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Antimicrobial Spectrum of *Allium* Species – A Review

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ABSTRACT

Onion and garlic are best known for their pungent aromas, but these potent veggies have powerful effects on health and also there is urgent need to identify superior populations, quickly characterize and select elite candidates and breed new varieties for achieving current as well as future food and global health security needs. Hence this review article is focused on the analysis of the biological activity of *Allium cepa* (onion) and *Allium sativum* (garlic) to understand the degree and spectrum of bioactivity of these species. Among the onion and garlic, garlic is found to be slightly better species in antimicrobial activity than onion.

Keywords: Onion, garlic, human pathogens, antimicrobial activity, solvent extracts.

1. INTRODUCTION

Allium is a monocot genus of flowering plants, informally referred to as the onion genus. The generic name *Allium* is the Latin word for garlic. The genus including the various edible onions, garlics, chives and leeks, has played a pivotal role in cooking worldwide, as the various parts of the plants, either raw or cooked in many ways, produce a large variety of flavours and textures.

The genus contain hundreds of distinct species, many have been harvested through human history, but only about a dozen are still economically important today as crops or garden vegetables (Simonetti 1990) and many others are cultivated as ornamental plants. *Allium* is taxonomically difficult and species boundaries are unclear. *Allium* is a genus of perennial bulbulous plants that produce chemical compounds (mostly cysteine sulfoxide) that give them a characteristic onion or garlic taste and odour. Many are used as food plants, though not all members of the genus are equally flavourful. In most cases, both bulb and leaves are edible. Their taste may be strong or weak, depending on the species and on ground sulphur (usually as sulphate) content (Block 2010). In the rare occurrence of sulphur-free growth conditions, all *Allium* species will lack their usual pungency altogether.

2. ANTIMICROBIAL ACTIVITY OF *ALLIUM* SPECIES

Garlic is a strong antibacterial agent and acts as an inhibitor on both gram positive and gram negative bacteria including such species as *Escherichia, Salmonella, Streptococcus mutans, Porphyromonas gingivalis, Staphylococcus, Klebsiella, Proteus* and *Helicobacter pylori* (Ankri and Mirelman, 1999; Bakri and Douglas 2005). Garlic (*Allium sativum*) has a long folklore history as a treatment for cold, cough and asthma and is reported to strengthen the immune system (Borek 2001). It has many medicinal effects such as lowering of blood cholesterol level (Yeh and Yeh 1994), antiplatelet aggregation (Steiner et al 1996), anti-inflammatory activity (Baek et al 2001) and inhibition of cholesterol synthesis (Piscitelli et al 2002). Garlic has long been known to have antibacterial (Ekweney and Elegalan, 2005), antifungal (Yoshida et al 1987), anticancer (Pan et al 1985) and antiviral properties (Block, 1985).

The effectiveness of garlic extract against a range of plant pathogenic organisms was tested invitro and in plants in diseased tissues by Curtis et al 2004. A wide range of microorganisms including bacteria, fungi, protozoa and viruses have been shown to be sensitive to crushed garlic preparations (Delaha and Garagusi 1985). Moreover, garlic has been reported to reduce blood lipid and cholesterol levels (Gebhardt and Beck 1996), possess anticancer effects and prevent aging (Hong et al 2000; Sheen et al 1996). Lyang et al 2008¸determined the synergistic effect of nisin and garlic shoot juices (GSJ) against *Listeria monocytogenes* ATCC 19118 found in whole (3.5%, low (1%) and skim (no fat content) milk.

However, garlic contains nearly three times more sulphur containing compounds as onions (Lawson 1996). The mature, intact *Alliums* contain mainly cysteine sulfoxides, and when tissues are chopped, the enzyme allinase is released, converting the cysteine sulfoxides into the thiosulfinates. These compounds are reactive, volatile, odor producing and lachrymatory (Block et al 1992). In addition to their nutritional effects, the antibacterial and antifungal activities against a variety of gram negative and gram positive were, and continue to be extensively investigated (Whitemore and Naidu 2000). Han et al (1995) reported that the antibiotic activity of 1mg of allicin, which is a (+)-s-methyl-L-cysteine sulfoxide, has been equated to that of 15 IU of penicillin. Recent investigations have also demonstrated an inhibitory effect by aqueous extracts on numerous bacterial and fungal species (Sivam et al 1997; Ward et al 2002). Onions are effective against common cold, heart disease, diabetes, osteoporosis, coughs and sore throat (Augusti 1996). They also act as bacteriostatic (Saulis et al 2002). Certain chemical compounds believed to have anti-inflammatory, anti-cholesterol, anticancer and antioxidant properties such as quercetin are present in onions (Wilson et al 2007). Benkeblia (2004) studied the effect of essential oils extracts of various onion types and garlic on two major bacterial pathogens, and three fungal species usually causing rotting of *Allium* crops during their storage.

Sulphur and polyphenols present in garlic respond to the antibacterial, antifungal and antioxidant activity was carefully studied in previous reports (Chung et al 2006; Bozin et al 2008 and Wan et al 2009).

