

Importance of Garlic (*Allium sativum*)

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Garlic (*Allium sativum*) is not only a spice, but also a plant with immense medicinal value. According to historical records, soldiers and athletes in ancient Greece and Egypt had taken garlic containing diets to enhance their strength and working capacity. Garlic is a well-known folk medicine in Asia; it is used as a Chinese folk medicine for depression, fatigue, headaches, to improve male potency, and to decrease platelet aggregation.

Diversity of garlic

Garlic is a monocot plant which belongs to *Liliaceae* family and there are 600-750 species discovered from the genus *Allium*, including onion, leeks *etc.* Garlic is a perennial flowering plant, which bears an erected flowering stem up to 3 feet tall. The flat, linear leaf blade of this plant ends up with an acute apex. Not only the bulb of garlic, but also its leaves, stems and flowers are edible. Hard-neck (or stiff-neck) garlic and soft-neck (or short-neck) garlic are the subspecies of this plant (Fig. 1).

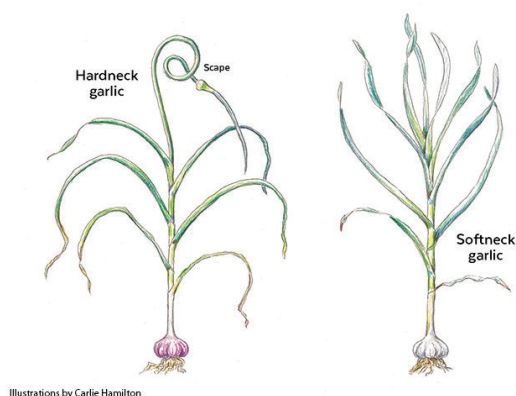


Figure 1. Morphological difference between subspecies of garlic plant

Hard-neck garlic (*e.g.*, *Allium sativum* ssp. *ophioscorodon*) produces scape (or flowering stalks) with 6-11 cloves in the bulb which are gathered around the woody stalk. Soft-neck garlic (*e.g.*, *Allium sativum* ssp. *sativum*) bulbs do not have a woody scape; but

about 24 cloves are packed as layers around a soft central stem (Fig. 2).



Figure 2. Morphological difference between the soft-neck and hard-neck garlic bulbs

The color of the bulb (Fig. 3) may depend on the phytochemicals present in garlic. Saponin content of purple garlic is about 40 times higher than that of white garlic. Various saponins such as degalactotigonin-rhamnose, voghierside D1, sativoside B1-rhamnose, proto-degalactotigonin, proto-degalactotigonin-rhamnose, and sativoside R1 are some of the phytochemicals found only in purple garlic.



Figure 3. Purple and white garlic

Garlic varieties (*i.e.*, rocambole, purple stripe, marble purple stripe, porcelain, silver skin *etc.*) are categorized using DNA analyses.

Black garlic (Fig. 4) has become popular now-a-days, though it is not a variety of garlic. It can be considered as aged garlic, because it is prepared by keeping fresh garlic bulbs under specific temperature

and humid conditions. Long shelf-life, soft texture and less pungent flavor are some of the reasons for its popularity. Bio-accessibility of organosulfur (OS) compounds in black garlic is higher than those in fresh garlic. Bio-accessibility of polyphenols is lower in black garlic when compared to fresh bulbs. The presence of coumarin in black garlic has become a concern for its consumption, as coumarins are moderately toxic to the liver and kidney.



Figure 4. Black Garlic

Phytochemicals in garlic

Mainly four types of sulfur-based compounds are present in garlic; S-alk(en)yl-L-cysteine sulfoxides (ACSO) and thiosulfinate analogs, ajoene derivatives, cysteine analogs and sulfide species.

(+)-S-methyl-L-cysteine sulfoxide (methiin) (1), (+)-S-allyl-L-cysteine sulfoxide (alliin) (2), (+)-S-propyl-L-cysteine sulfoxide (propiin) (3) and (+)-S-trans-1-propenyl-L-cysteine sulfoxide (isoalliin) (4) are the major ACSO compounds that are present in the cytoplasm of the garlic cell.

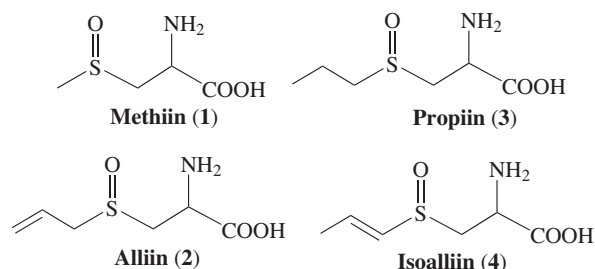


Figure 5. Structures of ACSO

When the cells are disrupted alliinase enzyme which comes with vacuole secretes, converts alliin (2) into alkenyl-alkene thiosulfate allicin (5). This

compound decomposes to form diallyl disulfide (DAD) (6), diallyl trisulfide (DAT) (7), diallyl sulfide (DAS) (8), ajoene (9), dipropyl disulfide *etc.*

