

Antibacterial Activity of Garlic (*Allium Sativum*) on *Salmonella*, *Shigella*, and *E. Coli*

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Research Article

Keywords: Garlic, E .coli, Salmonella, Shigella, allicin

Posted Date: March 15th, 2022

DOI: <https://doi.org/10.21203/rs.3.rs-1449153/v1>

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Abstract

Background

This experiment was conducted to see if garlic would inhibit the growth of Salmonella, Shigella and E. coli. This helps to understand the effectiveness of home remedies such as natural herbs includes garlic for medicinal purpose.

Methods

This study focuses on significant antibacterial activity of garlic (Allium sativum) extract against gram negative bacteria like Salmonella, Shigella and E. coli. The plant parts are known to have antimicrobial activity on bacteria which are known to be pathogenic to animals in general and to human in particular. The plant extracts were inoculated on prepared media of microbial culture contains Salmonella, Shigella and E. coli species.

Results

The result obtained indicates garlic has strong effective on Salmonella by reducing number of colonies that survive due to exposure of the anti-microbial agent is approximately similar to that of Salmonella but E. coli species showed some percent of resistance in comparison to Salmonella and Shigella.

Conclusions

The result obtained from this study could serve as an evident that Ethiopian traditional medicinal plants have a great effectiveness on different pathogenic organism.

Introduction

Garlic (*Allium sativum*) is an herb used widely as a flavoring in cooking has also been used as a medicine throughout ancient and modern history to prevent and treat wide range of conditions and diseases. Note that Garlic is one of the most known traditional herbal remedy for a wide range of ailments. It's used to improve blood circulation to reduce the risk of heart disease. Garlic also thought to help reduce high cholesterol and elevated blood pressure. Note that garlic also contains anti oxidants that help to remove environmental toxins and waste product of normal body pressure in the blood. Antioxidants help to contains and remove those harm full substances before they can accumulate and damage the body. The oils that extracted from the species and herbs are found to be effective in killing bacteria, viruses and others. Garlic is used for many conditions related to heart and blood system these conditions include high blood pressure, high cholesterol coronary heart disease and hardening of arteries.

Infectious rate by microorganism in developing countries is remaining high. Diseases continue to be a problem where nutrition, sanitary conditions are poor and emerging disease is more dangerous for such population. In Ethiopia studies indicate that common bacterial infection is *Salmonella*, *E. coli* and *Shigella*. The mode of transmission is through water and food contamination. In urban and rural area of Ethiopia these sanitary conditions are poor. This condition exposed the population by those strains of bacteria. Disease due to food borne pathogens also remains a problem largely by consumption of improperly processed and stored food. Understanding the source of contamination and developing ways to limit the growth of pathogen is the role of education (WHO, 2005).

Salmonella, *Shigella* and *E. coli* bacteria are the most problems causing food poisoning and disease. This study was aimed on antibacterial activity of garlic (*Allium sativum*) on bacterial growth. Ethiopia has various topographic land forms and biodiversity of plant species which are applicable for traditional medicine among these traditional plants the one widely used is garlic. But the effectiveness of the garlic has not been scientifically evaluated. This kind of research contributes to scientifically evaluate and increase the use of garlic to reduce infection (Jonkers *et al.*, 1999).

Many studies have been conducted on different plant species of traditional medicine and in Ethiopia garlic has been considered to be a wonder drug for treatment and prevention of variety of disease but for generation people have information of its medicinal value through garlic has been widely used as antibiotic and treatment of cardiovascular disease, bites, tumors, ulcer, wounds, cancers, measles and many more (Jonkers *et al.*, 1999). Vaccines and antibiotics have lessened the impact of pathogens in the developed world. But microbial infection in developing countries is high and new illness caused by microorganisms continue to emerge and known pathogens becoming resistant.

Salmonella infection is a common bacterial disease that affects the intestinal tract. Typically it lives in animal and human intestinal and is shed through feces. Humans infected most frequently through contaminated water and food. *Salmonella* is the second most frequent bacterial infectious disease in the world. Infection with salmonella includes fever, abdominal pain and diarrhea.

