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Evolution The antibacterial and Antioxidants Activity of Garlic Extracts

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Abstract: The improving in the query for artificial medications for of the surge in the illustrations of drug-resilient infectious bacteria has controlled to the hunt for new medications in plants, some plants partake chemicals compounds that are talented to attend medicinal purposes. This study prominences on the antibacterial activity and antioxidant potential commotion of Garlic (Allium sativum) alcoholic and aqueous extracts on clinical pathogenic isolates (Escherichia .coli and Staphylococcus aureus) by Agar well-diffusion method, the results showed that the effect of extracts were increase with increasing the concentration, 19mm embarrassment zone Staph. aureus growth at 200mg/ml of alcohol garlic extract, the diameter of the inhibition zone then gradually decreased to 16 at a concentration of 50mg/ml. Similarly, for E.coli, the largest inhibition zone diameter was 17 mm at a concentration of 200, while the smallest was 15 mm at a concentration of 50mg/ml. The efficacy of the aqueous garlic extract in inhibiting bacterial growth also reduced as the extract concentration decreased. The highest free radical scavenging activity (68.68%) was recorded for the ethanolic garlic extract at a concentration of 1 mg/ml, while the lowest activity (5.09%) was monitored for the aqueous extract at a concentration of 0.12 mg/ml. This activity is attributed to the various compounds found in garlic, particularly phenolic compounds.

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INTRODUCTION

Antibiotics are treatments that are applied to evading and extravagance bacterial infections, antibiotic resistance, on the contrary, happens when bacteria change because of antibiotic use. A scenario in which bacteria develop and cease to respond to drugs, creation infections more difficult to treatment and raising the danger of disease spread, sickness, serious and death (Nwobodo *et al*., 2022). The Problem of antimicrobial Resistance and the Means Forward Presently, yearly, 700 000 patients perish globally because of antimicrobial resistance (AMR). It has been projected that this death peal will increase to ten million by 2050. Although antibiotics have helped humanity well for the previous 70 years or so, the capability of bacteria to quickly develop has made it authoritative to look for other choices (Ghosh *et al*., 2018). With antibacterial being extensively used in clinical settings, several microorganisms, have modified to synthetic antibiotics then become actual resistant toward these drugs over time, although some of these organisms can living harmlessly in humans then are carried in the nasal way and on the skin, they be able to cause fatal infection in hospices and nursing homes, where patients with open wounds, invasive devices and immunodeficiency are at the higher risk of infections than healthy people (Li *et al*., 2015). World Health Organization (WHO) believes the 'post-antibiotic' era to happen around the year 2050 after assessing data from 129 member states (Machado *et al*., 2023). Natural products are careful to be the most preferred group of structures changed to react with a broad range of protein targets for definite action on bacteria. Numerous efforts have been directed to exploring the possible importance of plants extracts and a few dynamic chemical formulations for their adequacy to fight against the issues of antibacterial resistance. The plant extracts including a complex mixture of important compounds and their secondary metabolites near traditional anti-infection managers produce probable joint impacts. It is well recognized that several illnesses with difficult pathophysiology progress an feeling for pharmaceutical mixtures (Extended-spectrum *et al*., 2022)

Numerous fortunate conditions of expending natural products as antimicrobial agents contain fewer undesirable side effects, enhanced patient tolerance, and relatively less cost-effective, broad approval because of their conventional benefits, sustainability and improved biodegradability. Some plant extracts from different references (Abdallah *et al*., 2023)

Therefore, it has become necessary to search for a safe alternative strategy to combat infection.

Medicinal plants and herbs have been used for several years in the treatment of a massive number of human diseases via the community, specifically in the traditional medicine. They are considered the main sources of new, natural, and safe drugs to be used in managing diseases as an actual and harmless alternative medicine, due to they are not expensive and posture minimum side effects toward humans, according to a report available in 2002 by the World Health Organization (WHO) in Geneva, the medicinal plants have important value and could be reflected as the best source of alternative and complementary natural medicines (Gabriel *et al*., 2022).

The *Allium sativum* (garlic) has been grownup on a great scale on all continents hundreds of decades ago. The classes is one of the eldest vegetables cultivated by human not only for its exact taste and smell but for its therapeutic properties too. The presence of several biologically active materials in garlic, particularly in its underground bulb, creates the plant suitable for usage in alternative medicine. Moreover, due to the novel challenges facing contemporary drug, the therapeutic action of the species is being deliberate and the plant is progressively being applied in treatment (Magryś *et al.*, 2021). Garlic contents bioactive substances that produce Allicin chiefly after cutting or breaking garlic. Its effective antibacterial properties create Allicin an effective material which halts the development of dangerous microorganisms and materials present in garlic include prebiotics together fungus and viruses (Abdul *et al*., 2025). Garlic contains at least 100 sulphur-containing compounds basicto medicinal uses with Allicin representing 70 to 80 percent of the total thiosulphinates found in it (Discovery, 2018)

Due to its many phytochemicals, reserves and

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dietary fiber, the garlic is considered a valuable spice. Moderate amounts of calcium, selenium, magnesium, iron, manganese, vitamins A, C, B complex, and sodium are also extant. Potassium, sulfur, zinc, and phosphorus are all initiate in substantial concentrations. Dietary fiber comprises about 1.5% of the garlic bulb's structure, followed by protein (2%), organosulfur materials (2.3%), carbohydrates (28%) and water (65%) (El-Saadony *et al*., 2024). In addition to minerals, antioxidants, flavonoids, and 8 types of amino acid, garlic enhancement and exhibits anticancer, anti-inflammatory, antioxidant, antimicrobial, hypocholesterolemic, antithrombotic, hypotensive activities and hypoglycemic, treat diabetes, hyperlipidemia, atherosclerosis, hypertension and against blood clots (Divya *et al*., 2017). Garlic extract has also been used to activate carbon and is used in the treatment of domestic wastewater(Alvarino *et al.*, 2023)

