3.3 Medicinal Qualities of Garlic

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Abstract

Garlic (*Allium sativum* L.) has been used for its medical properties for thousands of years. However, investigations of its medical substances are relatively new. It has a broad spectrum of actions such as antibacterial, antiviral, antifungal, and antiprotozoal. It also has positive effects on the cardiovascular and immune systems. This review aims to address the historical use of garlic and its sulfur chemistry, and to provide a brief summary of its botanical properties.

Keywords: garlic, medical properties, therapeutic effects

Introduction

Garlic is one among the oldest cultivated plants in the world. It belongs to the large botanical species of the genus *Allium*. It was known to protect against diseases and epidemics. In the past, garlic was taken as a spice, a vegetable, and a medicinal plant. It has been used in fresh and dried forms, as an essential oil and in various extracts, by the food industry, canning industry, and manufacturers of pharmaceuticals and cosmetics. In its long history, it has gained both admirers and opponents. People have always loved garlic, mainly for its medicinal properties. Garlic gives a unique flavour to dishes and has been known for its very distinctive aroma which penetrates all body fluids.

The Taxonomy and Botanical Properties of Garlic

Garlic belongs to the botanical genus *Allium*. It includes about 700 botanical species, according to estimates by a Swedish botanist P. Wendelbo. Most of them come from countries in Asia and Europe continents. A few species come from the Americas and a few from North Africa. In Australia, *Allia* does not occur at all. The areas with the largest number of species are found in a geographic belt situated around latitude 37 north and from the Mediterranean sea to Iran and Afghanistan (Mann, 1952). The region with particularly a high diversity of species of the genus *Allium* is located in Iran, northern Iraq, Afghanistan, Kazakhstan and western Pakistan. The number of species decreases towards the center of diversity. The greatest loss of the species is on the southern boundary of this area. This is due to the significant climate change in the Himalayas and the northern Indian plains. In smaller quantities, the species of the genus *Allium* grow in northern Gaza. One or two species grow well in the subarctic zone. The other less important center of species' diversity is located in the west of North America. The species also grow in the highlands and mountain areas. Several species of the genus *Allium* are found outside the main centers in the highlands and mountains in the tropics and subtropics such as Sri Lanka, Ethiopia, and Central America (southern Honduras, western Guatemala and southern Mexico) (Block, 2010). The species of the genus *Allium* are highly adaptable. They are able to adapt to different environmental conditions. The main species of the genus *Allium* grows in open, sunny, and rather dry places. The representatives of the genus are characteristic of members of the plant communities of steppe, semi-desert, dry mountain slopes, cliffs, coastal cliffs, and sunny Mediterranean forest steppe. Garlic (*Allium sativum* L.) is a permanent crop. The plants grow according to type, and their height ranges from 0.30 to 0.60. Garlic multiplied by generative methods is unknown with long-term cultural cultivation. Related species retain the ability to reproduce vegetatively and generatively. The main parts of garlic are root, corm, leaves, collateral buds, stem, and inflorescence (Brodnitz *et al.*, 1971). The stem is located at the basal part of the plant, which is considerably shortened below the soil surface (Fig. 11). This is referred to as root and corm. In mature bulbs, a new corm of garlic is separated by a cork layer from the old one. After peeling off a clove, it characteristic track remains on the old

