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Review Article

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ALLIUM SATIVUM: REDISCOVERING ITS CULINARY AND MEDICINAL HERITAGE

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ABSTRACT
Since the early beginning of mankind, medicinal plants have played a crucial role in human healthcare, serving as ingredients in traditional medicines, spices, and food components. Among these botanical treasures is *Allium sativum L.*, commonly known as Garlic, a highly revered herb and spice derived from tubers. Garlic is a valuable herb with a rich history of culinary and traditional medicinal applications worldwide. Extensive scientific investigation has explored the wide array of biological activities associated with *A. sativum*, including its antioxidant, blood sugar-regulating, anti-inflammatory, cholesterol-lowering, anti-cancer, antithrombotic, antidiabetic, antihypertensive, obesity-regulatory, antimicrobial, and liver-protective properties, as substantiated by previous studies. *A. sativum* is renowned for its effectiveness in addressing a wide range of health issues, including cardiovascular conditions, cancer progression, rheumatism, diabetes, intestinal parasites, bloating, colic, dysentery, liver disorders and various other ailments. This review thoroughly examines updated data till last year of both traditional and therapeutic activities including anti-inflammatory, anti-cancer, and antimicrobial of *Allium sativum.*

INTRODUCTION

Garlic, botanically identified as *Allium sativum L.*, belongs to the Amaryllidaceae family and has its roots in Asia. It is cultivated on a wide scale in various parts of the world, including Egypt, Mexico, China, and Europe. Notably, garlic holds a prominent place in the diet and traditional medicine of Iran, with various parts of the plant, including its leaves, flowers, and cloves, being utilized for medicinal purposes [1]. It's intriguing to observe that garlic's medicinal efficacy has been recognized and harnessed for more than 5,000 years. Garlic has garnered a significant reputation in the folkloric traditions of numerous societies as both a preventative and remedial remedy. Historical accounts, such as those found in the Bible and various literary sources from civilizations like the Chinese, Egyptians, Greeks, Indians, Israelis, and Babylonians, indicate that garlic was employed in ancient times to address a diverse range of ailments, encompassing conditions such as leprosy, diarrhea, constipation, asthma, fever, and infections [2]. In India, *A. sativum* is utilized to manage fever and cough and is externally used to alleviate

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issues like scabies, premature hair graying, and eczema. Additionally, it is used to alleviate inflammation in cases of tetanus and lung ailments [3]. In Pakistan, people ingest plant extracts to address stomach issues, respiratory conditions, and fevers. In a few Asian and South Asian countries, mainly in Nepal, this plant is applied externally to address various health issues, including fevers, liver ailments, diabetes, dysentery, tuberculosis, high blood pressure, facial paralysis, and bronchitis. Furthermore, the plant is recognized in Africa for its purported antibiotic, antiviral, hypolipidemic, hypoglycemic, and antithrombotic qualities [3–5]. In World War II, garlic was utilized to address soldiers' injuries due to its antimicrobial properties. Recently, a plethora of epidemiological, experimental, and clinical data has unveiled the manifold health advantages of garlic and its derivatives. These benefits encompass reducing blood lipid levels, lowering blood pressure, and inhibiting the growth of various microbes, including viruses, fungi, and bacteria. [6,7]. Furthermore, we reviewed the bioactive compounds of garlic (Figure 1)

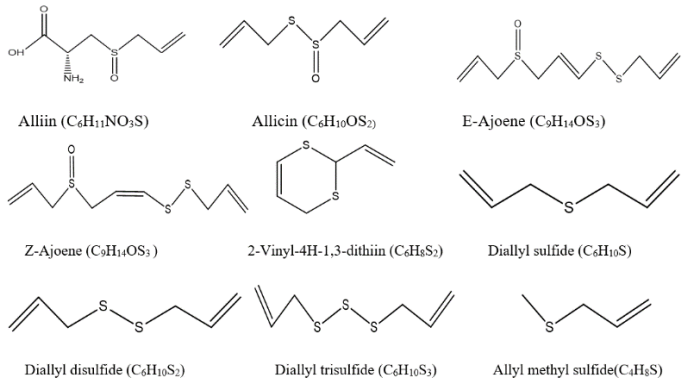

Figure 1: Chemical structure of bioactive constituents present in garlic.

