The Chemistry Of Garlic Health Benefits

Garlic has been viewed for its health benefits for thousands of years, and recently science has begun to show why.

**By Richard A. Passwater, Ph.D.**

A good example of this situation is macerate of garlic, a product formed when garlic is chopped (“macerated”) with salad oil or other edible oils. Macerate of garlic is a rich source of “naturally-formed” garlic-derived compounds having the scientific names ajoene, methyl ajoene, and dithiins. These products are stable enough to be stored at room temperature for more than a year, for example when dissolved in an edible oil.

The fifth category is materials prepared by heating garlic in boiling water and condensing (collecting) the steam as it becomes a vapor, a technique known as steam distillation. The product is termed the distilled oil of garlic. The scientific name for the major component of distilled oil of garlic is diallyl disulfide. It has a strong, slightly medicinal, “artificial” smell of garlic. Distilled garlic oil is used as a food flavoring agent.

To summarize, when we cut or crush fresh garlic, we release an enzyme called allinase, which rapidly converts odorless alliin to allicin, the latter having the typical odor and taste of fresh garlic. Allicin is unstable and rapidly reverts to ajoene (pronounced ah-hoe-ene) and dithiins (pronounced di-thigh-ins) in the presence of edible oils (e.g. macerates) or to diallyl disulfide on standing or heating in water.

**Passwater:** Are you saying that it is not the alliin and allicin themselves that are important, but compounds that are formed from these compounds, either in the body or by certain types of cooking?

**Block:** If by “important” you mean “having a positive health benefit” the answer to that question is still actively being sought by researchers. There seems to be health benefits associated with most of the sulfur-rich components of garlic following its normal use in cooking and consumption. For example, I’ve already mentioned that ajoene and dithiins are naturally formed when garlic is macerated with various edible food oils.

**Passwater:** I had seen several recent articles describing the benefits of ajoenes, but I was not familiar with them. In fact, I didn’t even remember ever studying “ajoenes,” and they didn’t seem to fit into standard terminology, so I had to check the Merck Index for details.

**Block:** Don’t feel too bad. I discovered them in 1984 and named them in honor of my collaborators in this research from Venezuela. “Ajo” is the Spanish word for garlic. I’m quite proud that ajoene has been included in the latest edition of the Merck Index. By the way, alliin and allicin are derived from the botanical Latin name for garlic, Allium sativum.

**Passwater:** How many papers have been published about ajoenes since you discovered and named them?

**Block:** I have seen more than a dozen scientific papers from laboratories around the world dealing with medical benefits of ajoenes. I have also seen quite a few papers dealing with ajoene analysis and occurrence. These latter papers indicate that macerated garlic is the only form of garlic where significant quantities of ajoene and dithiins have ever been detected.

**Passwater:** What health benefits do ajoenes provide?

**Block:** As I said, ajoenes and dithiins are among the most active compounds formed from fresh garlic. Ajoenes have been shown to: possess antithrombotic (ant clotting) activity in human platelet suspensions (1-8); possess antitumor activity (9); display significant antifungal activity, inhibiting the growth of Aspergillus niger, Candida albicans, Paracoccidioides-Brasilienis, and Fusarium species (10-12); inactivate human gastric lipase, a sulfhydryl enzyme involved in the digestion processes around the world dealing with medical benefits of ajoenes. I have also seen quite a few papers dealing with ajoene analysis and occurrence. These latter papers indicate that macerated garlic is the only form of garlic where significant quantities of ajoene and dithiins have ever been detected.