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one, which differentiates each of the botanical forms. Not only the number of cloves but also the construction of the number of bulb leaves can be seen according to the tracks. The shape of an inverted cone acquires its height as the stem growing. The leaves initiate in the growth cone and its center. Fundamental leaves can be seen under the microscope as the circles with increased marginal areas form later in the leaf sheath. The inner part of the circle extends into the leaf blade. The upper part of the stem expands on the both sides, which means upwards and sideways (Fritsch *et al.*, 2002). The space inside the circular leaf bases grows and thus gives rise to new leaves. Garlic is a formed fibrous root system (Fig. 11). Winter varieties with wide leaves (type U) consist of a considerably shortened fibrous root system. The forms requiring irrigation create a shallow, fibrous root system. In winter varieties, root development is stopped in early June and later in northern areas. The roots develop stronger and deeper in forms with narrower leaves that interrupt their development at the end of June. Garlic leaves are bifacial with parallel veins. The leaves are developed in varying numbers (4–16). The first leaf is stiffer, shorter, and more upright with a darker color. The leaf has to break through the soil. The emergence of the leaf occurs fairly soon. The color of the leaves is typically green, and turns to light green, sometimes (Brewster, 1994). The leaves are flat and striated. The shape may be wider or narrower. The upper part of the leaf is peaked with a thicker sheath on the basal side. The flower stem occurs in almost all cultivated species of the genus *Allium* grown from root corm. Flower stem consists of one node extending between the last leaf and the spathe. A fully developed flower stem can reach a height of more than 1 m in species of the genus *Allium*. The flower stem is cylindrical, solid, and leafed up to one third. The inflorescence is topped by the umbel protected by the spathe, which is composed of membranous bracts. The flowers are only about 4–6 mm long, having six stamens and petals. Garlic sticks are about 2 mm long (Kamenetsky *et al.*, 2006). They are accompanied by fibrous bodies, filaments, and species-specific sheaths. These flowers are sterile, and the number of somatic chromosomes is 2n = 16. In the basal part of the umbel, the bulbils are formed. They are vegetative organs and have nothing to do with sexual propagation (Fig. 11) (Lesna *et al.*, 2004). If many bulbils are produced, they tend to be small. If few bulbils are produced, they can grow quite large. The bulbils can be used for the reproduction. The color of their tunic is the same as the color of garlic's tunic. According to Lužný and Vaško (1982), garlic can be divided into three groups in terms of flowers:

1. Garlic which does not form flower stalks – *Allium sativum subsp. vulgare* (softneck) white in color.
2. Garlic which produces flower stalks – *Allium sativum subsp. sagittatum* (hardneck) blue, purple or pink in color. This group consists of flower stalks and bulbils. According to the number of bulbils and their size, it can be divided into two groups:
   - Garlic consisting of many small bulbils in the umbel.
   - Garlic forming a small number of large bulbils.
3. Garlic incompletely projecting into a flower – the umbel with bulbils may remain closed, as a “false stem”. In extreme cases, they remain inside the garlic bulb. At one stalk, several bulbils can be created. The flower is not usually developed. The rate of development varies significantly even with the same clones. The storage organ of garlic is a morphologically metamorphosed leaf. There are 4 types of bulbs:
   - Covering (*Bulbus tunicatus*) – making up slightly pulpy bases leaves widely adjoining to the corm and lying close to each other (onion).
   - Scaly (*Bulbus squamous*) – with a tapered corm adjoining pulpy scaly leaves (lily – *Lilium*)
   - Composed (*Bulbus compositum*) – the corm consists of membranous scales with collateral buds (garlic)
   - Full (*Bulbus solidus*) – with a single leaf (wild garlic)

Garlic has a compound bulb consisting of easily separable, and shuttle, curved sickle cloves growing from a common corm. There can be from 1–50 cloves. They are the supply and reproductive organs.

11: *The stem of garlic with leaves, root and bulbils*
Source: Author's Archive

Origin and Extension

Garlic is one of the oldest cultivated vegetables. Its positive effects on the human organism have been known for several millennia. It comes from Central Asia. From there, it was spread to the Mediterranean and throughout Europe, the Far East, China, Korea, and Japan. It was used mainly as a spice and medicinal plant (Fritsch *et al.*, 2002).

The remains of garlic have been found in caves inhabited ten thousand years ago. The first written mention of this herb was written on a Sumerian cuneiform clay table from the period around 3000 BC. Garlic was also found in the oldest medical text called the Ebers papyrus dating from around 1500 BC. The entire ancient world from Spain to China loved garlic. More than any other nation, the Egyptians were fond of this medicinal plant, and believed that the plant helped prevent disease, and increase strength and endurance. Over the centuries, the upper class returned to use garlic, but only for medical reasons (Fritsch *et al.*, 2002). The English herbalist of 17th century Nicholas Culpeper recommended this herb in cases such as rabid dog bite or bites by other venomous animals, as well as for killing intestinal parasites in children, releasing mucus, clearing the head, and curing plague (Brewster, 1994).