E. coli bacteria normally live in the intestine of animals. Most of *E. coli* is harmless and actually important part of healthy human intestinal tract. However, some *E. coli* are pathogenic meaning they can cause illness either diarrhea or illness outside of intestinal tract. *Shigella* also causes intestinal disease of shigellosis. The main sign is diarrhea, fever, abdominal pain and malaise, but it is easily treated bacterial infection.

The purpose of this study was to evaluate the antibacterial activity of garlic (*Allium sativum*) extract against *Shigella*, *Salmonella* and *E. coli*.

The concept of traditional medicine

Traditional medicine is remained as the most affordable and easily accessible source of treatment in the primary health care system of resource poor communities and the local therapy is only means of medical treatment for such communities. Traditional medicine defined as a health practices, approaches, knowledge and beliefs incorporating plant, animal and mineral based medicines, spiritual therapies manual techniques and exercise, applied singularly or in combination to treat, diagnose and prevent illness and maintain well-being. It is known that many countries in Africa, Asia and Latin America use traditional medicine to meet some their primary health care needs. In Africa, up to 80% of the population uses traditional medicine for primary health care (WHO, 2003).

Traditional medicine has maintained its popularity in all region of developing world and its use is rapidly spreading in the industrialized countries. For example in china it accounts for 30%-50% of total medicinal consumption. In most African countries about 70% with high fever resulting from malaria uses herbal medicine at home (WHO, 2003)

Characteristics of traditional medicine in Ethiopia

Ethiopia has long history of traditional medicine and has developed ways to combat disease through it and the ways are also as diverse as different cultures. The majority of the population (90%) that lives in Ethiopia depend mainly on traditional medicines to meet their healthcare needs (WHO, 2002). In the country healing the protection of and promotion of human physical, spiritual, social, mental and material well-being are based on traditional medicine. It widely believed in Ethiopia that the skill of traditional health practitioners is given by God and knowledge on traditional medicine is passed orally from parent to favorite child, usually a son or is acquired by some spiritual procedure. Traditional healing knowledge is guarded by certain families or social groups (Lambert, 2001).

Healers obtain their drugs mainly from natural substances. Drugs prepared in various dosage forms including liquids, ointments, powders and pills. Drugs were administrated using different routes; the main one is being topical, oral and respiratory. When side effects became severe, antioxidants were claimed to be used. In this content, garlic has been used its medical properties for thousands of years, however, investigations in to mode of its action are relatively recent. Medicinal plants like thyme, lemon, ginger, lavender, and onions are used extensively today. Among these plants the most intensively and wide spread used is garlic (*Allium sativum*) (Ellmorre et al., 1994).

History of garlic

Native to central Asia, garlic is one of the oldest cultivated plants in the world and has been grown for over 500 years. Ancient Egyptian seems to have been the first to cultivate this plant that played an important role in their culture. Garlic began to find its way into other cultures and every life of ancient civilization such as Greece, Rome, Northern Europe and China. The medicinal purposes and properties of garlic eventually became known throughout the known world and celebrated in pre-and recorded history. In folklores, garlic was attributed with the ability to bring good luck, protect against evil forces, serve as aphrodisiac, repel scorpions and sorcerers, were wolves war locks and vampires (mostly because of it

odorous quality) among other things. It was also used to increase strength and life – energy, improve blood circulation, respiratory disorders, intestinal disorders, and conditions such as diarrhea, dysentery and flatulence, worms, skin disease and other ailments (Pizzorno and Murray,1996).

Garlic was not only bestowed with sacred qualities and placed in the tomb of pharaohs, but it was given to the slaves that built the pyramids to enhance their endurance and strength. This strength enhancing quality was also honored by ancient Greeks and Romans civilization whose athletes ate garlic before they sporting events and whose soldier consumed it before going off war. Garlic was introduced into various regions throughout the globe by migrating cultural tribes and explorers. Garlic is one of the powerful medicinal foods which exemplify the Hippocratic expression 'Use your food as your medicine' (Dylan, 2009).

Throughout the millennia, garlic has been a beloved plant in many cultures for its catenarines and medicinal properties. Over the last few years it gained unprecedented popularity since researchers has been scientifically validating its numerous health benefits currently. China, South Korea, India, Spain, United states are among the top commercial producer of garlic (Pizzorno and Murray, 1996).

