

Allicin from fresh Garlic Nature's Original Antimicrobial

The Englishman's Doctor (Harrington, 1609)

"Garlic then have power to save from death Bear with it though it maketh unsavory breath And scorn not garlic like some that think It maketh men wink and drink and stink"

A rich history

Garlic is one of the edible plants, which has generated a lot of interest throughout human history as a medicinal panacea. A wide range of microorganisms including, bacteria, fungi, protozoa and viruses have been shown to be sensitive to crushed garlic preparations. Moreover, garlic has been reported to reduce blood lipids and to have anticancer effects. Chemical analyses of garlic cloves have revealed an unusual concentration of sulfur-containing compounds (1—3%) [1,2]. A quick search of the medical database at the National Library of Medicine in the USA reveals that garlic is top of the league for published research papers that cover a wide variety of disease conditions, the most prevalent of which are its significant antimicrobial properties.

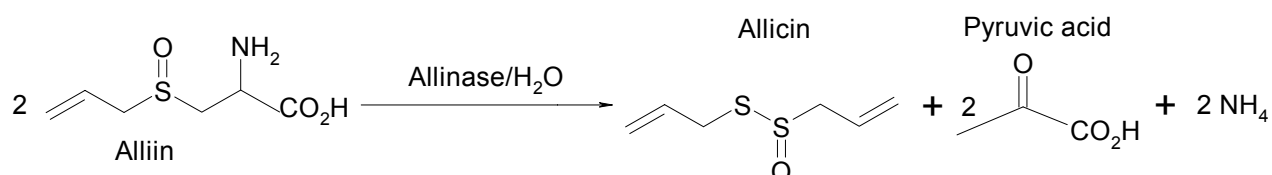
National Library of Medicine

Research papers on popular herbal supplements since published since 1963

Garlic	1600
Ginseng	1550
Hypericum	650
Ginkgo	855
Tea Tree	103

Analysis of steam distillations of crushed garlic cloves performed over a century ago showed a variety of allyl sulfides. However, it was not until 1944 that Cavallito and his colleagues [3] isolated and identified the component responsible for the remarkable antibacterial activity of crushed garlic cloves. The compound turned out to be an oxygenated sulfur molecule, which they termed allicin, from the Latin name of the garlic plant, *Allium sativum*.

The debate on the presence of allicin in crushed cloves versus its absence in odourless intact cloves was resolved after Stoll and Seebeck [5] isolated, identified, and synthesized an oxygenated sulfur



Alliin + Allinase enzyme and Water = Allicin + Pyruvate
Figure 1. Generation of allicin in a garlic clove.

amino acid that is present in large quantities in garlic cloves and which they named alliin (*figure 1*). Alliin was found to be the stable precursor that is converted to allicin by the action of an enzyme termed allinase, which is also present in the cloves [6].

The transformation of alliin into the biologically active allicin molecule upon crushing of a garlic clove is extremely rapid, being complete in seconds. The enzyme responsible for this conversion is allinase, which is present in unusually large amounts in garlic cloves: at least 10% of the total protein content (10 mg/g fresh weight).

Garlic cloves are odor-free until crushed or processed when garlic supplements are manufactured and cross-section studies have indicated that the substrate alliin and the enzyme allinase are located in different compartments [2, 6]. This unique organization suggests that it is designed as a potential defense mechanism against microbial pathogens in the soil. Invasion of the cloves by fungi and other soil pathogens causes the interaction between alliin and allinase that rapidly produces allicin and which in turn inactivates the invader. The reactive allicin molecules produced have a very short half-life, as they react with many of the surrounding proteins, including the allinase enzyme, making it into a quasi-suicidal enzyme.

Type of supplement	Fresh garlic source declared on pack	Process to manufacture supplement	Allicin potential	Published blinded clinical data
Garlic Oil	No	Steam distillation	No	No
Aged Garlic	No	Aged over 2 years	No	Some
Garlic Macerates	No	Crushed and dried	Some	No
Garlic powder	Sometimes	Cloves chopped and dried under pressure and temperature control	Yes (Stomach acid protection needed)	Yes
Allicin powder extract	No	Specialised patented extraction process produces allicin liquid that is spray dried	Product is allicin	Yes

Table 1 Types of garlic supplement found on Healthfood Store shelves

This very efficient organization ensures that the clove defense mechanism is only activated in a very small location and for a short period of time, whereas the rest of the alliin and allinase remain preserved in their respective compartments and are available for interaction in case of subsequent microbial attacks.