METHODOLOGY

The authors of this review article meticulously scoured the literature for pertinent publications on the impact of blood glucose (BG) on human health conditions. Their search encompassed primary data, authoritative books, and national and international journals up to October 2023. Furthermore, they performed thorough data inquiries on various online platforms. When crafting this review article, the primary references were drawn from reliable sources, including Google Scholar, Web of Science, Scopus, NCBI, Science Direct, ResearchGate, Medline (PubMed), and other reputable journal publishers.

Bio Applications of Garlic

Traditional uses of garlic (*Allium sativum L*)

Garlic, known for its pungent flavor, is a crucial bulb vegetable extensively employed worldwide as a seasoning and flavor enhancer. The primary contributors to its sharp taste and spicy scent are organosulfur compounds such as allicin and DADS. Garlic finds wide application in culinary practices, particularly in preserving dried foods and certain soup varieties, and it can be harnessed in its fresh and dehydrated forms [8]. Historically, garlic and its associated compounds have been recognized for their diverse biological properties, which encompass anticarcinogenic and antioxidant effects [9], renoprotective, antibacterial, anti-atherosclerotic, antidiabetic, antifungal [10], and antihypertensive activities [11]. Furthermore, garlic has a history of application in traditional medicine for addressing issues such as digestive discomfort, respiratory and urinary tract infections, and cardiac problems have been observed. This substance has demonstrated characteristics such as aiding digestion, reducing fever, inducing relaxation, enhancing libido, and promoting increased urine production [12].

Pharmacological activities of garlic (*Allium sativum L*)

Pharmaceutical research and clinical studies have extensively explored the ethnopharmacological uses of *A. sativum*. In the following section, we will delve into the pharmacological characteristics of *A. sativum* L, commonly known as Garlic.

Antibacterial Activity

The potency of garlic's antimicrobial properties is associated with the actions of allicin, which has been noted for its ability to combat a broad spectrum of microorganisms, encompassing antibiotic-resistant bacteria, as well as both Gram-positive and Gram-negative bacteria like Shigella and Escherichia coli [13], Staphylococcus aureus, and Pseudomonas aeruginosa [14], S. faecalis, Streptococcus mutans, *S. pyogenes*, *Klebsiella aerogenes*, *Salmonella enterica*, [15], Mycobacteria, Vibrio, Enterococcus faecalis and Proteus vulgaris [16]. Different garlic extracts, including aqueous, chloroform, methanolic, and ethanolic extracts, exhibited varying levels of effectiveness in inhibiting the growth of various pathogenic bacteria. Notably, one study demonstrated that the ethanolic garlic extract had a more pronounced inhibitory effect on *E. coli* and *S. typhi* than the aqueous extract, which displayed minimal to no inhibitory effects [17]. In their research, Meriga and colleagues observed that an aqueous garlic extract exhibited antibacterial properties against both Gram-negative strains. On the other hand, the

methanolic garlic extract exhibited antimicrobial efficacy against all the tested strains except S. aureus [18]. Significantly, the hexane, ethyl acetate, and chloroform extracts showed no antibacterial effects in this investigation. In contrast, garlic extracts not only restrained the growth of enterotoxigenic E. coli strains and other detrimental intestinal bacteria, which are the primary culprits behind diarrhea in humans and animals, but also demonstrated the ability to counteract the toxins generated by bacterial infections [19]. Allicin's antimicrobial properties are attributed to its chemical interaction with enzymes containing thiol groups, including thioredoxin reductase and alcohol dehydrogenase. This interaction involves the oxidation of cysteine residues in proteins under typical physiological conditions. Allicin displays a biocidal activity that depends on the dosage and can disrupt the essential metabolism of cysteine proteinase. Consequently, this disruption eliminates eukaryotic cells, as thiol groups are universally found in all living cells [20].

Antioxidant Activity

Based on research findings, *A. sativum* exhibits significant antioxidant characteristics. An investigation compared the antioxidative attributes of fresh and cooked garlic cloves and observed that uncooked garlic displays potent antioxidant potential, whereas prepared garlic cloves exhibit substantial antioxidant effects, primarily through the decolorization of β-carotene [21]. The use of ethanolic garlic seedling infusion in experiments involving HT22 rodent hippocampus cell culture demonstrated its antioxidant properties through its ability to scavenge DPPH radicals and reduce ROS production [22]. Extracts obtained from aged garlic (AG) and non-aged garlic (NG), using different solvents, displayed remarkable antioxidant properties.