Furthermore, some research studies have shown that garlic supplements might be beneficial for overweight or obese people who are suffering from osteoarthritis as it reduces their resistance. Hence, garlic was effective in suppressing inflammatory pathways in both in vivo vitro and in vitro studies by decreasing inflammatory mediators tumor necrosis factor-alpha (TNF-α) and NO) (including interleukin (IL)-1. Garlic exhibits probable as a therapeutic interference for inflammatory conditions, plus arthritis in humans as shown in figure (1), meanwhile its toxicity is minimal or non-existing (Upadhyay, 2016).

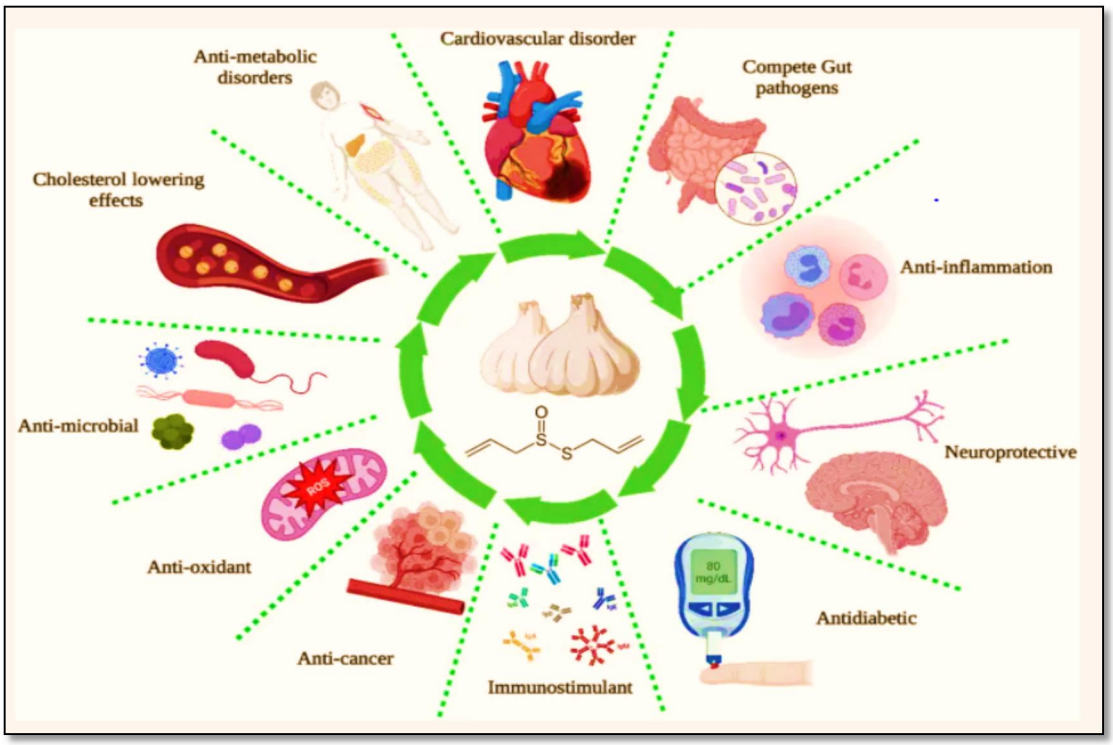

Fig. 1: Biological activities of garlic (El-Saadony et al., 2024)

Garlic extracts have been reported to inhibit growing of various gram-negative and gram-positive bacteria including*: Staphylococcus aureus, Escherichia coli, Salmonella, Shigella, Klebsiella, Proteus, Pseudomonas, Enterobacter, Micrococcus, helicobacter pylori* in addition garlic extracts have also been reported their activity as antifungal and antiviral (Gebreyohannes & Gebreyohannes, 2013; Rajendrasozhan, 2024). Lysine plays a crucial role in eliminating bacterial cells, which may occur through cell wall destruction, oxidative stress, or inhibition of DNA synthesis as shown in figure (2).

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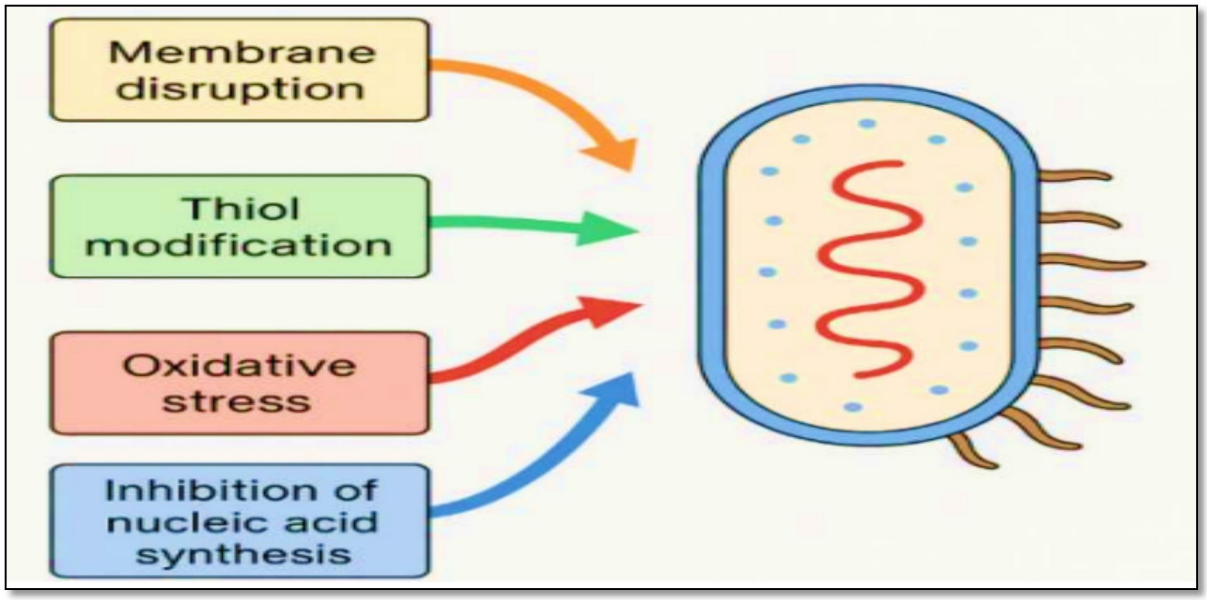

