). The disadvantage of this approach is that allicin can react with water to form diallyl disulphide, which does not exhibit the same level of antibacterial activity of allicin (Lawson and Wang, 1996).

### **Antifungal**

Ajoene is an active compound found in garlic which plays a great role as topical antifungal agent (Ledezma and Apitz-Castro, 2006). 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). 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).

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 ring-worm, 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).

### **Antiparasitic**

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). *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). 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).

### **Role of garlic against multi-drug resistant bacteria**

Garlic is active against microorganisms that are resistant to antibiotics and the combination of garlic extracts with antibiotics leads to partial and total synergism (Didry et al., 1992). The emergence of multi-drug resistant strains of Gram negative (*Pseudomonas*, *Klebsiella*, *Enterobacter*, *Acinetobacter*, *Salmonella* species, etc) and Gram positive (*Staphylococcus*, *Enterococcus*, *Streptococcus* species, etc) bacteria is troubling for human and animals. The emergence of epidemic methicillin resistant *Staphylococcus aureus* (MRSA) resistant to mupirocin has led many authors to suggest that the use of mupirocin should be controlled more strictly, especially as there is a lack of alternative agents. Consequently, garlic is an alternative agent for the treatment of MRSA and in a great demand (Sharma et al., 2005).

### **Role of garlic against multi-drug resistant tuberculosis (MDR-TB)**

Scientific evidence from randomized clinical trials supports the use of garlic and enhances access for MDR-TB infected people, through the public health system. Its use can allow an effective MDR-TB management, due to its affordability and the absence of toxic effects (Catia et al., 2011). In view of the increased incidence of MDR-TB, the research of new anti-tubercular drugs based on affordable and more effective treatments has already begun. Studies on innovative alternative plant extracts of medicinal values need to be emphasized, as plants are an important source of new antimicrobial agents, with little toxicity, able to replace drugs to which *Mycobacterium* resistance has occurred (Amin et al., 2009).

As garlic is concerned, the *in vitro* tests undertaken about the inhibitory effect on MDR-TB are at an advanced stage whereas few researches *in vivo* have been conducted. The concentration of garlic extract required was in the range of 1.34 to 3.35 mg/ml suggesting that there is only a slight variation in the susceptibility of the strains to allicin (Delaha and Garagusi, 1985). The anti-tuberculosis activity *in vivo* of garlic oil preparation was demonstrated in a study of guinea pigs which were given an intra-peritoneal dose of 0.5 mg/kg. However, when garlic oil was used, a reduced causative process was noted in the organs involved, indicating that garlic oil administration causes less marked lesions in the viscera of the animals inoculated with tubercle bacilli (Jain, 1998). The high potential of garlic extract was revealed to inhibit the growth of *Mycobacterium tuberculosis* H37Rv and *M. tuberculosis* TRC-C1193, susceptible and resistant to isoniazid (first-line anti-tuberculosis medication), respectively. The minimum inhibitory concentration (MIC) of garlic was between 80 and 160 µg/ml for the

susceptible strain and 100 and 200 µg/ml for the resistant strain. In addition, water extract of garlic was proven to inhibit the incorporation of <sup>14</sup>C glycine into the whole cells, indicating that the primary mechanism of action is by inhibition of protein synthesis (Ratnakar and Murthy, 1996).

An interesting *in vitro* test about the anti-tubercular activity of garlic was performed in Nigeria using disc diffusion method and compared with standard antibiotics. The anti-tubercular activity of garlic on multiple-drug resistant *Mycobacterium* was investigated among Nigerian HIV-infected-persons and it exhibited maximal activity against all isolates even at reduced concentrations. Only two of the standard anti-tubercular antibiotics used, streptomycin and rifampicin, showed significant activity against isolates tested (Dibua, 2010).

### Antioxidant

Whole garlic and aged garlic extract exhibit direct antioxidant effects and enhance the serum levels of two antioxidant enzymes, catalase and glutathione peroxidase (Prasad *et al.*, 1995). Garlic extract, allicin is efficiently scavenged exogenously generated hydroxyl radicals in a dose dependent fashion, but their effectiveness was reduced about 10% by heating to 100°C for 20 min. Other garlic constituents, such as S-allyl cysteine, also confirmed significant antioxidant effects. The sulfur compounds found in fresh garlic appear to be nearly 1000 times more potent as antioxidants than crude, aged garlic extract. Garlic (both the homogenate of 10% in physiological saline solution and its supernatant) was able to reduce the radicals present in cigarette smoke (Torok *et al.*, 1994).