These properties were assessed through various radical scavenging tests like ABTS and DPHH [23]. In contrast to garlic extracts from multiple cloves (MCG), those from single cloves (SCG) exhibited a significantly improved capacity to neutralize DPPH and superoxide radicals. Furthermore, SCG demonstrated increased resistance to CCl4-induced hepatotoxicity compared to MCG, suggesting its potential as an effective alternative treatment for severe oxidative hepatotoxicity [24].

Anticancer Activity

Among various raw vegetable extracts tested against multiple cancer cells, raw garlic extract displayed the highest efficacy and remarkable specificity as an anticancer treatment, with no discernible impact on non-cancerous cells [25]. Garlic extracts have been associated with their capacity to hinder cell growth and proliferation, control the metabolism of carcinogens, encourage apoptosis, and deter angiogenesis, invasion, and migration, all contributing to their anticancer attributes [26]. This, in turn, mitigated the adverse effects of anticancer agents. Intriguingly, it was reported in 1960 that tumor cells could be eliminated when placed in an allicin solution [27]. Allicin, extracted from garlic, has been documented for its ability to inhibit the spread of colorectal cancer by bolstering the immune system, impeding the development of tumor blood vessels, and reducing the expression of the surviving gene, thus promoting apoptosis in cancer cells.

Additionally, it exhibits potential for improving the management of pancreatic cancer by reversing gene silencing and curbing the proliferation of cancer cells [28]. Fleischauer and Arab [29] noticed in their study that the consistent consumption of garlic inhibits the spread of various types of cancer in the body, such as lung cancer and prostate cancer. In their research, Piscitelli and colleagues [30] found that ingesting garlic supplements for three weeks led to a 50% decrease in the plasma levels of saquinavir in healthy individuals. Furthermore, Z-ajoene exhibits anti-proliferative effects on various cancer types, including the inhibition of proliferation in human breast cancer cells and glioblastoma multiforme cancer stem cells [26]. Moreover, it was noted that it triggered apoptosis in human leukemic cells by stimulating peroxide production and activating caspase-3-like and caspase-8 activities. [31].

Antifungal Activity

The limited progress in developing new antibiotics, along with the scarcity of antifungal drugs that effectively kill fungi by inhibiting ergosterol synthesis, has created a necessity to investigate natural sources for phototherapeutic agents possessing unique targets and mechanisms of action [32]. When diluted in both aqueous and ethanol solutions, the garlic extracts demonstrated complete inhibition (100%) of botrytis cinerea at their respective higher concentrations of 80% and 60%. At an 80% concentration, the aqueous and ethanol-diluted extracts inhibited *Penicillium expansum* by 96.21% and 99.21%, respectively. Notably, ethanol-diluted extracts exhibited greater efficacy against Neofabraea alba, with the 80% ethanol extract achieving a 79.63% inhibition rate. When the ethanolic garlic

extracts were tested against *A. flavus, A. niger*, and *C. herbarum*, they displayed inhibition diameters of 3.766cm, 4.750cm, and 1.883cm, respectively, after a seven-day incubation period on PDA medium. In contrast, the inorganic water-based extraction medium yielded garlic extract inhibition diameter growths of 0.934cm on *A. flavus*, 0.884cm on *A. niger*, and 5.750cm on *C. herbarum* after seven days of incubation [33].

The study revealed that the average zone of inhibition for Candida albicans was 28.0±1.0 mm when treated with aqueous garlic extract and 27.5±0.5 mm with clotrimazole. This finding suggests garlic juice exhibits comparable or potentially superior efficacy against Candida albicans compared to a conventional commercial antifungal medication [34]. It was noted that the aqueous garlic extract displayed a more significant inhibition zone against Aspergillus niger, measuring 41.0±4.0 mm, compared to 22.5±1.5 mm with 4% clotrimazole. Both the aqueous and methanolic extracts of *A. sativum* demonstrated antifungal properties against nearly all the tested strains of Candida albicans [35].