Fig. 2: Antibacterial mechanisms of garlic (Jarosz et al., 2026)

Garlic plays an important role in neutralizing free radicals; it is a powerful antioxidant due to its content of compounds such as flavonoids, saponins, organosulfur compounds, in addition to phenolic compounds(Melguizo-Rodríguez *et al*., 2022). Researchers indicate that the sulfur compounds originate in garlic play a main role in inhibiting free radicals and in garlic's antioxidant activity (Bazaraliyeva *et al*., 2022).

Materials and Methods

Bacterial Isolates

A pathogenic bacterial isolate from Najaf Teaching Hospital used *Staphylococcus aureus* and *E. coli*, the bacterial isolates were diagnosed using the VITEK system. The isolates of bacteria were reactivated using nutrient broth media by incubating them in the medium for 24 hours at a temperature of 37°C.

Garlic extraction

A suitable number of Iraqi garlic, offered in local markets, was used. It was shed, thinly sliced, and positioned in glass dishes in an electric oven at 40°C. After aeration, it ground into a powder by means of an electric grinder and kept in a sterilized glass bottle until use. Then, twenty g of the garlic powder was mixed with 2handered ml of sterile distilled water and left to stand for twenty-four hours at room temperature, stirring continuously by a Magnetic mixer. The solution was then filtered by using filter paper and the filtrate was in a sterilized Petri dishes . These dishes was then incubated at 40°C for twenty-four hours. After it had fully dried, the powder was collected in clean sterilized bottles (Moazeni & Nazer, 2010), the alcoholic garlic extract was prepared in the same way as above, with the distilled water replaced by 70% ethyl alcohol as shown in Figure (3)



Figure (3): Alcoholic extract (A) and aqueous extract (B) on a magnetic mixer

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Preparation of Concentrations

A sensitive balance to weigh and prepare three concentrations for each extract (50, 100, and 200 mg/ml). Two grams of the powder were mixed with 10 ml of distilled water to prepare a 200 mg/ml concentration. From this, the series of dilutions used in the study were prepared: 5 ml of the first concentration was mixed with 5 ml of distilled water to prepare the second concentration (100 mg/ml), and 5 ml of the second concentration was mixed with 5 ml of distilled water to prepare the third concentration (50 mg/ml).

Antibacterial Activity Testing

This activity test was performed inside the inoculation chamber. Bacterial isolates were activated by culturing them in nutrient broth and incubated at 37°C for 24 hours. The agar diffusion method was used according to (WHO, 1987), Petri dishes containing Mueller-Hinton agar were used, and the medium was inoculated with 0.5 ml of bacterial suspension after its turbidity was equalized to that of a 1×10^8 McFarland tube. The bacterial suspension was then spread using a sterile cotton swab and allow the plates to dry at room temperature. After drying, four wells were made in the first plate and four wells in the second plate using a 6 mm diameter cork drill. Ten microliters of each of the three aqueous extract concentrations were added to each well in the first plate, and distilled water was placed in the fourth well for comparison. The same method was used for the alcoholic extract concentrations in the second plate, using a micropipette. The plates were then incubated at 37°C for 24 hours. 3 replicates of the test were performed, the diameter of the inhibition zone was then dignified with a ruler. The results were read based on common criteria used in the initial screening of extracts. A extract that formed an inhibition zone diameter of 12 mm, was considered ineffective, while a diameter of 6-12 mm was deliberated moderately effective, and a diameter above 16 mm was considered effective(Nader & Azhar, 2010).

Antioxidant Testing

A previously prepared 2,2 Diphenyl -1-picrylhydrazyl (DPPH) was used as a source of free radicals by mixing (0.006% w/v) with 95% methanol. This solution is characterized by a purple color, and the lighter the color, the greater the substance's ability and effectiveness in reducing free radicals. The antioxidant activity of the alcoholic and aqueous garlic extract was investigated. 100 microliters of (DPPH) were mixed with 100 microliters of garlic extract at each of the concentrations used in the experiment (0.12, 0.25. 0.50 and 1mg/ml). The solution was placed in a 96-well microplate and incubated for half an hour in a dark place (because the substance is light-sensitive). A color change from dark purple to light yellow was observed. The absorbance was measured using a Microplate reader at a wavelength of 514 nm (Lee et al., 2015). A well containing only garlic extract was used as a negative control, and a well containing methanol solution was used as a positive control, the percentage of root scavenging was then measured using the following equation:

$[AA_{514}$nm control $- AB_{514}$ nm sample/ AA_{514} nm control$] \times 100$

AA: Absorbance of control AB: Absorbance of sample

Results

The results of Vitek 2 compact system confirm identification of both E.coli and Staphylococcus aureus as showed in (Tables 1 and 2)

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Table (1): The result of the vitek 2 compact identified *Escherichia. coli*

Identification Information	Analysis Time:	9.93 hours	Status:	Final
Selected Organism	95% Probability Bionumber:	Escherichia coli 0405611544501652		
ID Analysis Messages				

Biochemical Details

2	APPA	-	3	ADO	-	4	PyrA	-	5	IARL	-	7	dCEL	-	9	BGAL	+
10	H2S	-	11	BNAG	-	12	AGLTp	-	13	dGLU	+	14	GGT	-	15	OFF	+
17	BGLU	-	18	dMAL	+	19	dMAN	+	20	dMNE	+	21	BXYL	-	22	BAlap	-
23	ProA	+	26	LIP	-	27	PLE	-	29	TyrA	+	31	URE	-	32	dSOR	+
33	SAC	-	34	dTAG	-	35	dTRE	+	36	CIT	-	37	MNT	-	39	5KG	+
40	ILATk	+	41	AGLU	-	42	SUCT	+	43	NAGA	-	44	AGAL	(-)	45	PHOS	-
46	GlyA	+	47	ODC	-	48	LDC	-	53	IHISa	-	56	CMT	+	57	BGUR	+
58	O129R	+	59	GGAA	-	61	IMLTa	+	62	ELLM	-	64	ILATa	+			

Table (2): The result of the vitek 2 compact identified Staphylococcus aureus

Identification Information	Analysis Time:	5.92 hours	Status:	Final
Selected Organism	95% Probability Bionumber:	Staphylococcus aureus 010402033763231		
ID Analysis Messages				

Biochemical Details

2	AMY	-	4	PIPLC	-	5	dXYL	-	8	ADH1	+	9	BGAL	-	11	AGLU	-
13	APPA	-	14	CDEX	-	15	AspA	-	16	BGAR	-	17	AMAN	-	19	PHOS	+
20	LeuA	-	23	ProA	-	24	BGURr	-	25	AGAL	-	26	PyrA	+	27	BGUR	-
28	AlaA	-	29	TyrA	-	30	dSOR	-	31	URE	+	32	POLYB	+	37	dGAL	-
38	dRIB	+	39	ILATk	+	42	LAC	-	44	NAG	+	45	dMAL	+	46	BACI	+
47	NOVO	-	50	NC6.5	+	52	dMAN	+	53	dMNE	+	54	MBdG	+	56	PUL	-
57	dRAF	-	58	O129R	+	59	SAL	-	60	SAC	+	62	dTRE	+	63	ADH2s	-
64	OPTO	+															

Agar diffusion method by means of alcoholic and aqueous garlic extract were performed on *Staphylococcus aureus*, reprehensive of Gram-positive bacteria and *E. coli*, reprehensive of Gram-negative bacteria. and the Garlic extracts show good efficiency in inhibiting the growth of the bacterial isolates that were used in the test. The study results demonstrated a clear inhibitory effect of both aqueous and alcoholic garlic extracts on the growth of *E. coli*. The alcoholic extract produced varying zones of inhibition, an increase in the inhibition zone diameter was observed as the concentration increased. Specifically, the diameters were 15 mm at a 50 mg/ml concentration, 15 mm at 100 mg/ml, and 17 mm at 200 mg/ml as shown in figure(3). The control showed no zone of inhibition, indicating the absence of an inhibitory effect in the absence of the extract. In aqueous extract, the diameter of the inhibition zone against bacteria was 14 mm at a concentration of 50 mg/ml and 15 mm at a concentration of 100 mg/ml, whereas it reached 16 mm at a concentration of 200 mg/ml.

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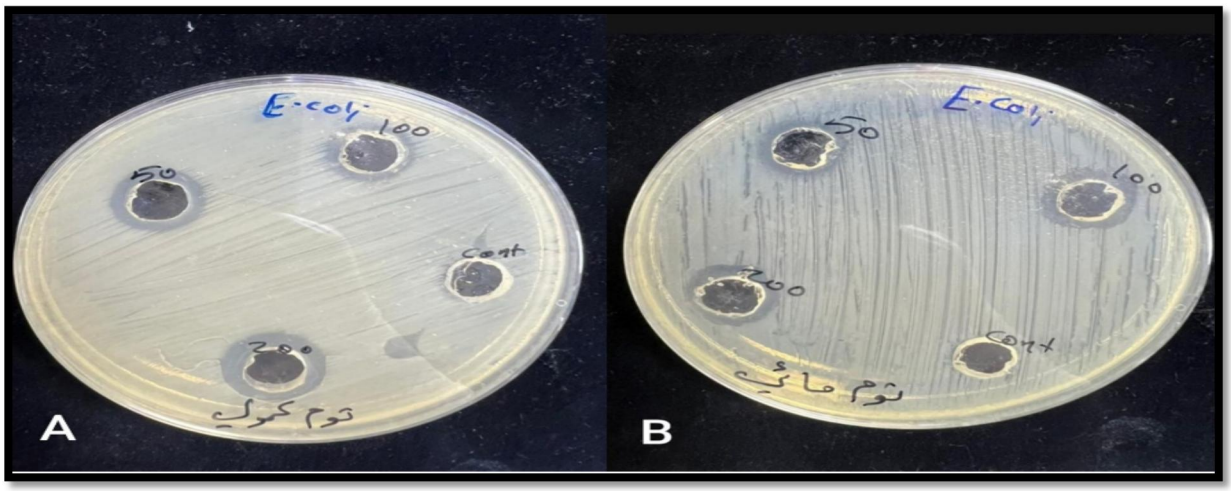
Garlic extract was also observed to have an effect on *Staph. aureus* bacteria, with the alcoholic extract proving somewhat more potent than the aqueous extract. The alcoholic extract produced an inhibition zone diameter of 19 mm at a concentration of 200 mg/mL; this diameter decreased as the concentration was lowered, measuring 17 mm and 16 mm at concentrations of 100 mg/mL and 50 mg/mL, respectively as shown in figure (4).