### Drug toxicities and pharmacokinetics

Glutathione is a compound necessary for liver to facilitate detoxification of substances. It has been hypothesized that garlic organo-sulfur compounds may be able to prevent glutathione depletion. Patients who experience increasing in reactive oxygen induced stress on liver function may be protected by garlic ingestion (Sabayan *et al.*, 2006). It was found in *E. coli* cultures that aged garlic extract, S-allyl cysteine, diallyl sulfide and diallyl disulfide do not interfere with the antibiotic activity of gentamycin but may improve gentamycin-induced nephrotoxicity (Maldonado *et al.*, 2005). Aged garlic has also been shown to reverse oxidant effects of nicotine toxicity in rat studies. More researches are required in the future garlic may be a unique choice to help minimize the toxic effects of therapeutic drugs (Sener *et al.*, 2005).

### Reduces stress

Among the many uses of garlic, it appears to have the fortunate capacity for protecting against the negative effects of stress that affects the autonomic nervous and neuroendocrine system. Rats that were trained with endurance exercises to physical fatigue enjoyed improved parameters of aerobic glucose metabolism, attenuated oxidative stress, and vasodilations, when given garlic at a dosage of 2.86 g/kg for 30 min before exercise (Morihara *et al.*, 2006). In rats exposed to psychologically stressful situations, aged garlic extracts significantly prevented the decreases in spleen weight seen in control animals. Additionally, the garlic significantly prevented the reduction of hemolytic plaque forming cells in spleen cells. Moreover, garlic was able to block the lipopolysaccharide induced immune cytokine and plasma corticosterone and catecholamine changes following cold water immersion stress (Nance *et al.*, 2006). Aged garlic extract is also effective to prevent adrenal hypertrophy, hyperglycemia and elevation of corticosterone in hyperglycemic mice induced by immobilization stress. Given the extreme chronic stress many people now face in their daily life, garlic may prove useful to counter the negative impact of this stress on human physiology (Kasuga *et al.*, 1999).

### 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) and anaphylaxis (Yin and Li, 2007). 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). 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).

### CONCLUSIONS

Garlic, from crushed to capsules, is consumed through-out the world. The active chemical in garlic is allicin, which is produced when raw garlic is crushed, allowing the enzyme allinase to act on the stable precursor allin. Garlic's antidiabetic, antibiotic and perhaps anticancer effects are well-accepted would over because of the many of scientific literature supporting these effects. Garlic also has hepatoprotective, antioxidant, and antihelminthic effect. This review paper demonstrated some of the benefits

of garlic for its potential uses in preventing and curing different diseases, and acting as antioxidant for many radicals. Fresh and powdered garlic are popular for food flavor and should continue to be used. Today, with the ever-growing resistant organisms, taking of garlic extract remains a powerful antimicrobial agent. Clearly more studies are needed to refine the use and improvement of the efficacy of this important medicinal plant. It is corresponding that substitute medicines practices with plant extracts including garlic as a means of decreasing the burden of diseases would be of public health importance.