Alexander Fleming discovered penicillin in 1928, and this was the starting point of antibiotics. Since World War II, garlic was replaced by penicillin-based drugs sulfates. Nowadays, the herbal doctors recommend garlic for colds, coughs, flu, bronchitis, ringworm, intestinal parasites and cardiovascular disease. The therapeutic effects of garlic are shown in Tab. III.

III: *The therapeutic effects of garlic*

Disease	Treatment with garlic
Gastric ulcers	two garlic cloves per day is an effective prevention against infection caused by *Helicobacter pylori*
Stroke and heart attack	daily consumption of garlic reduces the risk of heart attack by up to 24%
Cancer	diet containing lots of garlic significantly reduces the possibility of developing stomach cancer
Diabetes	garlic reduces blood sugar in humans and animals
Saturnism	garlic helps the body to excrete lead and other toxic heavy metals
Leprosy	garlic has been used in the treatment of this disease, improving health significantly
AIDS	the use of garlic leads to significant improvements in immune reactions, which are weakened by the disease

Source: Author's Archive

Medicinal Properties of Allium sativum

The most important compounds with therapeutic and beneficial nutritional properties are the sulfur-containing compounds, carbohydrates, vitamins, hormonal agents, ferments, antibiotics, sulfur-free antibiotics, and microelements. The content of individual compounds in garlic differs considerably depending on variety, soil, weather, and fertilization treatment. Yoshida *et al.* (1998) and McKenna *et al.* (2002) stress that the sulfur content varies in different varieties, in a range of more than 100%. The sulfur content is proportional to the antibiotic or other therapeutic efficacy. The sulfur compounds include alliin which is the starting material of sulfur bonds in garlic. Rees *et al.* (1998) speak about alliin, which is derived from the amino acid cysteine. Alliin is ineffective as a pharmaceutical substance. It forms bunches of white, soft, odorless crystals, which are soluble in water, but not in organic solvents. There is no allicin in garlic. According to Hassan (2004), it develops from alliin by conversion of the enzyme alliinase which is present in almost all species of the genus *Allium*, and with some other plants. Allicin is an extremely unstable, slightly yellowish oily liquid, with garlic's smell and pungent taste; it is optically inactive, and when mixed with organic solvents, it is slightly soluble in water at 10 °C. According to Jamison (2003: 541–546), it is the main carrier of a number of the active antibiotic properties of garlic. Its antibiotic activity depends on the presence of oxygen. The reduction is significantly inactivated. Allicin proves to be important in many of the health effects of garlic. Hassan (2004) argues that the anti-cancer effect of garlic might be shared between allicin and other unidentified compounds. Garlic contains about 1% of alliin, which is converted enzymatically by allicinase into allicin and other sulphur-containing compounds.

Kasuga *et al.* (1999) stress that garlic is effective in lowering serum glucose levels in STZ-induced, as well as alloxan-induced diabetic rats and mice. Most of studies show that the garlic reduces blood glucose levels in diabetic mice, rats and rabbits. Augusti (1996) and Sheela (1992) consistently show that S-allyl cysteine sulphoxide, (allicin), a sulphur-containing amino acid in garlic (200 mg/kg body weight), has the potential to reduce the diabetic condition in rats almost to the same extent as glibenclamides and insulin. Sheela (1992) and Sheela (1995) stress that aged garlic extract is also effective in preventing adrenal hypertrophy, hyperglycemia and elevation of corticosterone in mice made hyperglycemic by immobilization stress.