The major flavour component of garlic (*Allium sativum*; Liliaceae/Alliaceae) is a thiosulphinat called allicin. This compound is formed when garlic tissue is damaged as a hydrolysis product of S-allyl cysteine sulphoxide (alliin) brought about by the pyridoxal phosphate-dependent enzyme alliinase. Under these conditions, alliin is cleaved by an elimination reaction, and two molecules of the sulphenic acid then form allicin (McElnay and LiWan, 1991).

Medicinal properties of garlic

Garlic is a plant, which kills bacteria fungus, parasites and glycaemia and cholesterol and liver protector property and includes anti-tumor agents. Garlic with >200 chemical substances in the body, has capacity to protect against many illness. Although, it is said that garlic should be consumed as fresh for it can be effective, garlic cloves include mixture of mono and polysulphides smelling very heavy. Some researchers argue that in some situation it should be cooked and waited extracts and oils can provide better protection against free radical and infection than fresh garlic (Concagul and Ayaz, 2010).

Garlic is used both medicinally for a range of skin and stomach problems and also in preparing food, particularly some kinds of stew and in making dried food for storage (Gebre Egziabher and Edwards, 1997). Garlic is used for a variety of reasons, and some of the attributes associated with it, e.g. for cancer prevention, or to reduce heart attacks, may not be substantiated. Other properties such as antimicrobial activity, effects on lipid metabolism, and platelet aggregation inhibitory action have been demonstrated. Ajoene has been shown to be a potent antithrombotic agent through inhibition of platelet aggregation.

How to use garlic as medicinal remedy

Garlic preparations used medicinally include steam-distilled oils, garlic macerated in vegetable oils (e.g. soybean oil), dried garlic powder, and gel-suspensions of garlic powder. Analyses indicate wide variations in the nature and amounts of constituents in the various preparations. Thus, freshly crushed garlic cloves typically contain allicin (about 0.4%) and other thiosulphinates (about 0.1%, chiefly allyl methyl thiosulphinate) (Lawson et al., 1991). Bad breath and perspiration odours which often follow the ingestion of garlic, either medicinally or culinary, are due to allyl methyl sulphide and disulphide, diallyl sulphide and disulphide, and 2-propenethiol. Plant-eating insects are best controlled by pesticides made from strong-smelling plants such as garlic (Conant and Fadem, 2012). Sitting or standing a lot can make hemorrhoids worse. But sitting in a cool bath or lying down can help. Some women say it helps to soak a clove of garlic in vegetable oil and then insert it into the anus (Klein *et al.*, 2013).

According to Werner *et al.* (2015) report a drink made from garlic may help get rid of pinworms. Chop finely, or crush, 4 cloves of garlic and mix with 1 glass of liquid (water, juice, or milk). Dosage: Drink 1 glass daily for 3 weeks. These authors also reported that to treat vaginal infections with garlic: you can also use a clove of garlic as a vaginal insert. (Peel the garlic, taking care not to puncture it. Wrap it in a piece of clean cloth or gauze, and put it into the vagina). Use the douche 2 times during the day, and each night insert a new clove of garlic for 10 to 14 days.

The best remedy uses fresh, uncooked, crushed organic cloves – used in warm tea or mixed with raw, unprocessed honey, fresh garlic juice may also utilized. Garlic also is found as powder and pearl or capsule of oil. For use garlic in small children, its best to simply rub raw crushed garlic on the bottom of their feet and apply socks. To combat high level of cholesterol, triglycerides, and blood sugar, maintains as regular daily of intake of one to three fresh cloves of garlic. For internal bacterial, fungal, viral, parasites infection, for respiratory, congestion, consider fresh garlic tea or syrup with honey. However, fresh garlic always the best choice. For prevention of wounds or treatment of wounds, you can use cool compresses of garlic tea, honey garlic syrup, fresh minced garlic syrup.

Raw garlic also uses as antibacterial, viral and anti-fungal properties that help to boost the immune system and help to fight infection. Even though garlic is a potent herbal medicine that can adversely interacts with other herbal drugs. The primary infection fighting compound in garlic is called allicin. These antibacterial and anti-viral substances found in raw garlic and in small amount and in other vegetables. Many of uses come from the anti-biotic and immune stimulating effects of garlic constituents. Therefore, garlic can treat many disease caused by infection bacteria, virus, molds parasites.