## REFERENCES

- Abdullah TH, Kandil O, Elkadi A, Carter J. (1988). Garlic revisited: therapeutic for the major diseases of our times? *J Natl Med Assoc.* 80:439-445.
- Amin M, Segatoleslami S, Hashemzadeh M. (2009). Antimycobacterial activity of partial purified extract of *Allium ascalonicum*. *Jundishapur J Microbial.* 2(4):144-147.
- Ankri S, Miron T, Rabinkov A, Wilchek M, Mirelman D. (1997). Allicin from garlic strongly inhibits cysteine proteinases and cytopathic effects of *Entamoeba histolytica*. *Antimicrob. Agents Chemother.* 10:2286-2288.
- Bajpai M, Pande A, Tewari SK, Prakash D. (2005). Phenolic contents and antioxidant activity of some food and medicinal plants. *Int. J. Food Sci. Nutr.* 56(4):287-291.
- Benavides GA, Squadrito GL, Mills RW, Patel HD, Isbell TS, Patel RP, Darley-Usmar VM, Block E. (1985). The Chemistry of garlic and onions. *Scientific American* 252:94-99.
- Bordia A. (1981). Effect of garlic on blood lipids in patients with coronary heart disease. *Am. J. Clin. Nutr.* 34:2100-2103.
- Borek C (2006). Garlic reduces dementia and heart-disease risk. *J. Nutr.* 136(3):810-812.
- Bradley PR. (1992). *British herbal compendium: a handbook of scientific information on widely used plant drugs/published by the British Herbal Medicine Association and produced by its Scientific Committee.* Bournemouth, Dorset. pp. 105-108.
- Breithaupt-Grogler, K., *et al.*, (1997). *Circulation* 96(8): 2649-2655.
- Capraz M, Dilek M, Akpolat T. Garlic. (2006). Hypertension and patient education. *Int. J. Cardiol.* 3:15-19.
- Catia D, Alessia F, Andrea G. (2011). The potential role of garlic (*Allium sativum*) against the multi-drug resistant tuberculosis pandemic: a review *Ann 1st Super Sanità.* 47(4):465-473.
- Cavallito C., Bailey J.H., (1944). Allicin, the antibacterial principle of *Allium sativum*. Isolation, physical properties and antibacterial action. *J. Am. Chem. Soc.* 66 (1944) 1944-1952.
- Davis L.E., Shen J., Royer R.E., (1994). In vitro synergism of concentrated *Allium sativum* extract and amphotericin B against *Cryptococcus neoformans*. *Planta Med.* 60 (1994) 546-549.
- Dehghani F, Merat M, Panjehshahin MR, Handjani F. (2005). Healing effect of garlic extract on warts and corns. *Int. J. Dermatol.* 44:612-615.
- Delaha EC, Garagusi VF. (1985). Inhibition of mycobacteria by garlic extracts *Allium sativum*. *Antimicrob Agents Chemother.* 27(4):485-486.
- Dibua UE, Odo GE, Udengwu S. (2010). Esimone CO. Cytotoxicity and antitubercular activity of *Allium sativum* and lantana camara against mycobacterial isolates from people living with HIV/AIDS. *The Internet J. Infec. Diseas.* 8(1):1-10.
- Dorant E, van den Brandt PA. (1996). Goldbohm RA. A prospective cohort study on the relationship between onion and leek consumption, garlic supplement use and the risk of colorectal carcinoma in The Netherlands. *Carcinogen.* 17(3):477-484.
- Eidi A, Eidi M, Esmaeili E. (2006). Antidiabetic effect of garlic (*Allium sativum* L.) in normal and streptozotocin-induced diabetic rats. *Phytomed.* 13(9):624-629.
- Ernst E. (1994). Fibrinogen: An important risk factor for atherothrombotic disease. *Ann Med.* 26:15-22.
- Feldberg R.S., Chang S.C., Kotik A.N., Nadler M., Neuwirth Z., Sundstrom D.C., Thompson N.H., (1988). In vitro mechanism of inhibition of bacterial cell growth by allicin. *Antimicrob. Agents Chemother.* 32 (1988) 1763-1768.
- Focke M., Feld A., Lichtenthaler K., (1990). Allicin, a naturally occurring antibiotic from garlic, specifically inhibits acetyl-CoA synthetase. *FEBS Lett.* 261 (1990) 106-108.
- Friedman T, Shalom A, Westreich M. (2006). Self-inflicted garlic burns: our experience and literature review. *Int. J. Dermatol.* 45(10):1161-1163.
- Friesen N, Fritsch RM, Blattner FR. (2006). Phylogeny and new intrageneric classification of *Allium* L. (Alliaceae) based on nuclear ribosomal DNA its sequences. *Aliso.* 22:372-395.
- Fukao H, Yoshida H, Tazawa YI, Hada T. (2007). Antithrombotic Effects of Odorless Garlic Powder both *in vitro* and *in vivo*. *Biosci Biotechnol. Biochem.* 7:21.
- Galeone C, Pelucchi C, Levi F, Negri E, Franceschi S, Talamini R, Giacosa A, La Vecchia C. (2006). Onion and garlic use and human cancer. *Am. J. Clin. Nutr.* 84(5):1027-1032.
- Hahn G. (1996). In: Koch HP, Lawson LD, eds. *Garlic: the science and therapeutic application of Allium sativum L and related species* (2nd edn). Baltimore Williams and Wilkins. Pp1-24. Lawson LD. (1996). The