Anti-Inflammatory Activity

Garlic extracts have been shown to possess the capacity to induce anti-inflammatory responses. A study found that applying garlic treatment effectively diminished the inflammation and liver damage from Eimeria papillata infections. An allicin-derived lead compound was identified as a promising initial candidate for creating anti-inflammatory medications that have reduced side effects. An additional research study demonstrated that thiacremonone, a sulfur compound derived from garlic, can potentially curb neuroinflammation and the formation of amyloids by suppressing NF-κB activity. This suggests its potential application in addressing neurodegenerative inflammation-related diseases [36]. The anti-inflammatory properties of aged black garlic (ABG) directly inhibited the TLR4 signaling pathway in macrophages. This inhibition resulted in decreased nuclear NF-kB levels and increased levels of NF-kB and I-B within the cytosol, which were observed in RAW264.7 cells activated by LPS [37].

Antidiabetic Activity

If not properly managed, diabetes can lead to memory issues, kidney disease, and heart-related conditions [38]. In a clinical study, individuals diagnosed with type II diabetes and hyperlipidemia were administered a daily dose of 900 mg of garlic supplements to investigate their potential impact on diabetes. The findings revealed that this dosage reduced cholesterol levels, fasting blood sugar, and serum lipids [39]. Allicin, cysteine sulfoxide, allyl propyl disulfide, and various compounds were found to lower blood sugar levels by inhibiting the liver's activation of insulin, promoting the secretion of insulin from pancreatic beta (β) cells, liberating insulin from its bound states, and enhancing cellular responsiveness to insulin [39].

Antithrombotic Activity

Several compounds extracted from garlic, such as polysulfides and notably allicin, have been associated with antithrombotic effects [40]. The primary role of the fibrinolytic system is to disperse fibrin clots throughout the bloodstream, and this process is regulated by two key factors: PAI-1 (plasminogen activator inhibitor-1) and PAI-2 (plasminogen activator inhibitor-2) [41]. It has been established that allicin and ajoene exhibit antithrombotic effects [42,43].

Antihypertensive Activity

Garlic powder has been shown to effectively lower blood pressure, mitigate the risk factors associated with cardiovascular diseases, and help manage related cardiovascular conditions [44]. Individuals who incorporated garlic essential oil supplements into their diets exhibited enhanced resilience against low-density lipoprotein oxidation, implying the potential anti-atherosclerotic attributes of the substance [45]. High blood pressure is a notable contributor to the risk of cardiovascular disease. Evidence indicates that individuals who increase their garlic intake might experience a reduction in their blood pressure [46,47]. Garlic boosts the production of nitric oxide and hydrogen sulfide, leading to vasodilation [48].

Anti-obesity Activity

Garlic extracts have been linked to anti-obesity benefits, attributed to their ability to activate AMPK, increase thermogenesis, and reduce the expression of genes related to adipogenesis [49]. Garlic essential oil, like DADS, reduced obesity by inhibiting lipogenic enzymes, and both substances also contributed to the reduction of hyperlipidemia [50]. Nevertheless, through its ability to reduce the expression miRNA-335, DATS effectively prevented weight gain and the buildup of white adipose tissue [51].

Adverse effects of Garlic (*allium sativum L.)*

Garlic (Allium sativum L.) has been shown in some recent research to have various conventional and therapeutic benefits on the human body. Still, we must also be aware of its limitations and side effects. Allium sativum L. has been linked to unpleasant body or breath odour in recent investigations, and the German Commission E report verified that "garlic odour may permeate the breath and skin" [52]. A few reports also indicate garlic has a well-known allergy propensity, with diallyl disulfide being recognized as the primary allergen [53]. An unidentified high molecular weight protein found in garlic is thought to cause systemic allergic responses [54]. Numerous intricate cardiovascular effects, including antiplatelet, antithrombotic, and fibrinolytic activity, are provided by garlic [55, 56].

Future direction and perspective

Garlic has been known for its antimicrobial, antioxidant, and anti-inflammatory properties, and research has explored its potential in combating various infections. Future pharmaceutical developments might focus on harnessing garlic's natural compounds to create novel antimicrobial drugs, especially in the context of increasing antibiotic resistance and the antioxidant and anti-inflammatory properties of garlic may be explored further for developing drugs that target oxidative stress and inflammation, which are implicated in various chronic diseases, including neurodegenerative disorders and certain types of cancer.