Pathogenic bacteria

Microbial infection in developing countries is high caused by microorganism and causing disease and known pathogen becoming resistant. Different strains of bacteria are associated with many illness and

condition in different part of organism. Infection of diarrhea is leading to the morbidity and death in world wide. Most bacterial pathogens that causes diarrhea include *Salmonella*, *Shigella*, and *E. coli*.

Salmonellosis: - is the second most frequent bacterial infectious disease in the world and infection with *Salmonella* includes diarrhea, fever, and abdominal pain. Small children will be in or near the hut in close contact with soil contaminated with faeces where *S. typhi* may abound. Infection of man by *Salmonella* parasite is closely associated with the sanitary habits of people in handling food and drinks. Transmission is through exposure to contaminated food and water. Environmental sanitation is a very important factor in such transmission.

Shigellosis:- *Shigella* infection cause abdominal pain, fever and malaise and also *E. coli* associated with severe diarrhea disease commonly known as hemolytic uremic syndrome.

In Ethiopia studies indicate that common bacterial infections are *Salmonella*, *Shigella* and *E. coli*. The mode of transmission is through contamination of water and food. Diseases due to food borne pathogens also remain a problem largely by consumption of improperly processed and stored food.

Despite the riches of Ethiopian traditional medicinal plants the scientific studies for the use of traditional medicinal plants as a source of modern medicine is not well developed when compared to the industrialized nation. There are a number of plants that medicinal property not properly known and it needs a lot of investigations to be functional from the wealth of traditional medicinal plants. Bacterial strains selected for this study (*Salmonella*, *Shigella*, and *E. coli*) are the most common bacterial infection in the rural and urban areas of Ethiopia. Their mode of transmission is associated with poor sanitary condition of food and water. Several studies have proposed that natural compounds in plants could offer a new strategy for developing therapies against bacterial infection. The local people are highly dependent on the traditional plants and many indigenous plants have the efficiency to cure more than one disease and according to the study garlic (*Allium sativum*) considered as high fidelity level by treating more than one disease. Therefore increasing scientific studies in this plant species increases the chance of success for developing an alternative drug (Jonkers, *et al.*, 1999).

Methods

The study was conducted in microbiology laboratory of Holeta agricultural research institute.

Garlic collection

Garlic (*Allium sativum*) is perennial cosmopolitan plant; it is distributed in the rural and urban areas of the world. By using its botanical identities about the garlic the sample for this study was collected from the market in Holeta town. To conduct this study the sample was taken from the healthy stem of garlic.

Preparation of aqueous garlic extract

By using glove the fresh garlic cloves were separated and peeled to obtain the edible portion. 100 grams of the edible portion was chopped and cleaned. Cleaned cloves were surface sterilized by immersing them up to 70% ethanol for two minutes. Ethanol on the surface was evaporated by air flow, followed by homogenized aseptically in sterile mortar and pestle. The homogeneity was then filtered by sterile cheese cloth to give a crude aqueous extract of 100ml. This was collected in sterile vial and stored in refrigerator until test of bacterial activity.

Source of bacterial strain

A total of three gram-negative bacteria isolates species were selected for study. The isolates were obtained from the microbiology laboratory of Holeta Agricultural Research Institute. Bacteriological isolates were identified as *Salmonella*, *Shigella*, and *E. coli* by using standard procedure.

Media preparation

In this study nutrient agar was formulated for the growth of three strains of tested bacteria that includes *Salmonella*, *Shigella* and *E. coli*. Nutrient agar media support the growth of total three coliform on agar. For this investigation 12 (twelve) agar media were prepared, 3 (three) for each strain of bacteria and 3 (three) for control group that was corresponding to the formulated test tubes.

Procedures and antibacterial test

The garlic extract was taken from refrigerator and using sterilized pipette it was spread in prepared separate media in different percent of concentration. The selected bacteria specimen dropped into nutrient agar medium and incubated for 48 hrs by 37°C in the incubator as described by Hughes (1999).

Antibacterial activity by Agar well diffusion method

Antibacterial susceptibility tests were carried out by cork borer method on Muller Hinton agar plate. Pathogen bacterial suspension of the isolate was spread on the Muller Hinton agar plate with the help of sterile cotton swab uniformly and 20 µl of the extracts were added separately and incubated at 37°C overnight, then the diameter of inhibition zones were measured to determine on the resistance of microorganisms tested.