- composition and chemistry of garlic cloves and processed garlic. In: Koch HP, Lawson LD, eds. *Garlic: the science and therapeutic application of Allium sativum L and related species* (2nd edn). Baltimore: Williams and Wilkins. pp. 37-107.
- Herbs of the Bible: (2000). *Years of Plant Medicine*-James A. Duke, Ph.D. 1999, Interweave Press.
- Hsing AW, Chokkalingam AP, Gao YT, Madigan MP, Deng J, Gridley G, Fraumeni JF Jr. (2002). Allium vegetables and risk of prostate cancer: a population based study. *Am. J. Med.* 94(21):1648-1651.
- Hughes B.G., Lawson L.D., (1991). Antimicrobial effects of *Allium sativum* L. (garlic) *Allium ampeloprasum* (elephant garlic) and *Allium cepa* L. (onion) garlic compounds and commercial garlic supplement products, *Phytother. Res.* 5 (1991) 154-158.
- Jaber MA, Al-Mossawi A. (2007). Susceptibility of some multiple resistant bacteria to garlic extracts. *Afr. J. Biotechnol.* 6(6):771-776.
- Jain RC. (1998). Anti-tubercular activity of garlic oil. *Indian Drug.* 30:73-75.
- Jaber MA, Al-Mossawi A. (2007). Susceptibility of some multiple resistant bacteria to garlic extracts. *Afr. J. Biotechnol.* 6(6):771-776.
- Jeyaraj S, Shivaji G, Jeyaraj SD, Vengatesan A. (2006). Effect of combined supplementation of fish oil with garlic pearls on the serum lipid profile in hypercholesterolemic subjects. *Indian Heart J.* 57(4):327-331.
- Josling P. (2001). Preventing the common cold with a garlic supplement: a double-blind, placebo-controlled survey. *Adv. Ther.* 18:189-193.
- Kalyesa R. (1975). Screening of indigenous plants for antihelminthic action against human *Ascaris lumbricoides*. *Indian J. Physiol. Pharmacol.* 19:47-49.
- Kao SH, Hsu CH, Su SN, Hor WT, Chang WH, Chow LP. (2004). Identification and immunologic characterization of an allergen, alliin-lyase, from garlic (*Allium sativum*). *J. Allergy Clin. Immunol.* 113(1):161-168.
- Kasuga S, Ushijima M, Morihara N, Itakura Y, Nakata Y. (1999). Effect of aged garlic extract (AGE) on hyperglycemia induced by immobilization stress in mice. *Nippon Yakurigaku Zassh.* 114:191-197.
- Kemper KJ *et al.* (2000). *Garlic (Allium sativum)*. The Longwood Herbal Task Force and the Center for Holistic Pediatric Education and Research 2000; 1-49.
- L.A. Shelef. (1983). Antimicrobial effects of spices. *J. food saf.* Vol. 6 29-44
- L.D.Lawson. (1996). Garlic: A review of its medicinal effects and indicated active compounds. In: L.D Lawson and R. Bauer, Editors, *Phytomedicines of Europe: Their chemistry and biological activity*, ASC Press , Washington DC, 176-200.
- Lau BH. (1991). Effect of odor modified garlic preparation on blood lipids. *Nutr. Res.* 7:139-149.
- Lau BH. (2006). Suppression of LDL oxidation by garlic compounds is a possible mechanism of cardiovascular health benefit. *Nutr.* 136(3):765-768.
- Lawson L.D., The composition and chemistry of garlic cloves and processed garlic. in: Koch Lawson LD, Wang ZYJ. (1996). Changes in the organosulphur compounds released from garlic during aging in water, dilute ethanol or dilute acetic acid. *J. Toxicol.* 14:214. lectin, *Glycoconj. J.* 12 (1995) 690-698.
- Uchida Y., Takahashi T., Sato N., (1975). The characteristics of the antibacterial activity of garlic, *Jpn J. Antibiotics* 28 (1975) 638-642.
- Ledezma E, Apitz-Castro R. (2006). Ajoene the main active component of garlic (*Allium sativum*): a new antifungal agent. *Rev Iberoam Micol.* 23:75-80.
- Lemar KM, Miguel AA, Sonia C, Brian O, Carsten TM, David L. (2007). Diallyl disulphide depletes glutathione in *Candida albicans*: oxidative stress mediated cell death studied by two-photon microscopy. *Yeast.* 24(8):695-706.
- M.Bajpai , A.Pande, S.K.Tewari, and D.Prakash. (2005). Phenolic contents and antioxidant activity of some food and medicinal plants. *Int J Food Sci Nutr.* Vol.56(4): 287-291.
- Maldonado PD, Chánez-Cárdenas ME, Pedraza-Chaverrí J. (2005). Aged garlic extract, garlic powder extract, S-allyl cysteine, diallyl sulfide and diallyl disulfide does not interfere with the antibiotic activity of gentamycin. *J. Chromat. A.* 19(3):252-254.
- Mansell P, Reckless J. (1991). Effects on serum lipids, blood pressure, coagulation, platelet aggregation and vasodilation. *BMJ.* 303:379-380.
- McMahon FG, Vargas R. (1993). Can garlic lower blood pressure? A pilot study, *Pharmacotherapy* 13:406-407.
- Mirelman D, Motsheit D, Vatou S. (1987). Inhibition of growth of *Entamoeba histolytica* by Allicin, the active principle of garlic extracts (*Allium sativum*). *J. Infect. Dis.* 156:243-244.
- Morihara N, Ushijima M, Kashimoto N, Sumioka I, Nishihama T, Hayama M, Takeda H. (2006). Aged garlic extract ameliorates physical fatigue. *Biol. Pharm. Bull.* 29(5):962-966.
- Morioka N, Sze LL, Morton DL, Irie RF. (1993). A protein fraction from aged garlic extract enhances cytotoxicity and proliferation of human lymphocytes mediated by interleukin-2 and concanavalin A. *Cancer Immunol. Immunother.* 37:316-322.
- Nance DM, Luczy-Bachman G, Min P, Chang MS, Amagase H. (2006). Effects of aged garlic extract (AGE) on the immunosuppressive effects of stress Brain, Behavior, and Immunity. *Isr. Med. Assoc. J.* 20(3):50-51.
- Ohaeri OC. (2001). Effect of garlic oil on the levels of various enzymes in the serum and tissue of