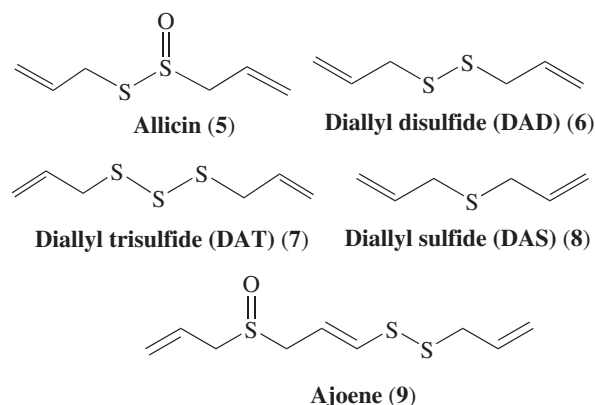


Figure 6. Structures of organo-sulfur compounds

Garlic is rich in vitamin B₁, B₂, B₃, C, adenosine and several minerals such as manganese and selenium. Saponins, polyphenols, flavonoids (such as quercetin (10), kaempferol (11), lipids (*e.g.*, linolenic acid) and polysaccharides are the other organic molecules isolated from garlic. Vitamin B₁ (thiamine) easily absorbs in the gut, and it forms allithiamine (12) with allicin. β-resorcylic acid (13) is the main phenolic compound present in garlic.

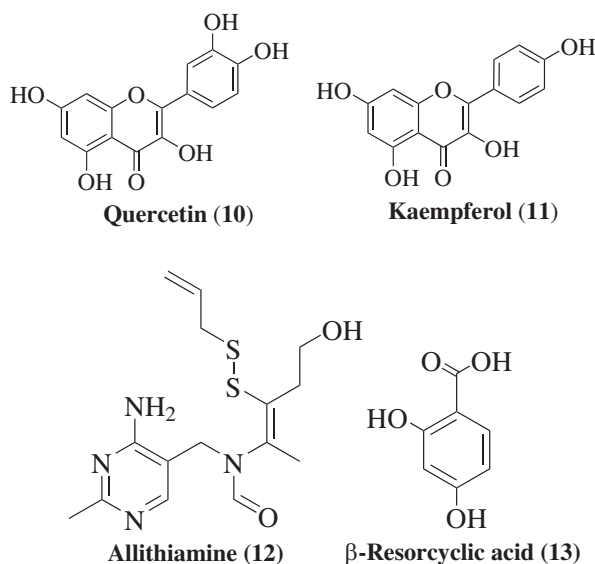


Figure 7. Structures of compounds (10)-(13)

Garlic for a healthy life

Garlic is a well-known anti-microbial agent; thus, most of the sulfur containing compounds act against gram-positive and gram-negative bacteria and fungi. Garlic is also used to destroy antibiotic resistant bacteria

such as *E. coli*, *Salmonella*, *Shigella*, *Pseudomonas*, *Staphylococcus* etc. which can cause diseases. Due to its anti-microbial property, garlic is used to increase the shelf-life of some of the food. Furthermore, the essential oil extracted from garlic is also used as a bio-pesticide. Polyphenols, flavonoids and organosulfur compounds in garlic play a vital role as antioxidants, anti-inflammatory and anticancer agents.

Garlic is a traditional herbal medicine used for the treatment of rheumatics, hypertension, respiratory infections etc. In Russia, garlic is commonly used as an inhalator for children. Garlic rapidly destroys *Mycobacterium tuberculosis* bacteria, which causes tuberculosis. Garlic has a miraculous power to fight against bronchitis infections. It is also known to boost the immune system. Ethiopians use garlic to treat malaria patients.

Sticky deposition of bacteria on teeth (dental plaque) can be prevented by treating them with garlic. Garlic bulbs are not only good for having shiny teeth, but also for keeping dandruff free scalp. *Helicobacter pylori* is a common bacterium which lives in stomach and cause severe gastritis. Consumption of garlic helps to get rid of these bacteria.

Garlic shows hepato-protective qualities such as inhibiting lipid peroxidation while reducing oxidative stress and inflammation. Garlic is one of the important Ayurvedic medicines which helps to have a healthy heart, by burning cholesterol in the body. Adenosine is the major anti-platelet compound that can be obtained in garlic which is important to prevent platelet aggregation. Garlic can be considered as an anti-obesity and anti-diabetes agent. It is important to maintain a healthy nervous system.

Some of the organosulfur compounds show lachrymatory property. Allicin (5) is the most bioactive sulfur compound which is sensitive to heat. Allicin (5) and isoallin (4) in garlic are used to treat eye diseases such as glaucoma and atropine toxicity. Garlic cloves are used to heal ear pains. Allicine (5) is important to activate the fibrinogen in the blood for healing wounds and curing infections, even though it causes gastrointestinal tract issues. However, due to its bad breath, most people do not like to consume garlic.

Garlic oil is a volatile edible oil which is considered

as a nutritional supplement as well as an insecticide. Garlic oil slows down renal damages.

Sometimes, over consumption of garlic can cause salivation, sweating, vomiting, diarrhea, allergy, coma etc. Allicin is unstable in high temperatures. In order to get better health benefits, garlic bulbs are added when the cooking is almost done.

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