



Review Article

Volume 10, Issue 6 -2024

DOI: <http://dx.doi.org/10.22192/ijcrms.2024.10.06.002>

Garlic: a potential traditional herbal medicine to combat COVID-19

Ankita Pal, Fatema Calcuttawala*

Department of Microbiology, Sister Nivedita University, Kolkata 700156, India

***Corresponding author:**

Email: fatema.c@snuniv.ac.in

Phone number: +91-9748518675

Abstract

From ancient times, medicinal plants and their products have been used as a remedy, to eradicate and reduce the effects and risks of various diseases. Garlic (*Allium sativum*) is a herbaceous plant that is used as a traditional medicine to ameliorate a lot of diseases. Garlic is a reservoir of organo-sulfur compounds such as alliin, allicin, ajoenes, vinylthiins, and flavonoids such as quercetin. It has been reported to exhibit various biological properties which include anticarcinogenic, antioxidant, anticoagulant, antidiabetic, anti-atherosclerotic, antibacterial, antifungal, antiviral, and antihypertensive activities. From studies, it has been found that garlic also possesses immunomodulatory effects which increase T-lymphocytes, Natural Killer cells, and macrophages. So, it is used as an immunity booster. Garlic shows some side effects when it is not taken in the correct dose. Therefore, it should be used properly for treatment of any disease. Recent studies have shown that garlic is beneficial in the treatment of COVID-19. This review examines the composition, biological properties, and inhibitory effect on COVID-19 directly via interaction with the viral proteins and indirectly through interaction with the host immune system, adverse effects, and therapeutic dose of garlic.

Keywords: Antioxidant, antiviral, COVID-19, garlic, immune system

1. Introduction

The pandemic of coronavirus disease 19 (COVID-19) caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has resulted in scientists all over the world carrying out research for the mitigation and eradication of the disease. They are actively engaged in the discovery of vaccines, medicines, and other ways of treatment to reduce the lethal

effects of this virus, as it is causing immense damage to humanity as well as animals.

COVID-19 is a zoonotic disease which mainly affects the lungs. The Angiotensin Converting Enzyme (ACE2 receptor) present in the lungs serves as the binding site for the entry of coronavirus into the body. SARS-CoV-2 is an RNA virus that belongs to the Coronaviridae family (Chen D et al., 2020). This virus has an

envelope with some spike on its surface. These spikes are composed of glycoproteins. The spike proteins are responsible for viral attachment and transmission of the viral genome into our body. These spike proteins mutate at a very fast rate. In comparison to the other RNA viruses, coronavirus has a larger genome (Fauquet C and Fargette D, 2005). Upon infection with SARS-CoV-2, COVID-19 patients show some symptoms, the most common ones being dry cough, respiratory problems, and loss of appetite (Chen D et al., 2020; Wang Y et al., 2020). Sometimes the patients are asymptomatic too. Studies have shown that SARS-CoV-2 is more infectious than SARS-CoV-1 and MERS (Wang Y et al., 2020). In order to combat COVID-19, garlic, a traditional medicine could be used as it boosts our immune system and is not so harmful.

Garlic (*Allium sativum*) is a species of the onion genus, *allium*. It has historical importance as it is used as a curative therapy for numerous diseases and diet conditions (Bayan L et al., 2014). It is found to harbor antioxidant, anticarcinogenic, antibacterial, antifungal, and many other antimicrobial properties. Apart from being used as a medicine, it has other uses such as preservatives for foods and as a flavoring agent (El-Saber Batiha et al., 2020). It assists in boosting the immune system as well as decreases the chances of getting diabetes and cardiovascular diseases (Rahman K, 2001). Aged garlic extract (AGE) (kyolic) was reported to decrease cholesterol levels and thus lower the risk of atherosclerosis (El-Saber Batiha et al., 2020). It was also found to decrease the oxidation of lipids and was reported to lower the blood pressure. Garlic exhibits antiviral activity against Cocksackie Virus species, Herpes Simplex Virus types 1 and 2, Influenza B virus, Vesicular Stomatitis Virus, Human Immunodeficiency Virus type 1, and human rhinovirus type 2 (Rahman K, 2001). Some studies found that it helps in reducing the ACE2 receptors, which are the main receptors for binding to the COVID-19 virus. Hence, garlic could be used to treat various diseases, from whooping cough to cardiovascular diseases. Even it is used in treating Alzheimer's patients. Garlic contains organosulphur-rich compounds, which are biologically important. Allicin is the most