Figure (3): The inhibitory effect of alcoholic and aqueous garlic extract on *E.coli*



A: alcoholic B: aqueous

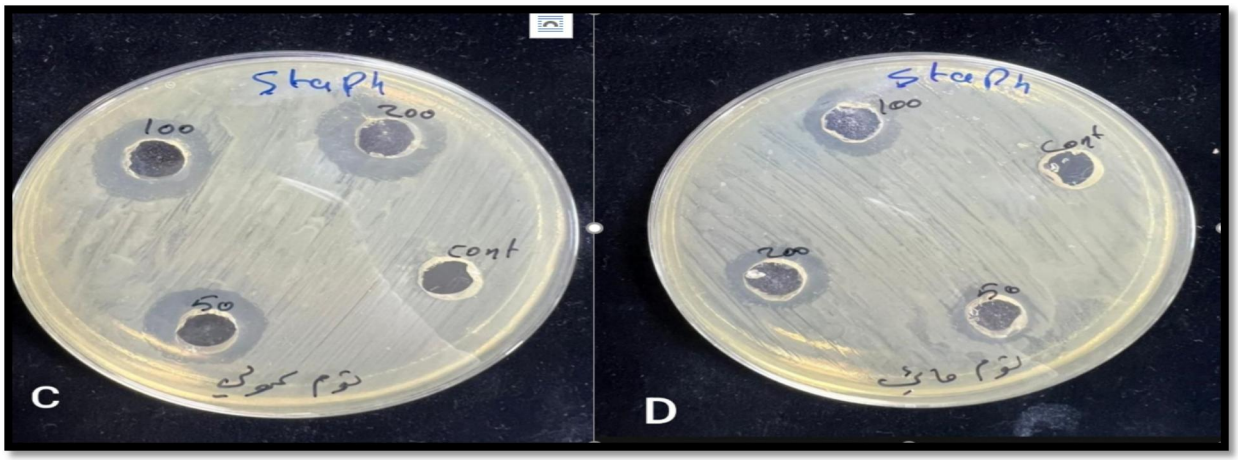


Figure (4): The inhibitory effect of alcoholic and aqueous garlic extract on *Staph. aureus*
A: alcoholic B: aqueous

Regarding the aqueous extract, the maximum inhibition zone diameter was 17 mm at a concentration of 200 mg/mL, subsequently decreasing alongside the concentration to 16 mm and 15 mm at concentrations of 100 mg/mL and 50 mg/mL, respectively as shown in table (3). According to the SPSS test, there is no significant difference at 0.05 probability level.

Table (3): Average diameters of inhibition zone resulting from the effect of Garlic extract on *E. coli* and *Staphylococcus aureus*

E.coli		*Staph. aureus*		Concentration %
alcoholic extract	aqueous extract	alcoholic extract	aqueous extract	

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17	16	19	17	200 mg/ml
15	15	17	16	100 mg/ml
15	14	16	15	50 mg/ml
0	0	0	0	control

The study results demonstrated that the aqueous and alcoholic extracts of garlic have inhibitory effect on the growth of both Gram-negative and Gram-positive bacteria, these results were constant with the findings of a number of researches (Herliawati *et al.*, 2023; Mushemesh *et al.*, 2023; Sathish Kumar *et a*l., 2024). *Staph. aureus* was somewhat more sensitive to the garlic extract than *E. coli*, a finding consistent with the results reported by other researchers(Gabriel et al., 2022)

The antibacterial activity of garlic is reported to be due to the action of allicin or diallyl disuphide or diallyl thiosulphinic acid (Avato *et al*., 2000). The compound allicin has a broad-spectrum antibacterial effect influenced by its thiol structure, which permits easy penetration of cell membranes then subsequently inactivates many intracellular and extracellular targets (Rahma *et al*., 2025), in addition to the contents of secondary metabolite compounds, organosulfur compounds can inhibit bacterial action through the reaction amongst the sulfur groups in organosulfur compounds and the sulfhydryl group in bacterial enzymes, which be able to form mixed disulfide bonds which can injury the bacterial wall·s cytoplasmic membrane, causing cell lysis and bacterial death(Destiana *et al*., 2025). The presence of secondary metabolite compounds in garlic such as phenolic and flavonoids can also have an influence on inhibiting bacterial growth, flavonoids act as antibacterial by inhibiting nucleic acid synthesis, energy metabolism , cytoplasmic membrane function so that the exchange of nutrients and energy stock in bacterial cells is hampered, phenolic compounds inhibit bacterial activity by denaturing bacterial proteins, inhibiting cell wall synthesis and damaging bacterial cell membranes (Putri *et al.*, 2026). These compounds are capable to prevent microbes and their infections by homicide them, preventing fighting toxins, the accumulation of biofilms, and reducing the signals that permit bacteria to thrive in groups (Subramanian *et al*., 2020).