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In one interesting study, administration of ajoene to dogs under
extracorporeal circulation (as used in open heart surgery) prevents the thrombocytopenia induced by contact of blood with artificial surfaces. In this same study, ajoene showed excellent activity in preventing loss of platelets and increasing the rate of restoration of platelet clotting activity (1-5). Exciting advances have also been reported for dithiins as well. For example a U. S. patent was recently awarded to a scientist at the Los Alamos National Laboratory for the invention of a copolymer involving the same dithiin formed from garlic for an “antithrombogenic and antibiotic composition for use as a coating for artificial prostheses and implants which remain in contact with blood” (15). Thus, basic research on garlic chemistry has led to the development of a new type of plastic in which a stable garlic-derived anticoagulation and antibiotic agent provides unique properties of potential use in heart valves, artificial blood vessels and other implant devices.

Passwater: Are the ajoenes and dithiins the only garlic components that are actively being studied for possible protection against heart disease? Block: As far as I am aware. Passwater: When we are talking about the health benefits from garlic and garlic’s sulfur-containing compounds, is it your view that we are not talking about sulfur-compound nutrition, such as with the sulfur-containing amino acids cysteine or methionine, but with the “herbal” properties of garlic, which are health benefits beyond those of nutrients? Block: I would like to respond with a qualified yes. In addition to those compounds formed from garlic such as allin and ajoene, there are various cysteine derivatives from garlic related to alliin containing allyl groups attached to cysteine sulfur, which may also have health benefits. However to be of value, these allylic compounds would have to be present in significant quantities in what is consumed. Passwater: You mentioned that we get the most beneficial compounds from cooked garlic or garlic prepared with edible oils and not directly from raw garlic—what about garlic supplements? Block: My basic research through the years has focused on fresh garlic and compounds such as ajoene directly derived from fresh garlic and on the biological activity of pure samples of ajoene and related compounds. I myself have not been involved in the preparation or evaluation of different commercial garlic supplements so I can only answer your question based on what I have read in the open literature. There are quite a variety of different garlic products on the market. There is certainly a need for independent testing and evaluation of these different products and careful examination of their claims. Some products talk about alliin content, allicin potential or allicin yield. Since there is no way to stabilize alliin itself, any claims concerning actual alliin content in a product cannot be correct. Intact garlic cloves themselves do not contain allicin, although upon cutting or crushing under ordinary circumstances alliin is formed. Thus, one can talk about the alliin potential or allicin yield from garlic cloves. If garlic cloves are frozen in dry ice, pulverized with acetone in the absence of water, and the powder is then briefly heated with alcohol, not a trace of allicin can be detected following addition of water because these conditions destroy or “denature” the alliinase enzyme, which is required for allicin production. These very conditions were employed 50 years ago by Chester Cavaillaye, a French microbiologist of alliin, to demonstrate that an active enzyme is a requirement for allicin formation. In this particular case, the alliin potential is unfulfilled because the enzyme has been denatured. With a garlic supplement claiming allicin potential, I would assume one is talking about some type of preparation in which water has been removed from garlic and the resulting product then pulverized and encapsulated. I further assume that when the contents of the capsule are exposed to water, allicin is produced. The critical question is whether or not the required enzyme is destroyed during the actual digestive process at the time when the coating of the capsule dissolves. Just as hot alcohol can denature the sensitive alliinase enzyme, so too can the strong acid present in our stomach. While allicin itself is highly unstable and can only be produced when both the precursor alliin and the enzyme allinase are present under non-denaturing conditions, the situation with ajoene-containing products such as allicin, ajoene and diallyl disulfide. When the sulfur compounds are digested they are broken down into simpler sulfur compounds, a portion of which enters the bloodstream and is then exhaled from the lungs or eliminated through our pores when we sweat. Since the human nose can detect less than one part of these sulfur compounds formed in one billion parts of exhaled air, it doesn’t require much garlic or garlic compounds to give us garlic breath. It has even been reported that babies born to mothers who consumed garlic prior to giving birth have allicin in their blood. Not that the babies complain! In fact, other studies suggest that babies actually prefer slightly garlicky mother’s milk. If we can assume that it is the sulfur compounds of garlic that are primarily responsible for its health benefit, then it seems illogical to expect benefits, from a product where not a trace of garlic breath can be detected after consumption.