important compound that gives garlic a characteristic smell and taste and is primarily responsible for its antibacterial activity (Chakraborty D and Majumdar A, 2020). Quercetin, a flavonoids compound that is also present is used for medications in combination with vitamins, especially vitamin C. From previous studies it has been found that quercetin is an antiviral agent that performs many functions such as inhibition of virus entry, interfering with DNA and RNA polymerases, and inhibition of proteases and other enzymes (Colunga Biancatelli RML et al., 2020). There are other compounds that are equally important and effective against various diseases. Garlic is used against COVID-19 effectively because it suppresses the Main protease (Mpro) enzyme which is responsible for the activation of the virus. The virus is viable, when it enters the body, due to the presence of the M protease enzyme which plays an important role in viral replication and the production of some functional proteins. Studies have shown that allicin, other organosulphur compounds, and flavonoids have a high potential against viral activity. It was found that quercetin blocks the protease at the initial attachment stage of the virus to inhibit viral action. The main reason behind the inhibition of the virus is the formation of hydrogen bonds between the enzyme protease and garlic compounds (Liu X and Wang XJ, 2020). Entry of virus into the cell affects the immune system, so the virus is inhibited not only by the interaction of garlic compounds with viral enzymes but garlic compounds also boost the immune system.

Bioactive compounds present in garlic exhibit immunomodulatory, antioxidant, antimicrobial, and anti-inflammatory activities which increase the activity of lymphocytes, natural killer cells, and macrophages thereby modulating the immune system.

The immune system under COVID-19 stress involves a decreased number of T cells, Natural killer cells, and macrophages. However, the production of leptin and some anti-inflammatory cytokines such as tumor necrosis factor-alpha (TNF-), interleukin-1 (IL-1), interleukin-2 (IL-2), and interleukin-6 (IL-6) increases (Qin C et

al., 2020). T cells are vital for the immune system. There are two types of T cells which are Helper T cells and Cytotoxic T cells. Both the cells protect the body from foreign particles and diseases. Helper T cells help other cells of the immune system whereas cytotoxic T cells destroy the infected cells and tumors. Natural killer cells have the same activity as the suppressor T cells, but the only difference lies in their way of killing (Donma MM and Donma O, 2020).

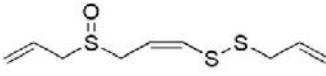
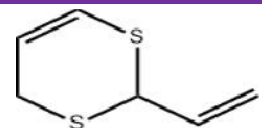
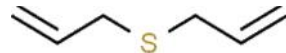
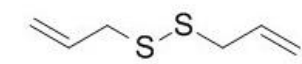
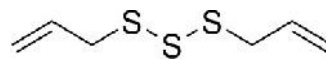
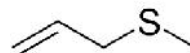
The loss of appetite is due to the increase in leptin, which is a hormone (Donma MM and Donma O, 2020). In this article, we will discuss the various aspects of garlic including the composition of garlic, the different activities of particular compounds present in garlic, the interaction between the M protease enzyme and bioactive compounds, how garlic is important for our body, the effect of garlic on the immune system during the COVID-19 pandemic and supplementation dosage of garlic.

2. Composition of garlic

Garlic contains a lot of chemical compounds mostly which are sulfur-compounds such as Alliin, Allicin, E-Ajoene, Z-Ajoene, 2-Vinyl-4H-1,3-dithiin, Diallyl sulfide (DAS), Diallyl disulfide (DADS), Diallyl trisulfide (DATS), Allyl methyl sulfide (AMS) (Bayan L et al., 2014; El-Saber Batiha et al., 2020; Chakraborty D and Majumdar A, 2020). Constituents of garlic have the ability to boost immunity and hence can ameliorate numerous diseases (El-Saber Batiha et al., 2020). The presence of allinase enzyme in garlic leads to the conversion of an alliin compound to allicin (El-Saber Batiha et al., 2020; Kaye AD et al., 2000). Allicin is a yellow oily liquid, which is unstable, hence it could be decomposed to ajoenes under specific temperatures. It is degraded to ajoenes ((E)- and (Z)- 4,5,9-trithiadodeca-1,6,11-triene-9-oxides) and vinylthiols (Khubber S et al., 2020).