Antioxidants play a significant role in protecting the body from the effect of free radicals then oxidative damage, thus the presence of antioxidants in the body is significant, antioxidants respond with DPPH through actual fast electron transfer and by slow transfer of hydrogen atoms, these reactions cause antioxidant compounds to prevent the action of free radicals, recent studies have established several of the medicinal possessions credited to garlic, antioxidants were the most important of those (Lestari *et al*., 2023). In this study, the antioxidant activity was increase by increasing the concentration for both type of extract, this resulte are agree with other researchers(Akullo *et al.,* 2023). A high percentage of the antioxidant activity was in alcoholic extract 68.68% at 1 mg/ml concentration, then the percentages decreased progressively as the concentrations decreased 28.39%, 12.86%, and 8.05% for concentrations 0.5, 0.25, and 0.12 mg/ml respectively. The same applies to the garlic aqueous extract, where the highest scavenging free radicals percentage was recorded at 1mg/ml , it was 39.9% , while the lowest percentage was detected at the low concentration 0.12 mg/ml, it was 5.09% as shown in figure (5).

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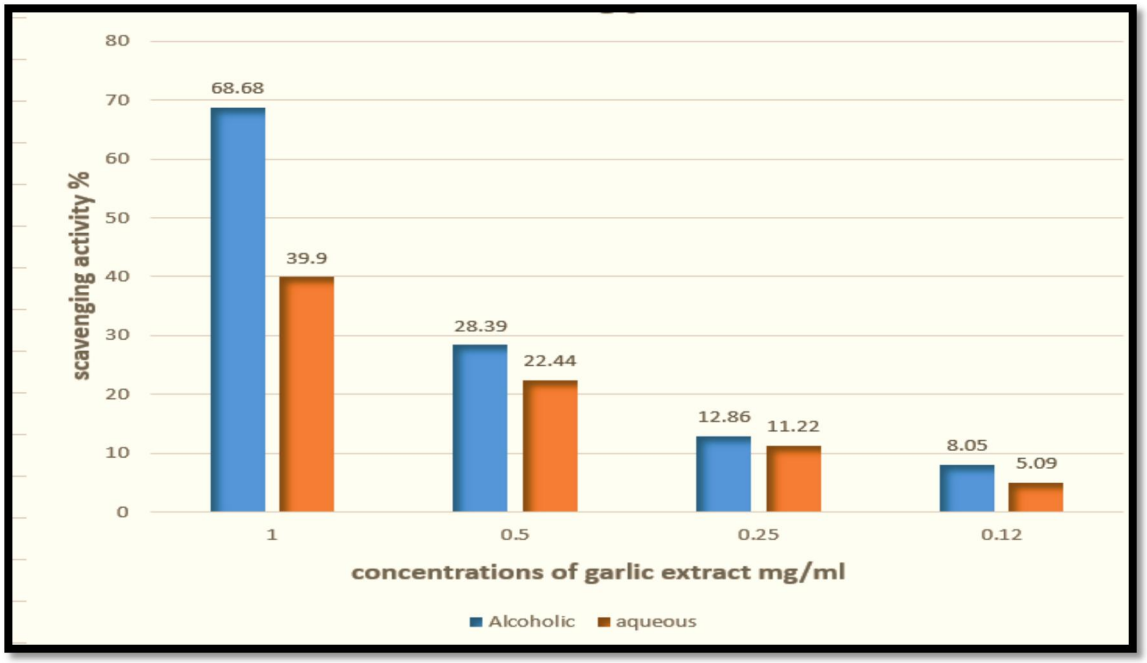

Figure (5): Antioxidants effect of alcoholic and aqueous Garlic extracts

The health possessions of garlic rely on its bioactive compounds and particularly on phenolic compounds, which have inspiring pharmacological properties, and are present in relatively high amounts, phenolic compounds are large groups of secondary metabolites that are talented to neutralize or slake the free radicals, flavonoids and their offshoots are the main group of polyphenols create in plants(Oyawoye *et al.*, 2022). In addition several compounds are available in the garlic such as tannins, terpenoids, flavonoids, alkaloids and glycosides (Busari *et al*., 2022) They are capable of effectively scavenging reactive oxygen species and neutralize free radicals, because of their phenolic hydroxyl groups, thereby making them potent antioxidants and potential candidates for the treatment(Madaki *et al*., 2019)

Conclusion

Garlic is a key plant in both traditional and modern medicine, serving as a significant source of phenolic compounds. This study found that both alcoholic and aqueous garlic extracts play a major role in inhibiting the growth of Gram-positive and Gram-negative bacteria. Furthermore, the extracts demonstrated excellent free-radical scavenging activity, with no statistically significant differences observed, this study supported the need for further research into using garlic as an alternative to chemical treatments.

References

1. Abdallah, E. M., Alhatlani, B. Y., de Paula Menezes, R., & Martins, C. H. G. (2023). Back to nature: Medicinal plants as promising sources for antibacterial drugs in the post-antibiotic era. *Plants*, *12*(17), 3077.
2. Abdul, M., Hameed, K., Haddwi, A., Alsafah, Z., Talib, H., Al-safah, D. H., & Majeed, M. W. (2025). *Garlic : an overview of its properties , sources , health benefits , and immunity*. *1*, 123–127.
3. Akullo, J. O., Kiage-Mokua, B. N., Nakimbugwe, D., & Kinyuru, J. (2023). Phytochemical profile and antioxidant activity of various solvent extracts of two varieties of ginger and garlic. *Heliyon*, *9*(8).
4. Alvarino, L. A. da S., Manzotti, F., Moreira, W. M., de Araújo, T. P., Vareschini, D. T., & de Barros, M. A. S. D. (2023). Antibacterial potential of activated carbon impregnated with garlic extract. Processes, 11(10), 2948.
5. Al-Fatlawey, Esraa S., Kadhim, D. A. and Omara, A. M. (2026). 'Thalassemia and Glycated Hemoglobin (HbA1c): Pathophysiological Interferences, Analytical Challenges, and Clinical Management

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Implications: A Comprehensive Review' .,Kuwait Scientific Research Journal of Medical Sciences, 3(2), pp. 1-15.