CONCLUSION

Allium sativum, a cherished culinary herb and a medicinal treasure, is famous for its rich nutrient profile and multifaceted health advantages. It boasts an impressive range of traditional and pharmacological properties, including antibacterial, antioxidant, anticancer, antifungal, anti-inflammatory, antihypertensive, antithrombotic, and anti-obesity attributes. Major phytochemicals such as flavonoids and polyphenols show potential health benefits in the realms of cancer and cardiovascular well-being. While significant strides have been made in comprehending its phytochemistry and medicinal properties, the prudent use of garlic as a seasoning is paramount for reaping its therapeutic benefits while mitigating unintended consequences.

FINANCIAL ASSISTANCE

Nil

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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REFERENCES

[1] Subroto, E., et al. "Bioactive compounds in garlic (Allium sativum L.) as a source of antioxidants and its potential to improve the immune system: a review." *Food Res* 5.1 (2021): 10-26656.

[2] Charu, K., S. Yogita, and S. Sonali. "Neutraceutical potential of organosulfur compounds in fresh garlic and garlic preparations." *Int. J. Pharm. Bio. Sci* 5.1 (2014): 112-126.

[3] Qiu, Zhichang, et al. "Bioactive polysaccharides and oligosaccharides from garlic (Allium sativum L.): Production, physicochemical and biological properties, and structure–function relationships." *Comprehensive Reviews in Food Science and Food Safety* 21.4 (2022): 3033-3095.

[4] Rouf, Razina, et al. "Antiviral potential of garlic (Allium sativum) and its organosulfur compounds: A systematic update of pre-clinical and clinical data." *Trends in food science & technology* 104 (2020): 219-234.

[5] Bhatwalkar, Sushma Bagde, et al. "Antibacterial properties of organosulfur compounds of garlic (Allium sativum)." *Frontiers in Microbiology* 12 (2021): 1869.

[6] Myneni, Ajay A., et al. "Raw garlic consumption and lung cancer in a Chinese population." *Cancer Epidemiology, Biomarkers & Prevention* 25.4 (2016): 624-633.

[7] Guercio, Valentina, et al. "Gastric cancer and allium vegetable intake: a critical review of the experimental and epidemiologic evidence." *Nutrition and cancer* 66.5 (2014): 757-773.

[8] Tesfaye, Azene, and Worku Mengesha. "Traditional uses, phytochemistry and pharmacological properties of garlic (Allium Sativum) and its biological active compounds." *Int. J. Sci. Res. Eng. Technol* 1 (2015): 142-148.

[9] Rahman, Khalid, and Gordon M. Lowe. "Garlic and cardiovascular disease: a critical review." *The Journal of nutrition* 136.3 (2006): 736S-740S.

[10] Davis, Stephen R. "An overview of the antifungal properties of allicin and its breakdown products–the possibility of a

safe and effective antifungal prophylactic." *Mycoses* 48.2 (2005): 95-100.

[11] Badal, Dipankar Singh, et al. "Effect of organic manures and inorganic fertilizers on growth, yield and its attributing traits in garlic (Allium sativum L.)." *Journal of pharmacognosy and phytochemistry* 8.3 (2019): 587-590.

[12] Souza, Gisele A., et al. "N-acetylcysteine an allium plant compound improves high-sucrose diet-induced obesity and related effects." *Evidence-Based Complementary and Alternative Medicine* 2011 (2011).

[13] Ross, Z. M., et al. "Antimicrobial properties of garlic oil against human enteric bacteria: evaluation of methodologies and comparisons with garlic oil sulfides and garlic powder." *Applied and environmental microbiology* 67.1 (2001): 475-480.

[14] Kuda, Takashi, Akiko Iwai, and Toshihiro Yano. "Effect of red pepper Capsicum annuum var. conoides and garlic Allium sativum on plasma lipid levels and cecal microflora in mice fed beef tallow." *Food and chemical toxicology* 42.10 (2004): 1695-1700.

[15] Cutler, R. R., and P. Wilson. "Antibacterial activity of a new, stable, aqueous extract of allicin against methicillin-resistant Staphylococcus aureus." *British journal of biomedical science* 61.2 (2004): 71-74.