- streptozotocin diabetic rats. Biosci. Rep. 21:19-24
- Onyeagba R, Ugobogu OC, Okeke CU, Iroakasi O. (2004). Studies on the antimicrobial effects of garlic (*Allium sativum* L.), ginger (*Zingiber officinale* Roscoe) and lime (*Citrus aurantifolia* L.). Afr. J. Biotechnol. 3:552-554.
- Ozolin O.N., Uteshev T.A., Kim I.A., Deev A.A., Kamzolova S.G., (1990). Specific modification of the alpha-subunit of *Escherichia coli* RNAS polymerase by monomeric derivative of fluorescein mercuric acetate, Mol. Biol.(Mosk.) 24 (1990) 1057-1066.
- Parekh J, Chanda S. (2007). In vitro antimicrobial activity of *Trapa natans* L. Fruit rind extracted in different solvents. Afr. J. Biotechnol. 6(6):766-770.
- Prasad G, Sharma VD, Kumar A. (1995). Efficacy of garlic (*Allium sativum* L.) therapy against experimental dermatophytosis in rabbits. Indian J. Med. Res. 75:465-467.
- Prescription for Nutritional Healing, Third Edition. James F. (2000). M.D., Phyllis A. Balch, C.N.C., Avery Publishing Group. processes in an HIV-infected cell system, Vestn. Ross. Akad. Med. Nauk. 11 (1992) 6-10.
- Rabinkov A., Miron T., Konstantinovski L., Wilchek M., Mirelman D., Weiner L., (1998). The mode of action of allicin: trapping of radicals and interaction with thiol containing proteins, Biochim. Biophys. Acta 1379 (1998) 233-244.
- Ratnakar P, Murthy S. (1996). Preliminary studies on the antitubercular activity and the mechanism of action of the water extract of garlic (*Allium sativum*) and its two partially purified proteins (garlic defensin?). Indian J. Clin. Biochem. 11 (1):37-41.
- Sabayan B, Foroughinia F, Chohedry A. (2006). A postulated role of garlic organosulfur compounds in prevention of valproic acid hepatotoxicity. Med. Hypotheses. 68(3):512-514.
- Sabitha P, Adhikari PM, Shenoy SM. (2005). Efficacy of garlic paste in oral candidiasis. Trop Doct. 35(2):99-100.
- Salman H, Bergman M, Bessler H, Punskey I, Djaldetti M. (1999). Effect of a garlic derivative (alliin) on peripheral blood cell immune responses. Int. J. Immunopharmacol. 21:589-597.
- Saw JT, Bahari MB, Ang HH, Lim YH. (2006). Potential drug-herb interaction with antiplatelet/anticoagulant drugs. Complement Ther. Clin. Pract. 12(4):236-241.
- Sener G, Sehirli AO, Ipci Y, Cetinel S, Cikler E, Gedik N. (2005). Chronic nicotine toxicity is prevented by aqueous garlic extract. Plant Foods Hum. Nutr. 60(2):77-86.
- Shams-Ghahfarokhi M, Shokoohamiri MR, Amirrajab N, Moghadasi B, Ghajari A, Zeini F, Sharma G, Sehirli AO, Ipci Y, Cetinel S, Cikler E, Gedik N. (2005). Chronic nicotine toxicity is prevented by aqueous garlic extract. Plant Foods Hum. Nutr. 60(2):77-86.
- Silagy CA, Neil HA. (1994). A meta-analysis of the effect of garlic on blood pressure. J. Hypertens. 12:463-468.