Table 1. Compounds present in garlic with their structures and functions

Compounds	MolecularFormula	Structure	Functions
Alliin	$C_6H_{11}NO_3S$		Anti-oxidant, Anti-microbial, Cardioprotective, Neuroprotective
Allicin	$C_6H_{10}OS_2$		Anti-oxidant, Anti-carcinogenic,
E-Ajoene	$C_9H_{14}OS_3$		Antioxidant, Antithrombotic

Z-Ajoene	C₉H₁₄OS₃		Antioxidant, Antithrombotic
2-Vinyl-4H-1,3dithiin	C₆H₈S₂		Anti-obesity
Diallyl sulfide	C₆H₁₀S		Antioxidant, Anticarcinogenic
Diallyl disulfide	C₆H₁₀S₂		Anti-neoplastic, Antifungal
Diallyl trisulfide	C₆H₁₀S₃		Anti-oxidant, Anti-fungal, Antitumor
Allyl sulfide methyl	C₄H₈S		Antioxidant, Anti-inflammatory

Each compound has a particular activity such as immunomodulatory, anti-inflammatory, anticancer, antitumor, antidiabetic, anti-atherosclerotic, and cardioprotective activity respectively (Khubber S et al., 2020) (Table1). Allyl mercaptan is the compound responsible for the odour of garlic and it is formed from the combination of allicin and cysteine via a complex compound (El-Saber Batiha et al., 2020; Kaye AD et al., 2000; Rahman S, 2007). There are many derived compounds of allicin such as N-acetyl cysteine (NAC), S-allyl cysteine (SAC), and S-allyl-mercapto cysteine (SAMC) (El-Saber Batiha et al., 2020) (Fig.1). It was found that SAC harbors some activities like anti-oxidant, anti-

inflammation, redox regulation, pro energetic (energizes the cells), antiapoptotic and cell signaling, whereas SAMC displays anticancer property, which helps in inhibition of cancer cell growth (El-Saber Batiha et al., 2020; Zeng Y et al., 2017). Studies have shown that allicin shows specific inhibition activity to acetyl CoA synthetases, hence affecting numerous biochemical pathways such as lipid biosynthesis, and RNA synthesis, which inevitably occur in mammals as well as microorganisms (Rahman MS, 2007). Experimentally, the antiviral activity of garlic constituents was found against influenza

viruses. It was found to produce antibodies in the presence of ajoene, allicin, and allyl methyl thiosulfate (El-Saber Batiha et al., 2020). Diallyl trisulfide (DATS) shows antiviral activity by stimulating Natural killer (NK) cells that kill the virus-infected cells. Ajoenes exhibit antiviral activity by fusion of leukocytes and prevention of

adhesive interaction of viral particles to cells (El-Saber Batiha et al., 2020). Ajoenes have been reported to stimulate apoptosis in leukemic cells and also promote peroxide production. Ajoenes can exhibit anti-obesity function also, it decreases body weight.