Data analysis

The collected quantitative data were analyzed using simple descriptive statistics such as percentages, mean and frequency while narration was used for the qualitative data. Finally, results observed from the analysis were presented in the form of tables and graph.

Results

The antibacterial test with different volume of aqueous garlic extract showed a growth inhibition in three tested bacterial species. The garlic aqueous extract in *Salmonella* showed a least growth inhibition but in *Shigella* there is somewhat resistance that means when we compare with *Salmonella* and *E. coli* it

showed a medium resistivity. But *E. coli* showed a high resistivity to garlic extraction when we compared to *Salmonella* and *Shigella*. The result obtained from antibacterial test in the study was presented in Table 1 below.

Table 1
Shows effect of garlic extraction and numbers of colonies formed by three species of bacteria

Aqueous garlic extract	Number of colonies within 48 hrs		
	<i>Salmonella</i>	<i>Shigella</i>	<i>E. coli</i>
Control group	42	46	51
1ml	14	17	38
3ml	8	7	14
5ml	3	2	5

The highest percentage indicates that the bacterial were resistant to the anti-microbial agent and the lowest percentage shows to the bacteria were susceptible to antimicrobial agent.

Table 2
Shows the percent of resistance of each tested bacteria with different volume of anti-microbial agent of aqueous extract of garlic

Aqueous garlic extract	Percent of resistance within 48 hrs			
	<i>Salmonella</i>	<i>Shigella</i>	<i>E. coli</i>	Control (0 ml) group
1 ml	33.3	36.9	74.5	100
3ml	15.2	19	27.5	100
5ml	7.1	4.3	19.6	100
The 100% shows that the bacteria without treatment or in control group showed its growth at maximum level.				

The above table showed that percentage resistance of *E. coli* is highest degree of resistance to anti-microbial agent when compared to others and *Salmonella* showed the highest degree of susceptibility when compared to the other two strains of bacteria.

Figure 1 indicates that aqueous garlic extracts have showed a growth inhibition in three tested bacteria.

The antibacterial activity of the aqueous garlic extracts were seen for three pathogenic bacteria; *Salmonella thypae*, *Shigella*, and *E. coli* as shown in Table 3. The zone of inhibition produced (in mm) was found to be 14, 16, and 20 respectively.

Table 3
The results of antibacterial activity by garlic extract

No	Microorganisms	Zone of inhibition produced (mm)
1	<i>Salmonella thypae</i>	14
2	<i>Shigella</i>	16
3	<i>E.coli</i>	20

Discussions

It was seen that extracts from garlic extract showed antibacterial activity against these bacteria. The zone of inhibition ranges from 14 to 20mm indicating the potential antimicrobial property of the extracts.

Although studies on the action of garlic (*Allium sativum*), have shown that such extracts exhibit in vitro effects against nematodes, it was often not possible to confirm this in in vivo tests with infected animals (Burke et al., 2009; Igbal et al., 2001; Bastidas 1969), or the degree of action was very low unless very large amounts were used (Ayaz et al., 2008).

Allium sativum derived compounds such as allicin and dialys sulfate have reported antihelmithic activity to *Trichinella spiralis* (Abu-El-Ezz, 2005; Grundzinsky et al., 2001). Garlic is said to repel mosquitoes if consumed in sufficient amounts (Fradin, 1998).

In the present study extracted garlic was effective on pathogenic bacteria. The tested bacteria associated with gastro intestinal infection include stomach pain, diarrhea, and fever, nausea, wound and vomiting. Soffar and Mokhtar (1991) also showed aqueous *Allium sativum* extract have antiparasitic effect against the *Hymenolepis nana* and *Giardia*.

According to the result of antibacterial screening test anti-microbial has stronger effectiveness on tested *Salmonella* and stronger antibacterial activities on *Shigella*. In *E. coli* the growth or colonies formation were inhibited to some extent but not as much as satisfactory compared to *Salmonella* and *Shigella*.