Cardiovascular properties

Successful clinical use of garlic for treating elevated blood pressure and arteriosclerosis has been known since the early part of this century. It has been reported that regular garlic intake causes both a prolonged lowering of hypertension and an improved sense of well-being in patients. As early as 1928, definite blood pressure decreases were achieved as well as increases in productive heart power with garlic therapy, not only in older patients, but also in younger hypertonic patients.

It is also well established that garlic extracts, in particular the powders can show a significant anti-cholesterol activity. A 12 week study comparing the effect of standardised garlic powder tablets (900mg daily) with that of bezafibrate (600mg daily), one of the most commonly prescribed blood lipid-lowering drugs until the advent of the statins, has also been conducted. The multi-centre, double-blind study was performed with 94 patients having cholesterol and/or triglyceride vales exceeding 250mg/dL. After 4 weeks of treatment, the decreases in cholesterol, LDL cholesterol, and triglyceride levels were all statistically highly significant, and there were no differences between the effects of garlic and bezafibrate. HDL cholesterol values in the course of 4 weeks also increased significantly, again without any differences between the two regimens [14].

Antibacterial activity of allicin

The antibacterial properties of crushed garlic have been known for a long time. Various garlic preparations have been shown to exhibit a wide spectrum of antibacterial activity against Gram-negative and Gram-positive bacteria including species of *Escherichia*, *Salmonella*, *Staphylococcus*, *Streptococcus*, *Klebsiella*, *Proteus*, *Bacillus*, and *Clostridium*. Even acid-fast bacteria such as *Mycobacterium tuberculosis* are sensitive to garlic [10]. Garlic extracts are also effective against *Helicobacter pylori* the cause of gastric ulcers [11]. Garlic extracts can also prevent the formation of *Staphylococcus* enterotoxins A, B, and C1 and also thermonuclease [12]. Cavalito and Bailey [4] were the first to demonstrate that the antibacterial action of garlic is mainly due to allicin [3]. The sensitivity of various bacterial and clinical isolates to pure preparations of allicin [14] is very significant. As shown in *table 2*. the antibacterial effect of allicin is of a broad spectrum. In most cases the 50% lethal dose concentrations were somewhat higher than those required for some of the newer antibiotics. Interestingly, various bacterial strains resistant to antibiotics such as methicillin resistant *Staphylococcus aureus* as well as other multidrug-resistant enterotoxigenic strains of *Escherichia coli*, *Enterococcus*, *Shigella dysenteriae*, *S. flexneri*, and *S. sonnei* cells were all found to be sensitive to allicin.

Bacterial Strain	Allicin Concentration (LD ₅₀ µg/ml)	Comments
<i>Escherichia coli</i>	15	Sensitive to antibiotics
<i>Escherichia coli</i>	15	Multidrug resistant MDR
<i>Staphylococcus aureus</i>	12	Sensitive
<i>Staphylococcus aureus</i>	12	Methicillin resistant
<i>Streptococcus pyogenes</i>	3	Sensitive
<i>Streptococcus β hemolyticus</i>	>100	Clinical MDR strain
<i>Proteus mirabilis</i>	15	Sensitive
<i>Proteus mirabilis</i>	>30	Clinical MDR strain
<i>Pseudomonas aeruginosa</i>	15	Sensitive to cefprozil
<i>Pseudomonas aeruginosa</i>	>100	MDR mucoid strain
<i>Acinetobacter baumannii</i>	15	Clinical isolate
<i>Klebsiella pneumoniae</i>	8	Clinical isolate

Table 2 Bacterial species sensitivity to aqueous garlic extracts containing allicin

Most recently the University of East London have shown that aqueous extracts of allicin when formulated into a simple cream are able to kill vast swathes of the so called “superbug” MRSA (methicillin resistant *Staphylococcus aureus*). This nasty bacterium is forever changing its structure and developing resistance to many pharmaceutical antibiotics. This may have a significant effect on people who suffer from skin diseases such as eczema and acne as this bacterium is 6 to 7 times more likely to colonise these patients.



Methicillin resistant *Staphylococcus aureus* with plain aqueous cream



Methicillin resistant *Staphylococcus aureus* with alliin cream added (Allimax cream) showing a large zone of inhibition

Immunomodulatory Effects

There is a growing body of evidence that garlic may have significant enhancing effects on the immune system. While most of the work has been conducted on animals or in vitro, the human studies that have been conducted are encouraging.