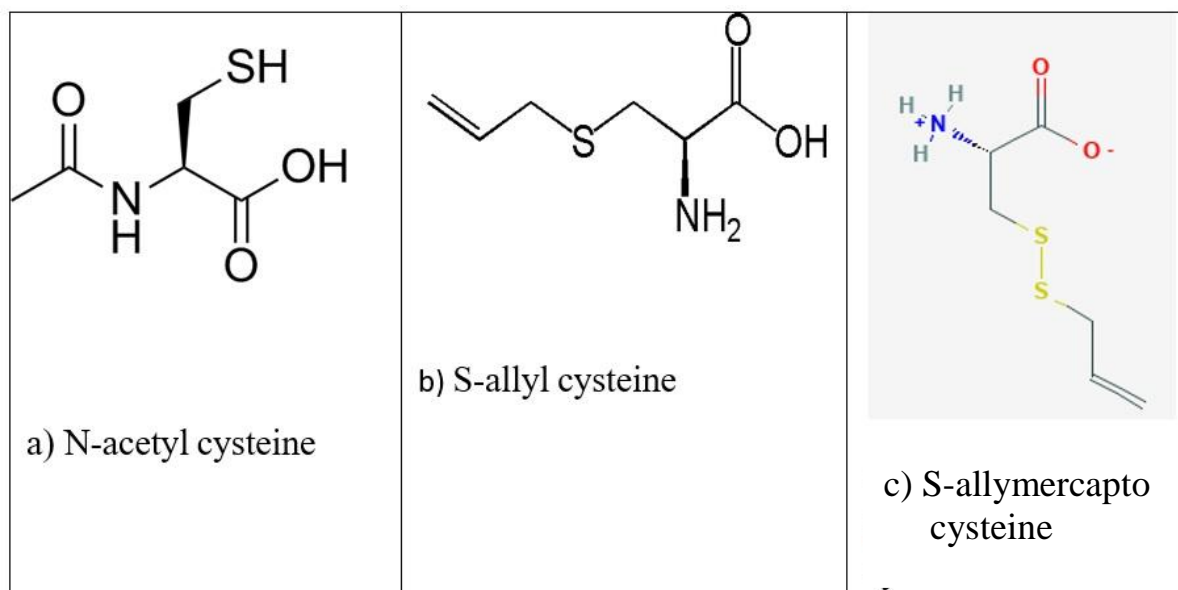


Fig 1. Compounds derived from allicin

Even,1,2-vinyldithiin shows anti-obesity activity.

Aged garlic extract (AGE)/Aged black garlic (ABG) is another widely studied compound, which has many beneficial effects. It is produced by storing garlic in 15-20% ethanol for a specified time. In the production of AGE, degradation of allicin occurs and activities of some newer compounds increase such as S-allyl cysteine, S-allyl mercapto cysteine, allixin, N-(4-oxo-5-oxo-1,2-dihydroxyethyl)-L-arginine and selenium which are more stable than allicin and importantly they exhibit antioxidant and anti-inflammatory properties (Bayan L et al., 2014; El-Saber Batiha et al., 2020). ABG is dark brown colored garlic with a sweet and sour flavor and has a jelly-like appearance. It has higher concentrations of components with free sugar and minerals compared to fresh raw garlic (FRG). ABG shows strong antioxidant effects but in comparison to

FRG, it shows lower anti-inflammatory, anti-coagulation, anti-allergic, and immunomodulatory functions (Ryu JH and Kang D, 2017). Quercetin is another effective compound that is also present in garlic. It is a flavonoid that is found in many vegetables, leaves, and grains in the form of glycosides (Khubber S et al., 2020; Wu W et al., 2015) (**Fig.2**). It mainly exhibits antiviral, antioxidant, and anti-inflammatory activities. During viral infections, this compound helps by inhibiting polymerases, proteases, reverse transcriptases, and DNA gyrases and binding to the viral capsid proteins (Wu W et al., 2015).

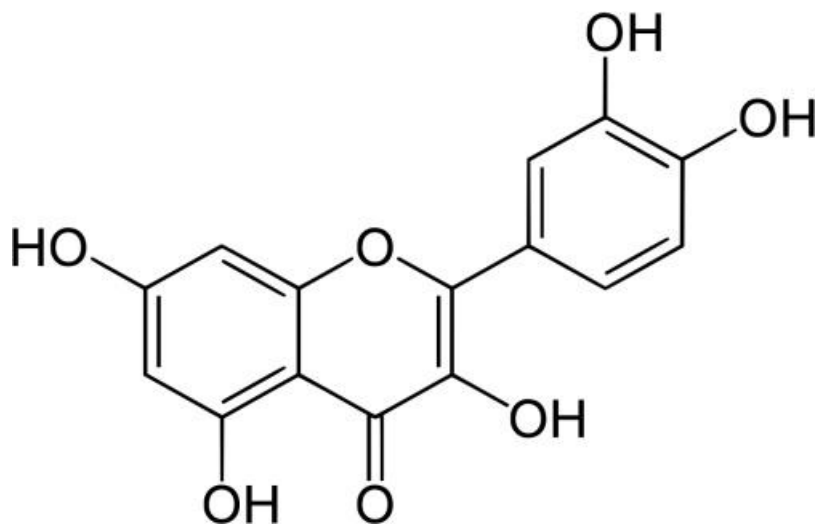


Fig 2. Structure of Quercetin

Other compounds such as Diallyl disulfide (DADS), and Diallyl trisulfide (DATS) exhibit similar properties such as anti-carcinogenic activity, lowering blood pressure (Rahman K, 2001), decrease in serum cholesterol levels (Zeng Y et al., 2017), reduction in body fat, increase in appetite (Donma MM and Donma O, 2020) and it has several other beneficial effects. Garlic extract (GE) has a lot of potential health advantages. Gamma-glutamylcysteine is a bioactive compound that shows anti-hypertensive activity by inhibiting ACE2. These could protect liver cells from toxic agents by antioxidant defense mechanisms. Hepatotoxicity is generally caused by acetaminophen. GE is also beneficial in diabetic patients, as it helps in lowering insulin resistance (Chakraborty D and Majumdar A, 2020). Platelets are thrombocytes and fibrin are the soluble proteins, which are essential for blood clotting. Higher amounts of fibrin can lead to a