Antifungal proteins have been isolated from various *Allium* species including onion seeds (Cammue et al 1995), bulbs of the round cloved (alternatively called single cloved) garlic (Wang and Ng 2000), chive shoots (Lam et al 2000), shallot bulbs (Wang and Ng 2002) and leek (Vergauwen et al 1998). In order to find out if bulbs of the multiple cloved garlic contain an antifungal protein similar to that isolated from bulbs of the round cloved garlic. Although much has been reported on the medicinal properties of garlic (Ali et al 2000), not much is known about its proteinaceous constituents (Smeets et al 1997).

Garlic has a wide spectrum of actions; not only antibacterial, antiviral, antifungal and antiprotozoal, but also has beneficial effects on the cardiovascular and immune systems (Harris et al 2001). During the last decade, the antimicrobial activity of garlic and garlic derived organosulfur compounds was widely investigated against both food spoilage bacteria and food-borne pathogens (Leuschner and Ielsch 2003). Besides its antimicrobial effect, garlic showed effective antioxidant activity in vivo and invitro (Jackson et al 2002). Garlic rich organosulfur compounds and their precursors (allicin, diallyl sulphide and diallyl trisulfide) are believed to play a key role in these biological effects (Kumar and Berwal 1998).

Avato (2000) described the antibacterial and antifungal action of garlic volatile oils, one of the plant products commercially available. Garlic has also proposed to treat asthma, candidiasis, colds, diabetes, and antibacterial effect against food borne pathogens like *Salmonella, Shigella* and *Staphylococcus aureus* (Teferi and Hahn 2002). Therapeutic use of garlic has been recognized as a potential medicinal value for thousands of years to different microorganisms. For example, antifungal, antiviral, antibacterial, antihelmantic, antiseptic and anti-inflammatory properties of garlic are well documented. Moreover, garlic extracts exhibited activity against both gram negative (*E.coli, Salmonella* sp. and *Citrobacter, Enterobacter, Pseudomonas, Klebsiella*) and gram positive (*S.aureus, S.pneumonia* Group A *Streptococcus* and *Bacillus anthrax*) all of which are causes of morbidity worldwide. Allium species have antimicrobial activity against bacteria, fungi, viruses, and parasites. Most research has focused on the antimicrobial activity of garlic followed by onion. However, intermittent reports on other Allium species have appeared. The antibacterial efficacy Allium is slightly different depending on the extraction solvents used. Water (Ivanova et al 2009; Gupta et al 2010), ethyl acetate (Ivanova et al 2009), and ethanol (Pundir et al 2010) are more frequently used compared with other solvents including acetone (Ivanova et al 2009), chloroform (Ivanova et al 2009), and butanol (Ivanova et al 2009). Shobana et al (2009) investigated the comparative antibacterial effect of ethanolic and aqueous extract of the two sub varieties (*Ophioscordon* and *sativum*) of garlic against enteric pathogens. Bioactive compounds present in two sub varieties were identified and analyzed using HPTLC and GC-MS analyses.

Allium extracts, which are expected to contain primarily thiosulfinates formed from sulfoxides, inhibit the growth of gram positive, gram negative, and acid fast bacteria. It is generally believed that gram negative bacteria are more sensitive to garlic than gram positive bacteria (Perry et al 2009). Garlic extracts are effective against various multi-drug resistant saprophytic and pathogenic bacteria (Gupta et al 2010).

Garlic also has been reported to produce various beneficial effects, including anti stress protection, growth promotion, appetite stimulation, immune stimulation and antimicrobial properties in fin fish and shrimp larviculture (Vaseeharan et al 2011). Guo et al (2012)

investigated the invitro antibacterial activity of garlic against *S.iniae* and the effect of garlic supplemented diets on growth and disease resistance in organge-spotted grouper challenged with *S.iniae*.

To date, most previous studies have focused independently on either antioxidant or antimicrobial activities of garlic in meat products, and Sallam et al (2004) studied the antioxidant as well as the antimicrobial effectiveness of three garlic preparations, i.e. fresh powder and oil at various concentrations in preserving raw chicken sausage during refrigerated storage. Daka (2011) studied on recent research on protective effects of garlic against *S.aureus.* Filocamo et al (2012) studied on the invitro evaluation of the effects of a commercial garlic powder upon the viability of representative members of human gut micro biota.

Ruiz et al (2010) evaluated in vitro the effects of two of these garlic derived compounds (PTS and PTS-O) on predominant faecal microbial populations of swine, and to determined teh concentrations active against some of the most relevant populations of swine intestinal microbiota. Additionally, activity against *Escherichia coli* and *Salmonella typhimurium,* two common pathogens of pigs, was also tested. Karuppiah and Rajaram (2012) evaluated the antibacterial properties of *Allium sativum* (garlic) cloves and *Zingiber officinale* (ginger) rhizomes against multi drug resistant clinical pathogens causing nosocomial infection.