- Singh VK, Singh DK et al., (2008). Pharmacological Effects of Garlic (*Allium sativum* L.). ARBS Annual Review of Biomedical Sciences 2008; 10: 6-26.
- Song S.I., Song J.T., Chang M.U., Lee J.S., Choi Y.D., (1997). Identification of one of the major viruses infecting garlic plants, garlic virus X, Mol. Cells 7 (1997) 705-709.
- Steinmetz KA, Kushi LH, Bostick RM, Folsom AR, Potter JD. (1994). Vegetables, fruit, and colon cancer in the Iowa woman's health study. Am. J. Epidemiol. 139:1-15.
- Sumioka I, Hayama M, Shimokawa Y, Shiraishi S, Tokunaga A. (2006). Lipid-lowering effect of *monascus* garlic fermented extract (MGFE) in hyperlipidaemia subjects. Hiroshima. J. Med. Sci. 55(2):59-64.
- Tatarintsev A.V., Vrzhets P.V., Ershov D.E., Turgiev A.S., Karamov E.V., Kornilaeva G.V., Makarova T.V., Fedorov N.A., Varfolomeev S.D., The ajoene blockade of integrindependent
- Tepe B, Daferera D, Sokmen M, Polissiou M, Sokmen A. (2004). In vitro antimicrobial and antioxidant activities of the essential oils and various extracts of thymus. J. Agric. Food Chem. 52:1132-1137.
- The Green Pharmacy-James A. (1997). Rodale Press.
- Timbo BB, Ross MP, McCarthy PV, Lin CT. (2006). Dietary supplements in a national survey: Prevalence of use and reports of adverse events. Am. Diet Assoc. 106 (12):1966-1974.
- Torok B, Belagyi J, Rietz B, Jacob R. (1994). Effectiveness of garlic on the radical activity in radical generating systems. Arzneimittelforschung 44:608-611.
- Tsai Y., Cole L.L., Davis L.E., Lockwood S.J., Simmons V., Wild G.C., (1985). Antiviral properties of garlic: in vitro effects on influenza B, herpes simplex and coxsackie viruses, Planta Med. 5 (1985) 460-461.
- Tsao SM, Yin MC. (2001). *In vitro* antimicrobial activity of four diallyl sulphides occurring naturally in garlic and Chinese leek oil. J. Med. Microbiol. 50:646-649.
- Urbina J.A., Marchan E., Lazardi K., Visbal G., Apitz-Castro R., Gil F., Aguirre T., Piras M.M., Piras R., (1993). Inhibition of phosphatidylcholine biosynthesis and cell proliferation in *Trypanosoma cruzi* by ajoene, an antiplatelet compound isolated from garlic, Biochem. Pharmacol. 45 (1993) 2381-2387.
- Vegetable crops in India* T.K. Bose & M.G. Som (Ed.) & NIN, Hyderabad.
- Yamada Y., Azuma K., (1997). Evaluation of the in vitro antifungal activity of allicin, Antimicrob. Agents Chemother. 11 (1997) 743-749.

- Mirelman D., Monheit D., Varon S., (1987). Inhibition of growth of *Entamoeba histolytica* by Allicin, the active principle of garlic extract (*Allium sativum*), J. Infect. Dis. 156 (1987) 243–244.
- Yeh GY, Davis RB, Phillips RS. (2006). Use of Complementary Therapies in Patients with Cardiovascular Disease. Am. J. Card. 98(5):673-680.
- Yin J, Li H. (2007). Anaphylaxis Caused by Younger Garlic. J. Allergy Clin. Immunol. 119 (1):34.

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