6. Avato, P., Tursi, F., Vitali, C., Miccolis, V., & Candido, V. (2000). Allylsulfide constituents of garlic volatile oil as antimicrobial agents. *Phytomedicine*, *7*(3), 239–243.
7. Alabbasy AJ, Alewi ZH. Antibacterial Effect of Al sider Honey and Mountain Honey Against E. coli and Staphylococcus aureus. Kuwait Research Journal of Agriculture and Life Science. 2026 Mar;5(1):12-21
8. Bazaraliyeva, A., Moldashov, D., Turgumbayeva, A., Kartbayeva, E., Kalykova, A., Sarsenova, L., & Issayeva, R. (2022). Chemical and biological properties of bio-active compounds from garlic (*Allium sativum*). *Pharmacia*, *69*, 955–964.
9. Busari, M. B., Ibrahim, Y. O., & Kabiru, A. Y. (2022). *Research Paper Antioxidant and Anti-trypanosomal Activities of the*. *16*(3), 153–162.
10. Destiana, R. T., Herdyastuti, N., Setyarini, W., & Arizandy, R. Y. (2025). Antibacterial Potential of Single Black Garlic Extract Organosulfur Compounds on *Staphylococcus aureus* Bacteria. *Jurnal Pijar Mipa*, *20*(4), 605–610.
11. Discovery, B. (2018). Chemical composition , phytochemical and mineral profile of garlic *(Allium sativum)*. *3*(October), 105–109.
12. Divya, B. J., Suman, B., Venkataswamy, M., & Thyagaraju, K. (2017). *A STUDY ON PHYTOCHEMICALS , FUNCTIONAL GROUPS AND MINERAL COMPOSITION OF ALLIUM SATIVUM (GARLIC) CLOVES*. *9*(3), 40–43.
13. El-Saadony, M. T., Saad, A. M., Korma, S. A., Salem, H. M., Abd El-Mageed, T. A., Alkafaas, S. S., Elsalahaty, M. I., Elkafas, S. S., Mosa, W. F. A., & Ahmed, A. E. (2024). Garlic bioactive substances and their therapeutic applications for improving human health: a comprehensive review. *Frontiers in Immunology*, *15*, 1277074.
14. Extended-spectrum, P., Alam, M., Bano, N., Ahmad, T., Sharangi, A. B., Upadhyay, T. K., Alraey, Y., Alabdallah, N. M., Rauf, M. A., & Saeed, M. (2022). *Synergistic Role of Plant Extracts and Essential Oils against Multidrug Resistance and Gram-Negative Bacterial Strains*.
15. Gabriel, T., Vestine, A., Kim, K. D., Kwon, S. J., Sivanesan, I., & Chun, S. C. (2022). Antibacterial activity of nanoparticles of garlic (Allium sativum) extract against different bacteria such as Streptococcus mutans and Poryphormonas gingivalis. *Applied Sciences*, *12*(7), 3491.
16. Gebreyohannes, G., & Gebreyohannes, M. (2013). Medicinal values of garlic: A review. *International Journal*, *5*(9), 401–408.
17. Ghosh, C., Sarkar, P., Issa, R., & Haldar, J. (2018). Alternatives to Conventional Antibiotics in the Era of Antimicrobial Resistance. *xx*, 1–16.
18. Herliawati, P. A., Wintariani, N. P., Olivia, B., Hildayanti, R. A., & Pratiwi, N. A. J. (2023). Effect of Black Garlic Extract in Feminine Liquid Soap as Antibacterial (*Escherichia coli*): Effect of Black Garlic Extract in Feminine Liquid Soap as Antibacterial (*Escherichia coli*). *Tropical Health and Medical Research*, *5*(2).
19. Jarosz, A., Drabik, K., Domaradzki, P., Sapała, M., Ziomek, M., Batkowska, J., & Grenda, T. (2026). The effect of allicin on the intestinal microbiota and production efficiency in selected farm animals. *Journal of Veterinary Research (Poland)*.
20. Lee, K. J., Oh, Y. C., Cho, W. K., & Ma, J. Y. (2015). Antioxidant and Anti-Inflammatory Activity Determination of One Hundred Kinds of Pure Chemical Compounds Using Offline and Online Screening HPLC Assay. *Evidence-Based Complementary and Alternative Medicine*, *2015*. Lestari, S. R., Ghofur, A., Maslikah, S. I., Sunaryono, Rahma, A. N., Aisyah, D. N., Mufidah, I. N., Rifqi, N. D., Prastita, N., Miasih, D. S., & El Baroroh, A. R. (2023). Profiling of Single Garlic Extract Microencapsulation: Characterization, Antioxidant Activity, and Release Kinetic. *Journal of Tropical Biodiversity and Biotechnology*, *8*(3).
21. Li, G., Ma, X., Deng, L., Zhao, X., Wei, Y., Gao, Z., & Jia, J. (2015). Fresh Garlic Extract Enhances the Antimicrobial Activities of Antibiotics on Resistant Strains in Vitro. *8*(5). https://doi.org/10.5812/jjm.14814
22. Machado, A., Zamora-Mendoza, L., Alexis, F., & Álvarez-Suarez, J. M. (2023). Use of plant extracts, bee-derived products, and probiotic-related applications to fight multidrug-resistant pathogens in the post-

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antibiotic era. *Future Pharmacology*, *3*(3), 535–567.

