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MEDICINAL PROPERTIES OF GARLIC (*ALLIUM SATIVUM* L.)

Sabahat Saeed

Department of Microbiology, University of Karachi, Karachi-75270, Pakistan.

ABSTRACT

Garlic (*Allium sativum*) has been used, since time immemorial for medicinal purposes in ailments like headache, bites, tumors and worm infestations etc. Recently antibacterial, antifungal, antiviral, anticancer, antiparasitic and cardiovascular properties of garlic have been established. Active constituents of garlic include allicin, alliumin, glutamyl peptides, scordinins, steroids, terpenoids, and flavanoids, which are responsible for its therapeutic effects. Side effects are generally mild and uncommon.

Key words: allicin, antibacterial, antifungal, antiviral, anticancer; antiparasitic, Garlic

INTRODUCTION

Over the centuries, garlic has acquired a special position as a prophylactic and therapeutic medicinal agent (Rehman, 2001). In this paper medicinal properties of garlic have been reviewed in the light of its antibacterial, antifungal, antiviral (Bakri and Douglas, 2005), antiprotozoal (Harris *et al.*, 2001), anticancer (Setiavan *et al.*, 2005), and antiparasitic properties (Vohora *et al*., 1973). Garlic also has beneficial effects on the cardiovascular and immune system (Harris *et al.*, 2001).

ACTIVE CONSTITUENTS

The thiosulfonates, including allicin, appear to be the active substances in garlic (Adetumbi and Lau, 1983; Feldberg *et al*., 1988; Ankri and Mirelman, 1999; Shadchan *et al*., 2004; Tattelman, 2005). The mechanism of bacterial inhibition by allicin was investigated by Feldberg *et al*. (1988). They reported a typical cycle of inhibition; initially there was a lag time of approximately 15 minutes between addition of allicin and onset of inhibition; then there was a "transitory inhibition phase" whose duration was directly propotional to the allicin concentration, this was followed by a resumed growth phase which showed a lower rate of growth than controls, and finally the culture reached a stationary phase at a lower culture density than the controls. They reported partial inhibition of deoxyribonucleic acid (DNA) and protein synthesis but concluded that the mechanism of action was likely the complete and almost immediate inhibition of ribonucleic acid (RNA) synthesis.

A protein designated as alliumin, isolated from garlic, is responsible for antifungal activity of garlic. Its activity was retained after boiling for 1 hour and also after treatment with trypsin or chemotrypsin (1:1, w/w) for 30 minutes at room temperature (Xia and Ng, 2005). Yoshida *et al*. (1987) investigated the antifungal activity of garlic and found that ajoen, isolated from garlic, has strong antifungal activity.

Other secondary metabolites of garlic including glutamyl peptides, scordinins, steroids, terpenoids, flavonoids and other phenols, may be responsible for the range of therapeutic effects reported for garlic (Sivam, 2001).

ANTIBACTERIAL ACTIVITY

Garlic has been recognized not only as a spice but also as a substance, which exerts control on microorganisms (Adetumbi and Lau, 1983). Louis Pasteur was the first to describe the antibacterial effect of garlic juice. Garlic exhibits a broad-antibacterial spectrum against both Gram-negative and Gram-positive bacteria (Sivam, 2001; Dankert *et al*., 1979; Elnima *et al*., 1983). A number of studies have reported the activity of garlic against various bacterial species (Dankert *et al*., 1979; Elnima *et al*., 1983; Chowdhury *et al*., 1991; Anesini and Prez, 1993; Kumar and Berwal, 1998).

Garlic was found effective against *Staphylococcus aureus, Escherichia coli, Salmonella typhi* and *Listeria monocytogenes* (Kumar and Berwal, 1998) and also active against Penicillin G resistant strains of *S. aureus* and *E. coli* (Anesini and Perez, 1993).

In another study, the aqueous extract of garlic and allicin both showed significant antibacterial activity *in vitro* against isolates of multi-drug resistant *Shigella dysentriae, Sh.flexneri, Sh. sonnei* and *E. coli* (Chowdhury *et al*., 1991). Antibacterial activity of garlic was resistant to heat treatment at 100^{o}C for 20 minutes and it was found

effective against *Salmonella enteritidis* (Sasaki *et al*., 1999) and methicillin-resistant *S. aureus* (MRSA) (Sasaki *et al*., 1999; Cutler and Wilson, 2004)

The crude extract of juice has been found to be strongly active against *E. coli, Pseudomonas pyocyaneus, S. typhi* and *Bacillus subtilis* (Abdou *et al*., 1972). Garlic has also been reported to inhibit *Aerobacter, Aeromonas, Bacillus, Citrella, Citrobacter, Clostridium,Enterobacter, Escherichia, Pseudomonas, Salmonella, Serratia, Shigella, Staphylococcus* and *Vibrio* (Reuter *et al*., 1996).