Guo et al (2012) investigated the in vitro antibacterial activity of garlic against *S.iniae* and the effect of garlic aganst *S.iniae* and the effect of garlic-supplemented diets as growth and disease resistance in orange-spotted grouper challenged with *S.iniae.* Lanzotti et al (2012) evaluated the antimicrobial activity of the isolated garlic saponins against two fungi; *Trichoderma harzianum* and *Botrytis cinerea*.

Lately, garlic has widely been used to treat intestinal parasites. The antihelminthic effect of garlic has been a matter of interest of researchers. Their results showed that treatment with garlic evoked a significant reduction in the worms (Soffar and Mokhtar 1991; Ayaz et al 2008; Rahman et al 1998; Sutton and Haik 1999; Riad et al 2009). In addition, garlic has been used successfully in a single uncontrolled study in China applied on 20 AIDS patients to treat Cryptosporidium (Fareed et al 1996). Moreover, garlic compounds were purified and tried as complementary medicine in the management of leishmaniasis (Wabwoba et al 2010). Thus because many of the microorganisms susceptible to garlic extract are medically significant, garlic holds a promising position as a broad-spectrum therapeutic agent (Adetumbi and Lau 1983). Reda (2012) designed to evaluate the prophylactic and therapeutic efficacy of *Allium sativum* (garlic) against cryptosporidium infection in experimentally infected immunocompetent and immunosuppressed mice.

Onion (*Allium cepa* L.) possesses strong, characteristic aromas and flavours, which have made them important ingredients of food. Onions and onion flavours (essential oil) are important seasonings widely used in food processing. Recent research has demonstrated that onions possess several biological properties, such as antibacterial (Griffiths et al 2002), Antimutagenic (Singh et al 2009) and antioxidant activities (Dini et al 2008). The medicinally most significant components of onion oil are the organosulfur containing compounds (Dron et al 1997).

The regular consumption of onions in food is associated with a reduced risk of neurogenerative disorders, cancer, cataract, ulcer, osteoporosis, vascular disease and heart disease (Kaneko and Baba 1999; Sanderson et al 1999). Onion is one of the major sources of various biologically active phytomolecules, eg., phenolic acids, flavonoids, cepaenes, thiosulfinates and anthocyanins (Singh et al 2009).

Although the antimicrobial effect of onion oil is known (Abdou et al 1972; Lewis et al 1977), very few reports are available on the effect of onion oil against dermatophytic and mycotoxin-producing fungi. Abdel-Nazzar (1995) examined the inhibitory effects of onion oil on the growth of eight isolates of bacteria and nine isolates of dermatophytic fungi as well as their effect on the growth and mycotoxins produced by four toxigenic fungi.

Adeshina et al (2011) investigated the antibacterial action of fresh juice of red and white *Allium cepa* (onion) against multidrug resistant pathogens isolated from salad. Santas et al (2010) evaluated the antimicrobial activity of onion extracts against the spoilage and pathogenic food-related microorganisms: *Bacillus cereus, Staphylococcus aureus, Micrococcus luteus, Listeria monocytogenes, Escherichia coli, Pseudomonas aeruginosa* and *Candida albicans.*

Piercey et al (2012) determined the antimicrobial effect of unentrapped AIT and its ICs (alpha and beta) on *Penicillium expansum, Escherichia coli* and *Listeria monocytogenes* in a model system; and of beta IC applied to an aerobically packaged fresh-cut onion product without or with prior inoculation with *L.monocytogenes.*

Yu et al (2013) studied the efficacy of essential oil of *Allium cepa* against food spoilage and food-borne pathogenic microorganisms and its antioxidant activity. The essential oil revealed an interesting antimicrobial effect against the tested microorganisms with the MIC and MBC values. Hindi (2013) evaluated the antibacterial activity of aquatic garlic extract, apple vinegar and apple vinegar-garlic extract combination against fourteen bacterial pathogens.

Oliveira et al (2014) examined the in vitro effects of *Allium cepa* L. extract (AcE) on *Porphyromonas gingivalis* LPS and *Escherichia coli* LPS-stimulated osteoclast precursor cells to viability to other future cell-based assays. Fozieh et al (2014) determined the antibacterial effects of garlic on multi-drug resistance *H.pylori* isolates from gastric biopsies. Juicy extracts of different medicinal plants, *Allium sativum* and *Allium cepa* were tested using agar-well diffusion method for their antimicrobial activity against the common bacterial pathogens *Escherichia coli, Bacillus subtilis* and *Staphylococcus aureus* and fungal pathogens *Aspergillus niger* and *Penicillium chrysogenum* (Rekha and Shruthi 2014).

In our study we determined the antimicrobial activity of onion and garlic against bacterial pathogens. Both the species of *Allium* showed good antimicrobial activity against the tested pathogens and reported in our previous studies. It showed best activity against *Staphylococcus aureus.* Garlic was found as slightly better plant source than onion to fight against those pathogens.

3. CONCLUSION

In conclusion, the *Allium* species has good antimicrobial activity against large number of microorganisms. It showed activity against both gram positive and gram negative bacterial pathogens concluding that it has broad spectrum antimicrobial activity. Due to the broad spectrum activity and its usage in our daily diet, onion and garlic can be used as neutraceuticals.

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