[16] Wallock-Richards, Daynea, et al. "Garlic revisited: antimicrobial activity of allicin-containing garlic extracts against Burkholderia cepacia complex." *PLoS One* 9.12 (2014): e112726.

[17] Mikaili, Peyman, et al. "Therapeutic uses and pharmacological properties of garlic, shallot, and their biologically active compounds." *Iranian journal of basic medical sciences* 16.10 (2013): 1031.

[18] Meriga, Balaji, Ramgopal Mopuri, and T. MuraliKrishna. "Insecticidal, antimicrobial and antioxidant activities of bulb extracts of Allium sativum." *Asian Pacific journal of tropical medicine* 5.5 (2012): 391-395.

[19] Shokrzadeh, M., and A. G. Ebadi. "Antibacterial effect of garlic (Allium sativum L.) on Staphylococcus aureus." *Pak. J. Biol. Sci* 9.8 (2006): 1577-9.

[20] Gruhlke, M. C., et al. "Allicin from garlic, effective in controlling several plant diseases, is a reactive sulfur species (RSS) that pushes cells into apoptosis." *Modern fungicides and antifungal compounds VI. 16th International Reinhardsbrunn Symposium, Friedrichroda, Germany, April 25-29, 2010*. Deutsche Phytomedizinische Gesellschaft eV Selbstverlag, 2011.

[21] Locatelli, Daniela Ana, et al. "Cooked garlic and antioxidant activity: Correlation with organosulfur compound composition." *Food chemistry* 220 (2017): 219-224.

[22] Zakarova, Alexandra, et al. "Garlic sprouting is associated with increased antioxidant activity and concomitant changes in the metabolite profile." *Journal of Agricultural and Food Chemistry* 62.8 (2014): 1875-1880.

[23] Jang HJ, et al. Antioxidant and antimicrobial activities of fresh garlic and aged garlic by-products extracted with different solvents. Food Science and Biotechnology, 27, 219-225 (2018).

[24] Naji KM, et al. Hepatoprotective and antioxidant effects of single clove garlic against CCl4-induced hepatic damage in rabbits. BMC Complementary and Alternative Medicine, 17, 1-12 (2017).

[25] Li Z, Le W, Cui Z. A novel therapeutic anticancer property of raw garlic extract via injection but not ingestion. Cell Death Discovery, 4, 108 (2018).

[26] Shang A, et al. Bioactive compounds and biological functions of garlic (Allium sativum L.). Foods, 8, 246 (2019).

[27] Gruhlke MCH, et al. The effects of allicin, a reactive sulfur species from garlic, on a selection of mammalian cell lines. Antioxidants, 6, 1 (2016).

[28] Chhabria SV, et al. In situ allicin generation using targeted alliinase delivery for inhibition of MIA PaCa-2 cells via epigenetic changes, oxidative stress and cyclin-dependent kinase inhibitor (CDKI) expression. Apoptosis, 20, 1388-1409 (2015).

[29] Fleischauer AT, Arab L. Garlic and cancer: a critical review of the epidemiologic literature. The Journal of Nutrition, 131, 1032S-1040S (2001).

[30] Piscitelli SC, et al. The effect of garlic supplements on the pharmacokinetics of saquinavir. Clinical Infectious Diseases, 34, 234-238 (2002).

[31] Bayan L, Koulivand PH, Gorji A. Garlic: a review of potential therapeutic effects. Avicenna Journal of Phytomedicine, 4, 1 (2014).

[32] Iwalokun BA, et al. In vitro antimicrobial properties of aqueous garlic extract against multidrug-resistant bacteria and Candida species from Nigeria. Journal of Medicinal Food, 7, 327-333 (2004).

[33] Daniel CK, Lennox CL, Vries FA. In-vitro effects of garlic extracts on pathogenic fungi Botrytis cinerea, Penicillium expansum and Neofabraea alba. South African Journal of Science, 111, 1-8 (2015).

[34] Abdallah EM. Potential antifungal activity of fresh garlic cloves (Allium sativum L.) from Sudan. Journal of Biotechnology Research, 3, 106-109 (2017).

[35] Hailu G, Bitew M, Temesgen M. In vitro antifungal activity of Croton macrostachys and Allium sativum extracts against Candida albicans and Trichophyton mentagrophytes isolates. International Journal of Biotechnology and Food Science, 5, 42-47 (2017).