Garlic showed antibacterial activity against mutans group of *Streptococci*, but not other oral microorganisms (Groppo *et al*., 2002). Garlic extracts also inhibited the growth of *S. mutans* and *P. gingivalis* (Bakari and Douglas, 2005).

Ethanolic and acetoneic garlic extract was found to be effective *in vitro* against *Helicobacter pylori*, the bacterium responsible for serious gastric diseases such as ulcers and gastric cancers (Canizares *et* al., 2004). Home made raw garlic extract was also found effective against *H. pylori* (Jonkers *et al*., 1999). *In vitro H. pylori* was susceptible to garlic extract at a fairly moderate concentration. Even some antibiotic resistant *H. pylori* strains were susceptible to garlic thus garlic may helpful to prevent stomach cancer and ulcer (Sivam, 2001; Martin and Ernst, 2003).

According to Delaha and Garagusi (1985) thirty strains of mycobacteria, consisting of 17 species, were inhibited by various concentrations of garlic extracts. Garlic oil showed good antituberculosis activity in guinea pigs with a intraperitoneal dose of 0.5 mg/Kg (Jain, 1993). On the other hand Kyung *et al*. (1996) isolated 26 species of *Leuconostoc mesenteroides* sub sp. *mesenteroides* and found that all of these isolates were resistant to antimicrobial activity of garlic.

ANTIFUNGAL PROPERTIES

Garlic possesses anti-yeast activity (Dankert *et al*., 1979; Rees *et al*., 1993). Garlic extract has been successfully used in treating cryptococcal meningitis caused by *Cryptococcus neoformans*. In a study commercial garlic extract was given intravenously to two patients with cryptococcal meningitis and three patients with other types of meningitis. Anti-cryptococcal activity was detected in four out of five cerebrospinal fluid samples (Davis *et al*., 1990). In a later report, Davis *et al*. (1994) investigated the scientific merit of using garlic as an antifungal agent by preparing a concentrated garlic extract that contained 34% allicin, 44% total thiosulfinates and 20% vinyldithirns. They found it to be very effective. In another study, Davis (2005) concluded that garlic derivatives are safe, cheap, wide-spectrum and immunostimulatory as well as synergistic with antifungal therapy. These properties make garlic derivatives ideal candidates for investigation into their use as prophylactic antifungal agents. The extract showed significant *in vitro* fungicidal and fungistatic activity against 3 different isolates of *C. neoformans.* In another study, anti-cryptococcal activity of garlic extract was evaluated and good results were found (Lal *et al*., 2003). *In vitro* synergism of concentrated *Allium sativum* extract and amphotericin B has also been demonstrated against *C. neoformans* (Davis *et al*., 1995).

A ubiquitous opportunistic pathogen, *Candida albicans*, is also sensitive to garlic (Sasaki *et al*., 1999; Lemar *et al*., 2002; Motsei *et al*., 2003).

Two different groups of scientists studied the efficacy of garlic extracts against the fungi belonging to the genus *Aspergillus*, the most common cause of otomycosis. Both aqueous garlic extract and concentrated garlic oil showed antifungal activity against *Aspergillus* species (Anesini and Preze, 1993; Pai and Platt, 1995).

Venugopal and Vanugopal (1995) studied the efficacy of garlic to treat ringworm. They concluded that it could be used as an effective antidermatophytic agent.

From a slightly different perspective a fresh extract of garlic was administered orally to human volunteers. At intervals, serum and urine were collected for detection of antifungal activity. No detectable antifungal activity was found in the excreted urine at any time after oral ingestion. Therefore it was concluded that oral garlic is of limited value in the therapy of human fungal infections (Caporaso *et al*., 1983).

ANTIVIRAL ACTIVITY OF GARLIC

Garlic has also been stated to possess antiviral properties (Parada *et al*., 1997; Weber *et al*., 1992). Ethanolic extract of garlic was found effective against Polio virus type 3 (Parada *et al*., 1997). Weber *et al*. (1992) reported the afficacy of allicin, isolated from garlic, and its various transformation products against Herpes Simplex virus 1 and 2 (HVS I and II), Vesicular stomatitis virus (VSV), Vaccinia virus (VV), and Para-influenza virus (Para-3). The garlic extract was effective against each virus tested.