Preliminary studies in humans, using an alliin standardised garlic powder preparation, have demonstrated positive effects on immunoreactions and phagocytosis. In geriatric 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. The cell counts of lymphocyte cell sub-populations were also increased. Another human study was conducted with an unrefined garlic extract (5-10 g/day) which was given to AIDS patients. For the seven patients who completed the 12-week study, there was a major increase in the percent natural killer cell activity from a seriously low mean value of $5 \pm 4\%$ to a more normal mean value of $36 \pm 15\%$ [16].

The biological activity of alliin extracted from fresh garlic is thought to be related to a combination of factors:

1. its activity as an antioxidant
2. its ability to attack the sulphur (SH) groups in enzymes and proteins and modify their activities and
3. its ability to rapidly penetrate into cells through the cell membranes.

Laboratory Studies

Allicin has a number of beneficial properties, which could act together to enhance the bodies response to disease. Published laboratory studies (3) have found that allicin:

- Enhances the activity of phagocytic cells
- Enhances the activity of natural killer cells
- Inhibits the growth of pathogenic micro-organisms
- Inhibits the growth of certain cancer cells

One of the main problems with laboratory studies has been the purity of the extracts used, only recently has a purified, natural, stable extract of allicin become available for testing. Recent studies in our own laboratory have confirmed the antibacterial activity of this purified allicin extract against a number of different bacteria including multiply antibiotic resistant *Staphylococcus aureus* (MRSA). Clinical trials with this substance are currently underway.

Clinical Trials

In the USA, trials in AIDS patients have demonstrated enhancement of natural killer cell activity using garlic extracts and Chinese studies with viral infections in bone marrow transplant patients have demonstrated a “potent antiviral activity”. Human population studies have shown that regular intake reduces the risk of oesophageal, 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 gastro-intestinal tract. 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 the number of days needed to recover from symptoms [17].

Treatment	Colds	Infected days	Recovery period Days
One capsule per day with food			
ACTIVE (ALLIMAX)	24	111	1.56
PLACEBO	65	366	5.6

Garlic has the potential to assist the immune system in a number of different ways, stimulating immune cells, killing pathogens and detoxifying carcinogens. Although the compound can be obtained directly from fresh garlic bulbs, one would have to regularly eat large amounts of cooked garlic to obtain any beneficial effect and few of us can eat large amounts of raw garlic. This leaves us with liquids and powders. Given the importance of the agent, any garlic liquids or powders should give an indication of the amount of allicin available from the product; many do not.

Contraindications

Taking too much garlic can hinder blood clotting and it would be sensible for people already on anticoagulants or those about to undergo surgery to advise their medical team before starting therapy with ANY garlic supplement but contrary to popular

belief it is not a contra-indication. Garlic can also cause reactions in people who are allergic.

The identity of the active compounds for the effects thus far observed on the immune system with garlic and garlic products is far from conclusive. Since both alliin-derived garlic oils as well garlic extracts not containing alliin are effective *in vivo* at moderate doses, it appears that both alliin and other unidentified compounds are responsible for the effects. Both types of compounds may be important to the overall effects of garlic, since the immune system involves several types of cell, each of which may be affected differently, as has been indicated in the *in vitro* studies.

The future of garlic research – its anticancer activity

A very important epidemiological (prospective cohort) study for Americans has recently been published in which the intake of 127 foods (including 44 vegetables and fruits) was determined in 41,387 women (ages 55-69) followed by a five-year monitoring of colon cancer incidence [18]. 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. Both a critique of this study and a good reply by the authors have been published hence one could predict that the future is bright the future is garlic.

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1. What is it that garlic is able to produce an unlikely large amount of?

A. Sulphur compounds

2. Which sulphur component is responsible for the antibacterial properties of garlic?

A. Allicin

3. When garlic is crushed or processed which two components react to produce allicin?

A. Alliin and allinase enzyme

4. Which bacteria, commonly involved in skin conditions including eczema and acne are sensitive to allicin?

A. Staphylococcus aureus

5. Which common viral disease has been shown to be prevented by an aqueous garlic extract containing allicin

A. The Common Cold

6 Which gold standard epidemiological study has shown the anticancer effects of garlic?

a. The IOWA Women's Study

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