Song & Milner (2001) show that as little as 60s of microwave heating or 45min of oven heating can block garlic's ability to inhibit in vivo binding of mammary carcinogens

[7,12-dimethylbenzene (a) anthracene (DMBA)] metabolites to rat mammary epithelial cell DNA. Allowing crushed garlic to "stand" for 10 minutes before microwave heating for 60 seconds prevents the total loss of anticarcinogenic activity. Their studies show that this blocking of garlic's ability is consistent with inactivation of alliinase. These studies suggest that heating is likely to destroy garlic's active allyl sulfur compound formation that may relate to its anticancer properties. Gorinstein (2007) reviewed that the contemporary data concerning atherosclerosis and the protecting properties of garlic. Recent advances in basic science have established a fundamental role for inflammation in mediating all stages of this disease from initiation through progression and, ultimately, to the thrombotic complications of atherosclerosis. These new findings provide important links between risk factors and the mechanisms of atherogenesis and garlic properties. Eisenbarth *et al.* (2003) confirm that numerous *in vitro* studies have demonstrated the ability of garlic to reduce the the risk of atherosclerosis: total cholesterol, LDL, triglycerides, oxidized LDL. The positive influences of garlic on plasma lipids, proteins, antioxidant activity, and some indices of blood coagulation are dose-dependent. Arguably, garlic is likely to be a valuable component of atherosclerosis-preventing diets only in optimal doses. Jelodar *et al.* (2005) further stress that many recently published reports show that the garlic possesses plasma lipid-lowering and plasma anticoagulant and antioxidant properties and improves impaired endothelial function. Ali and Thomson (1995) examine the effect of the consumption of a fresh clove of garlic on platelet thromboxane production.

A group of male volunteers aged 40–50 years participated in the study. Each volunteer consumed one clove (approximately 3 g) of fresh garlic daily for a period of 16 weeks. Each participant served as his own control. Thromboxane B_2 (TXB_2, a stable metabolite of thromboxane A_2), cholesterol and glucose were determined in serum obtained after blood clotting. After 26 weeks of garlic consumption, there was an approximately 20% reduction of serum cholesterol and about 80% reduction in serum thromboxane. Kiesewetter (1991) agrees that there is no change in the level of serum glucose. Thus, it appears that small amounts of fresh garlic consumed over a long period of time may be useful in the prevention of thrombosis. Garlic also contains a variety of vitamins and trace elements (Tab. IV).

IV: *The content of main vitamins and microelements in fresh garlic in mg/100g*

Vitamin	mg	Microelement	mg
Vitamin A (retinol)	0,085	Ca	50–90
Vitamin B_1 (thiamin)	0,003–0,280	P	390–460
Vitamin B_3 (nicotinic acid-PP factor)	0,12–4,0	K	100–120
Vitamin B_5 (pantothenic acid)	0,25	Na	10–22
Vitamin B_6 (pyridoxine)	0,03–0,08	Mg	43–77
Vitamin C (ascorbic acid)	0,03–66,5	Al	0,5–1
Vitamin E (tokoferol)	0,1	Ba	0,2–1
Vitamin H (biotin)	0,00022	Fe	2,8–3,9

Source: Authors' Archive

Summary

Garlic (*Allium sativum*) is one of the most popular plants used worldwide to reduce various risk factors associated with antibacterial, antiviral, antifungal, and antiprotozoal properties. Garlic is one of the plants most commonly used in modern medicine. Garlic is a permanent crop. Plants grow according to type and their height varies from 0.30 to 0.60 m or more. The most important compounds with therapeutic and beneficial nutritional properties are sulfur-containing. Aged garlic extract is also effective in preventing adrenal hypertrophy,

hyperglycaemia and the elevation of corticosterone in mice made hyperglycemic by immobilization stress. It appears that a small amount of fresh garlic consumed over a long period of time may be useful in the prevention of thrombosis. Numerous *in vitro* studies have confirmed the ability of garlic to reduce the risk of atherosclerosis: total cholesterol, LDL, triglycerides, oxidized LDL. The positive influences of garlic on plasma lipids, proteins, antioxidant activity, and some indices of blood coagulation are dose-dependent.

References

Ali, M. & Thomson, M. (1995). Consumption of a garlic clove a day could be beneficial in preventing thrombosis. *Prostaglandins Leukot. Essent. Fatty Acids,* 53, 211–212.