ANTICANCER ACTIVITY

Garlic has been shown to possess cancer-preventive properties (Caragay, 1992). Setiavan *et al.* (2005) confirmed protective effect of garlic against stomach cancer. It has also been reported to enhance the immune function by stimulating lymphocytes and macrophages to destroy cancer cells (Dauusch and Nixon, 1990). Garlic has also been reported to disrupt the metabolism of tumor cells (Belman, 1983). Components of garlic cause disruption of microtubules, cell cycle arrest, and apoptosis in cancer cells. A water-soluble extract of garlic arrested MDA-MB-435 cancer cells in mitosis and caused apoptosis (Lund *et al.,* 2005). Various studies have shown that garlic can slow the development of bladder, skin, stomach, and colon cancers (Belman, 1983; Lau *et al.,* 1986; Lau *et al.,* 1990; Steinmetz *et al.,*1994).

ANTIPARASITIC PROPERTIES

Garlic has been utilized to act against common parasites such as roundworms and hookworms (Bastidas, 1969; Vohora *et al*., 1973). Literature on the antiparasitic activity of garlic focused mainly on protozoan parasites. Lun *et al*. (1994) studied the efficacy of diallyl trisulfide, a stable transformation product of allicin, isolated from garlic, against various trypanosoma strains, and reported an IC_{50} (concentration which inhibits the growth of parasites by 50%) of 0.8-5.5 μg/ml. They also found IC_{50} levels of 59 μg/ml for *Entamoeba histolytica* and 14 μg/ml for *Giardia lamblia*. In another study, the whole garlic extract and some of its components were assayed for antigiardial activity. Whole garlic extract gave an IC_{50} at 24 h of 0.3 μg/ml while allyl alcohol and allyl mercaptane, with IC_{50} values of 7 μg/ml and 37 μg/ml respectively against *G. intestinalis* (Harris *et al*., 2000). Further more, allicin from garlic strongly inhibited cystein protienases, an important contributor to amoebic virulence of *Entamoeba histolytica* and destroyed the trophozoites of *E. histolytica* (Ankri *et al*., 1977).

Aqueous extract of garlic was used by Soffar and Mokhtar (1991) to determine the minimum lethal concentration of garlic against *Hymenolepsis nana* and *G. lambia*. It was found to be a safe and effective treatment for the parasite's respective diseases in 36 children. Nok *et al*. (1996) also investigated the garlic-induced death of protozoans. They found that, at a dose of 5 mg/ml, the oil extract of garlic pulp completely suppressed the ability of *Trypanosoma brucei* to cause African trypanosomiasis in mice. The extract appeared to be diallyl disulfide and was thought to interfere with the parasite's synthesis of membrane lipids.

OTHER PROPERTIES

Stevinson *et al.,* (2000) reported that garlic reduces total cholesterol level in man. In several studies, it has been concluded that regular use of garlic can be effective in reducing the risk of heart attack and stroke because it lowers total and low-density lipoprotein (LDL), cholesterol and triacylglycerol concentrations with out affecting high-density lipoprotein (HDL) cholesterol concentration (Kleijnen *et al.,* 1989; Warshafsky *et al.,* 1993; Craig, 1999). Blood lipid concentrations are also favorably altered in normocholesterolemic subjects taking garlic (Bordia, 1981). However, in contrast, a study with garlic powder has shown no significant effect on cardiovescular variables (Issacsohn *et al*., 1998). Researchers found that daily ingestion of 3g garlic for 6 months resulted in 80% decrease in serum thromboxane B_2 and 20% decrease in coronary heart disease in middle-aged men (Ali and Thomson, 1985). Garlic also improves arterial oxygenation in patients with hepatopulmonary symdrome (Gray and Michael, 1998). More recently, it has been investigated for fibrinolytic and antiplatelet effect (Bordia *et al.,* 1977; Reuter *et al.,* 1996; Amagase *et* al., 2001; Lal *et al.,* 2003). Chutani and Bordia (1981) investigated the effect of fried versus raw garlic on fibrinolytic activity in human and found that both raw and fried garlic enhanced fibrinolytic activity. Garlic preparations have also been found to exert an immunopotentiating effect by stimulating natural killer cell activity (Burger *et al.,* 1993).

Garlic has also been advocated for various ailments like headache, bite, tumors and worm infectations (Mansell and Reckless, 1991). It has also expectorant, diaphoretic, disinfectant and diuretic properties also (Lal *et al*., 2003).

SIDE EFFECTS OR CONTRADICTIONS

Side effects of garlic are generally mild and uncommon. The most common side effect of ingested garlic is bad breath and body odor. Consumption of excessive amount of raw garlic, especially on an empty stomach, can cause gastrointestinal upset, flatulence and change in the intestinal flora (Tattelman, 2005). Garlic use also has the potential for inducing bronchospasm, vomiting, diarrhoea, hypoglycaemia, and contact dermatitis (Candula *et*

al.,1995). It seems prudent to stop taking high dosages of garlic seven to ten days before surgery because garlic can prolong bleeding time (Tattelman, 2005).

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