The pure stem of garlic showed a growth inhibition in three tested bacteria's. In salmonella the pure stem extract reduces the growth of colonies by more than half. When we compared the numbers of colonies salmonella in garlic stem extract with the controlled group, in similar condition in all aspects and garlic stem extract in the experimental group 1ml, 3ml, and 5ml showed inhibit the growth 42 colonies to 14, 8, and 3 colonies respectively this indicates that garlic stem has strong growth inhibition on *Salmonella*. Similarly in *Shigella* the extract shows unexpected number of growth inhibition. But in *E. coli* it is not much effective as compared to others because of that resistivity of *E. coli* to different antibiotics and antibacterial agents. Some studies in Ethiopia on the stem of garlic and other traditional medicinal plants showed an effective anti-microbial activity on *E. coli* and other antibiotic resistance bacteria this difference may be due to environmental condition which support the organic compounds to the plant.

This result experimentally checked the pure extract of garlic have this kinds of efficiency on disease causing pathogen. Therefore it scientifically proven that extended use of stem of garlic as a medicine for gastro intestinal infection will minimize the risk of *Salmonella* and *Shigella*.

In *E. coli* that was resistant on different antibiotics showed some percent of growth resistance reduction, according to the data *E. coli* have high percent of growth resistance with 74.5%, 27.5%, and 19.6% for the 1ml, 3ml, and 5ml respectively when compared to other of two strains of bacteria.

Since the findings of this study showed that garlic has an inhibitory effect on *E. coli*, *Salmonella* and *Shigella* it could used for future medicinal purposes in battling bacterial infection.

Conclusions

Garlic extract showed remarkable efficiency with different effectiveness rate on gram negative bacteria such as *Salmonella*, *Shigella* and *E. coli*. It is also warrants a further investigation in this traditional medicinal plant for developing a modern anti-microbial drug by clinical testing but at these stage the data obtained from this study can be taken as an approval document for local people to use it as a medicinal for disease related to gastro intestines. So make clearer and check scientifically the effectiveness of garlic needs further investigation on different pathogens.

Recommendation

In the process of change of habits, community participation is essential. Without grassroots participation not much could be achieved in the usual top-down management practices. Create awareness the antibiotic properties of garlic and give important evidence regarding its antibacterial activity of garlic is recommended. Involvement of the envisaged beneficiaries of any program at all levels of planning and implementation is absolutely necessary.

Declarations

Ethics approval and consent to participate the study protocol was approved by a college of Natural and Computational Science, Biology Department using an agreement letter prepared from Ambo University. All the information that was obtained about the subjects was kept confidential. Informed consent was also obtained from the respondents after explaining them with all the necessary details about the study matters. Participation in the study was strictly on voluntary basis. Privacy and secrecy of the participants and data collected were guaranteed. **Consent for publication**

Not applicable

Availability of data and material

Data generated or analyzed during this study are included in this article.

Competing interests

Authors have declared that no competing interests exist.

Funding

The study was granted from Research and Community Services Office, Ambo University, Ethiopia

Authors' contributions

DB: Conceived designed, data management, analysis, and interpretation of the findings and drafting the manuscript. DB and GG: analysis, interpretation, and reviewing the manuscript. The two authors read and approved the final manuscript.

Acknowledgement

The authors would like to express special thanks to laboratory technicians in Holeta Agricultural research institute.

References

- Abu-El-Ezz NM. (2005). Effects of *Nigella sativa* and *Allium sativum* oils on *Trichinella spiralis* in experimentally infected rats. J Egypt Soc Parasitol 35:511–523
- Ayaz E, Turel GA, and Silmaz O. (2008). Evaluation of the anthelmintic activity of garlic (*Allium sativum*) in mice naturally infected with *Aspiculuris tραπερα* . Recent Pat Antiinfect Drug Disc 3:149–152.
- Bannerman RH, Burton J and Chien W.(1993). Traditional medicine and health care coverage, world health organization Geneva Switzerland.
- Bastidas G. (1969). Effects of ingested garlic on *Necator americanus* and *Ancylostoma caninum*. Am J Trop Med Hyg 18:9209–9923.
- Beshaw M. (1991). Promoting traditional medicine in Ethiopia: A brief historical overview of government Policy. Soc. Sci and Med; 33: 193-200.
- Burke JM, Wells IJ, Wsey P, Miller JE. (2009). Garlic and papaya lack control over gastrointestinal nematodes in goats and lambs. Vet Parasitol 159:171–174.
- Concagul, G. and Ayaz, E. (2010). Antimicrobial Effect of Garlic (*Allium sativum*) and Traditional Medicine. Journal of Animal and Veterinary Advances, 9: 1-4.
- Conant, J. and Fadem, P. (2012). A community guide to environmental health. Hesperian Health Guides, Berkeley, California 94704, USA, 636pp.