Augusti, K. T. (1996). Therapeutic values of onion (*Allium cepa* L.) and garlic (*Allium sativum* L.). *Indian J Exp Biol*, 34, 634–640.

Block, E. (2010). *Garlic and other alliums: The lore and the science.* Cambridge: Royal Society of Chemistry.

Brewster, J. L. (1994). *Onions and other vegetable alliums.* Wallingford: Cab International.

Brodnitz, M. H., Pascal, J. V. & Vanderslice, L. (1971). Flavour components of garlic extract. *J. Agric. Fd. Chem*, 19 (2), 273–275.

Eisenbarth, G. S & Kotzin, B. L. (2003). Enumerating autoreactive T cells in peripheral blood: a big step in diabetes prediction. *J. Clin. Invest.* (111), 179–181.

Fritsch, R. M. & Friesen, N. (2002). Evolution, domestication and taxonomy. In: Rabinowitch D., Currah L. (Eds.), *Allium crop science: Recent advances*. Wallingford: CAB International, 5–30.

Hassan, H. (2004). Ajoene (natural garlic compound): A new anti-leukaemia agent for AML therapy. *Leuk. Res.,* 28, 667–671.

Jamison, J. R. (2003). Garlic (Allium sativum). In: *Clinical guide to nutrition and dietary supplements in disease management.* London: Churchill Livingstone.

Jelodar, G. A., Maleki, M., Motadayen, M. H. & Sirus, S. (2005). Effect of fenugreek, onion and garlic on blood glucose and histopathology of pancreas of alloxan-induced diabetic rats. *Indian J Med Sci,* 59, 64–69.

Kamenetsky, R. & Rabinowitch, H. D. (2006). The genus Allium: A developmental and horticultural analysis. *Horticultural Reviews*, 32, 329–378.

Kasuga, S., Ushijima, M. & Morihara, N. (1999). Effect of aged garlic extract (AGE) on hyperglycemia induced by immobilization stress in mice. *Nippon Yakurigaku Zassh,*: 191–197.

Kiesewetter, H., Jung, F. & Pindur, G. (1991). Effect of garlic on thrombocyte aggregation, microcirculation, and other risk factors. *Int. Clin. Pharmacol. Ther. Toxicol.,* 29, 151–155.

Lesna, I., Conijn, C. G. M. & Sabelis, M. W. (2004). From biological control to biological insight: rust-mite induced change in bulb morphology, a new mode of indirect plant defense? *Phytophaga*, 14, 285–291.

Lužný, J. & Vaško, S. (1982). *Cibulové zeleniny* [Bulb vegetables]. Bratislava: Priroda.

Mann, L. K. (1952). Anatomy of the garlic bulb, and factors affecting bulb development. *Hilgardia,* 21, 195.

Mckenna, D. J., Jones, K., Hughes, K. & Humphrey, S. (2002). *Botanical medicines, the desk reference for major herbal supplements.* Second Edition, New York: The Haworth Herbal Press.

Rees, L. P., Minney, S. F., Plummer, N. T., Slater, J. H. & Skyrme, D. A. (1998). A quantitative assessment of the antimicrobial activity of garlic (Allium sativum). *World J Microbiol Biotechnol,* 9, 303–307.

Sheela, C. G. & Augusti, K. T. (1992). Antidiabetic effects of S-allyl cysteine sulphoxide isolated from garlic Allium sativum Linn. *Indian J Exp Biol,* 30, 523–526.

Sheela, C. G., Kumud, K. & Augusti K. T. (1995). Anti-diabetic effects of onion and garlic sulfoxide amino acids in rats. *Planta Med*, 61, 356–357.

Song, K. & Milner, J. K. (2001). The influence of heating on the anticancer properties of garlic. *J. Nutr.,* 131(3), 1054–1057.

Yoshida, H., Iwata, N. & Karsuzaki H. (1998). Antimicrobial activity of a compound isolated from an oil-macerated garlic extract. *Biosci. Biotechnol. Biochem.,* 62, 1014–1017.