[36] Hussein HJ, Hameed IH, Hadi MY. A Review: Anti-microbial, Anti-inflammatory effect and Cardiovascular effects of Garlic: Allium sativum. Research Journal of Pharmacy and Technology, 10, 4069-4078 (2017).

[37] You BR, et al. Anti-inflammatory effect of aged black garlic on 12-O-tetradecanoylphorbol-13-acetate-induced dermatitis in mice. Nutrition Research and Practice, 13, 189-195 (2019).

[38] Galicia-Garcia U, et al. Pathophysiology of type 2 diabetes mellitus. International Journal of Molecular Sciences, 21, 6275 (2020).

[39] Faroughi F, et al. Effects of garlic pill on blood glucose level in borderline gestational diabetes mellitus: a randomized controlled trial. Iran Red Crescent Medical Journal, 20, (2018).

[40] Makheja AN, Bailey JM. Antiplatelet constituents of garlic and onion. Agents and Actions, 29, 360-363 (1990).

[41] Subramanian MS, et al. Prevailing knowledge on the bioavailability and biological activities of sulphur compounds from alliums: a potential drug candidate. Molecules, 25, 4111 (2020).

[42] Ansari F, et al. Study of garlic effect on fibrinolytic activity of the blood clot in vitro. (2011): 48-52.

[43] Teranishi K, et al. Inhibition of baboon platelet aggregation in vitro and in vivo by the garlic derivative, ajoene. Xenotransplantation, 10, 374-379 (2003).

[44] Kwak JS, et al. Garlic powder intake and cardiovascular risk factors: a meta-analysis of randomized controlled clinical trials. Nutrition Research and Practice, 8, 644-654 (2014).

[45] Romeilah RM, Fayed SA, Mahmoud GI. Chemical compositions, antiviral and antioxidant activities of seven essential oils. Journal of Applied Sciences Research, 6, 50-62 (2010).

[46] Subramanian MS, et al. Prevailing knowledge on the bioavailability and biological activities of sulphur compounds from alliums: a potential drug candidate. Molecules, 25, 4111 (2020).

[47] Ried K. Garlic lowers blood pressure in hypertensive subjects, improves arterial stiffness and gut microbiota: A review and meta-analysis. Experimental and Therapeutic Medicine, 19, 1472-1478 (2020).

[48] Ried K, Fakler P. Potential of garlic (Allium sativum) in lowering high blood pressure: mechanisms of action and clinical relevance. Integrated Blood Pressure Control, (2014): 71-82.

[49] Lee MS, et al. Reduction of body weight by dietary garlic is associated with an increase in uncoupling protein mRNA expression and activation of AMP-activated protein kinase in diet-induced obese mice. The Journal of Nutrition, 141, 1947-1953 (2011).

[50] Lai YS, et al. Garlic essential oil protects against obesity-triggered nonalcoholic fatty liver disease through modulation of lipid metabolism and oxidative stress. Journal of Agricultural and Food Chemistry, 62, 5897-5906 (2014).

[51] Miura A, et al. Diallyl trisulfide prevents obesity and decreases miRNA-335 expression in adipose tissue in a diet-induced obesity rat model. Molecular Nutrition & Food Research, 65, 2001199 (2021).

[52] Nathan M. The Complete German Commission E Monographs: Therapeutic Guide to Herbal Medicines. Annals of Internal Medicine, 130, 459 (1999).

[53] Papageorgiou C, et al. Allergic Contact Dermatitis to Garlic (Allium Sativum L.). Identification of the Allergens: The Role of Mono-, Di-, and Trisulfides Present in Garlic. A Comparative Study in Man and Animal (Guinea-Pig). Archives of Dermatological Research, 275, 229-234 (1983).

[54] McGovern TW, LaWarre S. Botanical Briefs: Garlic--Allium Sativum. Cutis, 67, 193-194 (2001).

[55] Capasso F. Phytotherapy: A Quick Reference to Herbal Medicine. Springer Science & Business Media, (2003).

[56] Ernst E, et al. The Desktop Guide to Complementary and Alternative Medicine: An Evidence-Based Approach. Mosby International Ltd, (2001).