23. Madaki, F., Kabiru, A. Y., Ogbadoyi, E., Mann, A., Mannasseh, M., & Lawal, B. (2019). *Antioxidant potential of Waltheria Indica methanol leaf extract in Trypanosoma Brucei Brucei infected mice*.

24. Magryś, A., Olender, A., & Tchórzewska, D. (2021). Antibacterial properties of Allium sativum L . against the most emerging multidrug - resistant bacteria and its synergy with antibiotics. *Archives of Microbiology*, *203*(5), 2257–2268.

25. Melguizo-Rodríguez, L., García-Recio, E., Ruiz, C., De Luna-Bertos, E., Illescas-Montes, R., & Costela-Ruiz, V. J. (2022). Biological properties and therapeutic applications of garlic and its components. *Food and Function*, *13*(5), 2415–2426.

26. Moazeni, M., & Nazer, A. (2010). In vitro effectiveness of garlic (*allium sativum*) extract on scolices of hydatid cyst. *World Journal of Surgery*, *34*(11), 2677–2681.

27. Mushemesh, N. A. R., Mahmoud, A. R., Resan, D. K., Abdel-Baqi, Z. T., & Jassim, S. M. (2023). The biological activity of some medicinal plant aqueous extracts in inhibiting the growth of pathogenic Gram-negative and Gram-positive bacteria. DYSONA–Life Science, 4(2), 66–70.

28. U D Faisal Al-Saeedi, K T Khshan. Evaluation of Hemolysis and Their antibacterial Activities of Mirabilis jalapa (L.), Leaf's Extracts Against Bacteria Isolated from Diabetic Foot Ulcers.; Al-Harf Journal., No. 25., Vol. 2, May 2026

29. G H Al-Hakeem ,R M Hasan. Evaluation of Antibacterial Activity of Grape Seeds Extract. Al-Harf Journal., No. 25., Vol. 2, May 2026

30. Nader, M. I., & Azhar, D. A. (2010). Antibacterial activity of ginger extracts and its essential oil on some of pathogenic bacteria Antibacterial activity of ginger extracts and its essential oil on some of pathogenic bacteria. *7*(3).

31. Nwobodo, D. C., Chigozie, M., Clement, U., Anie, O., Al-, M. T. S., Joseph, O., Ikem, C., Chigozie, U. V., & Saki, M. (2022). *A*ntibiotic resistance : The challenges and some emerging strategies for tackling a global menace. *July*, 1–10.

32. Organization, W. H. (1987). Manual for laboratory investigations of acute enteric infections. In *Manual for laboratory investigations of acute enteric infections*.

33. Oyawoye, O. M., Olotu, T. M., Nzekwe, S. C., Idowu, J. A., Abdullahi, T. A., Babatunde, S. O., Ridwan, I. A., Batiha, G. E., Idowu, N., Alorabi, M., & Faidah, H. (2022). Antioxidant potential and antibacterial activities of Allium cepa (onion) and *Allium sativum* (garlic) against the multidrug resistance bacteria. *Bulletin of the National Research Centre*, *46*(1). Putri, A. S., Mufalla, S. N., Rusdi, H. O., Wonorahardjo, S., & Suharti, S. (2026). Effect of fermentation on the organosulfur compound profile and antibacterial activity of black garlic (*Allium sativum*) extract. *Ecletica Quimica*, *51*, 1–9.

34. Rahma, R. A., Paramita, A. L., & Akil, S. N. H. (2025). Antibacterial Activity of Aqueous Extract Combination of Garlic (*Allium sativum*) and Red Ginger (Zingiber officinale var. Rubrum) Against *Staphylococcus aureus*. *Biomedika*, *17*(1), 31–37.

35. Rajendrasozhan, S. (2024). Antioxidant, antibacterial and antiviral effect of the combination of ginger and garlic extracts. Bioinformation, 20(1), 11–17.

36. Z Younis J, J Mohammed H. Antibiotic Susceptibility of Escherichia coli Isolated from Urinary Tract Infections in Najaf., Al-Harf Journal., No. 25., Vol. 2, May 2026

37. Saja AM, Hussein AS, Ali ZH. A Study on the Effect of the Antibiotic Ibuprofen on the Histological Structure of the Kidneys in White Rats. Kuwait Research Journal of Agriculture and Life Science. 2025 Jul;4(3):1-7.

38. Sathish Kumar, K., Visnuvinayagam, S., Teena, G., Elavarasan, K., Bindu, J., Balange, A. K., Sivaranjani, R., & Narasimhamurthy, L. (2024). Biochemical, antioxidant, and antimicrobial profiling of essential oils of Indian origin for culinary applications. *International Journal of Food Science*, *2024*(1), 9326683.

39. Subramanian, M. S., Nandagopal MS, G., Amin Nordin, S., Thilakavathy, K., & Joseph, N. (2020). Prevailing knowledge on the bioavailability and biological activities of sulphur compounds from Alliums: A potential drug candidate. *Molecules*, *25*(18), 4111.

40. Upadhyay, R. K. (2016). Garlic: A potential

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source of pharmaceuticals and pesticides: A review. *International Journal of Green Pharmacy (IJGP)*, *10*(1).