Desta B, 1994, Ethiopian traditional herbal drugs, part two. Anti fertility activity of 70 medicinal plant.

Dylan, J. (2009). The good life with Jesse Dylan : redefining your health with the greatest visionaries of our time. John Wiley & Sons Canada Ltd, 241pp.

Ellmore, G.S. and Feldberg, R.S. (1994). Alliin lyase localization in bundle sheaths of garlic cloves (*Allium sativum*). American Journal of Botany, 81(1): 89-94.

Fradin, M.S. (1998). Mosquitoes and Mosquito Repellents: A Clinician's Guide. Annals of Internal Medicine, 128: 931-940.

Gebre Egziabher, T. and Edwards, S. (1997). Alliaceae. In: Edwards S. Demissew, S.

Hedberg, I. (eds). Flora of Ethiopia and Eritrea. Vol. 6, Hydrocharitaceae to Areceae. The National Herbarium, Addis Ababa, Ethiopia and the Department of Systematic Botany, Uppsala, Sweden.

Getahun, A. (1976). Some common medicinal and poisonous plant use in Ethiopian folk medicine. Registered in the data bank prelude; reference: VG 07 & HG 07, pp25

Grundzinsky IP, Frankiewitz-Kosko and A, Bany J. (2001). Dialyl sulfide – a flavour component from garlic (*Allium sativum*) attenuates lipid peroxidation in mice infected with *Trichinella spiralis*. Phytomedicine 8:174–177.

Igbal Z, Khadid-Nadeem Q, Khan MN, Akthar MSS, Waraich FN (2001). In vitro anthelmintic activity of *Allium sativum*, *Zingiber officinale* and *Ficus religiosa*. Int J Agric Biol 3:454–457.

Jonkers D, van den Broek E, van Dooren I, Thijs C, Dorant E, Hageman G, Stobberingh E. (1999). Antibacterial effect of garlic and omeprazole on *Helicobacter pylori*. J Antimicrob Chemother 43:837–839. <https://doi.org/10.1093/jac/43.6.837>

Klein, S., Miller, S. and Thomson, F. (2013). A book for midwives: care for pregnancy, birth, and women's health. Hesperian Health Guides, 1st ed. Berkeley, California 94704, USA, 544pp.

Lambert J. Ethiopia: Traditional medicine and the bridge to better health. World Bank, available at: <http://www.worldBank.org/afr/ik/dfefault.htm>. [accessed Oct 10 2021].

Lawson LD, Wang ZJ and Hughes BG (1991). Identification and HPLC quantitation of the sulfides and dialk(en)yl thiosulfinates in commercial garlic products. Planta Med 57, 363–370.

McElnay JC and Li Wan Po A (1991). Dietary supplements: garlic. Pharm J 246, 324 – 326.

Pizzorno JE and Murray, M.T. (1996). *Angelica species, A Textbook of Natural Medicine*. Bothell, WA: Bastyr University Publications, Vol. 1. Pp1,941.

Soffar SA, Mokhtar GM (1991). Evaluation of the antiparasitic effect of aqueous garlic (*Allium sativum*) extract in *Hymenolepis nana* and giardiasis. *J Egypt Soc Parasitol* 21:497–502.

Werner, D., Thuman, C. and Maxwell, J. (2015). *Where there is no doctor: a village health care handbook*, Rev. ed. Hesperian Health Guides 1919 Addison, Berkeley, California 94704 USA, 501pp.

WHO (2001). *Legal Status of Traditional Medicine and Complementary/Alternative Medicine: A World Wide Review*. Geneva.

WHO (2002). *WHO policy perspective on medicines – Traditional medicine – Growing needs and potential*. World Health Organization, Geneva. p6.

Who fact sheet, traditional medicine Geneva, may 2003.

WHO (2005). *National Policy on Traditional Medicine and regulation of Herbal medicines*, Report of a WHO Global Survey, Geneva, Switzerland.

Figures



Figure 1

Halo zone formation by aqueous garlic extract on the three bacterial isolates