heart attack. Garlic constituents can decrease the fibrin formation and also decrease the amount of fibrin present in blood (Chakraborty D and Majumdar A, 2020).

3. Effect of Garlic on the immune system

There have been several studies on the effect of the infection of a virus on the immune system cells. Those cells that decrease in number include, regulatory T cells, cytotoxic and helper T cells, Natural killer (NK) cells, interferon-gamma (IFN- γ), macrophages, and monocytes, whereas, pro-inflammatory cytokines such as tumor necrosis alpha factor (TNF- α), interleukin-1 (IL-1), interleukin-2 (IL-2), interleukin-6 (IL-6) and another compound leptin were found to be in the active state (Qin C et al., 2020; Donma MM and Donma O, 2020; Wang F et al., 2020) (**Fig.3**).

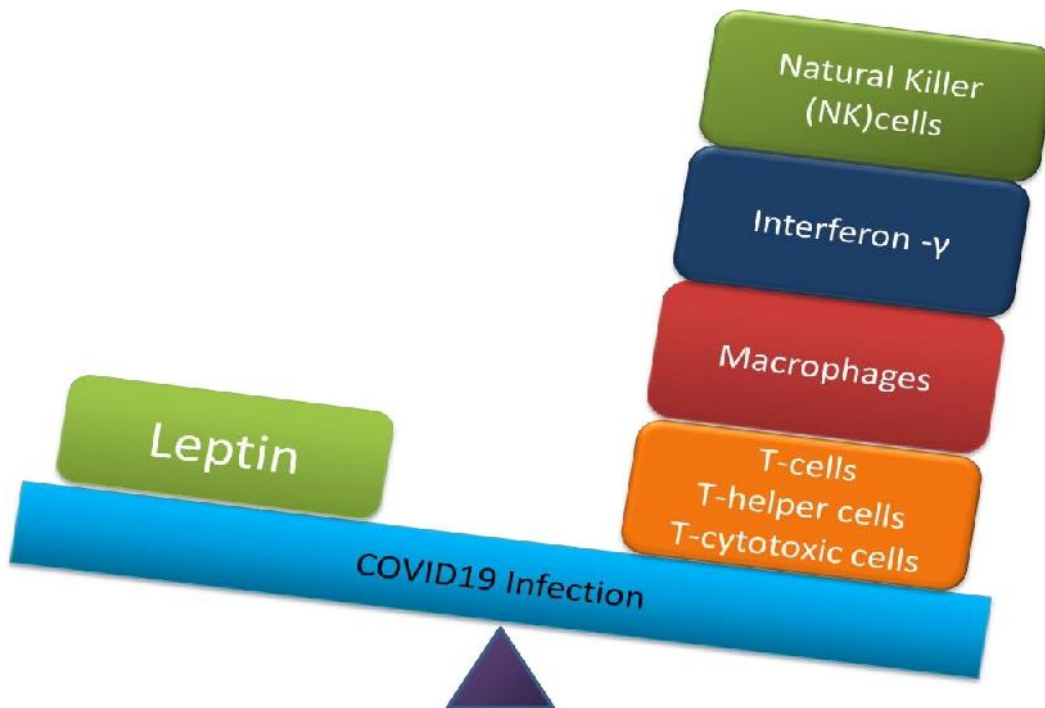


Fig 3. Fate of the immune system during COVID-19 infection

Consumption of garlic leads to the stimulation of Helper T cells and Cytotoxic T cells as well as Natural Killer cells (Donma MM and Donma O, 2020; Arreola R et al., 2015). On the other hand, leptin, leptin receptor, peroxisome proliferator-

activated receptor gamma (PPAR-), and IL-6 were downregulated (Donma MM and Donma O, 2020) (**Fig.4**). Hence Garlic counteracts the effects caused by the virus.

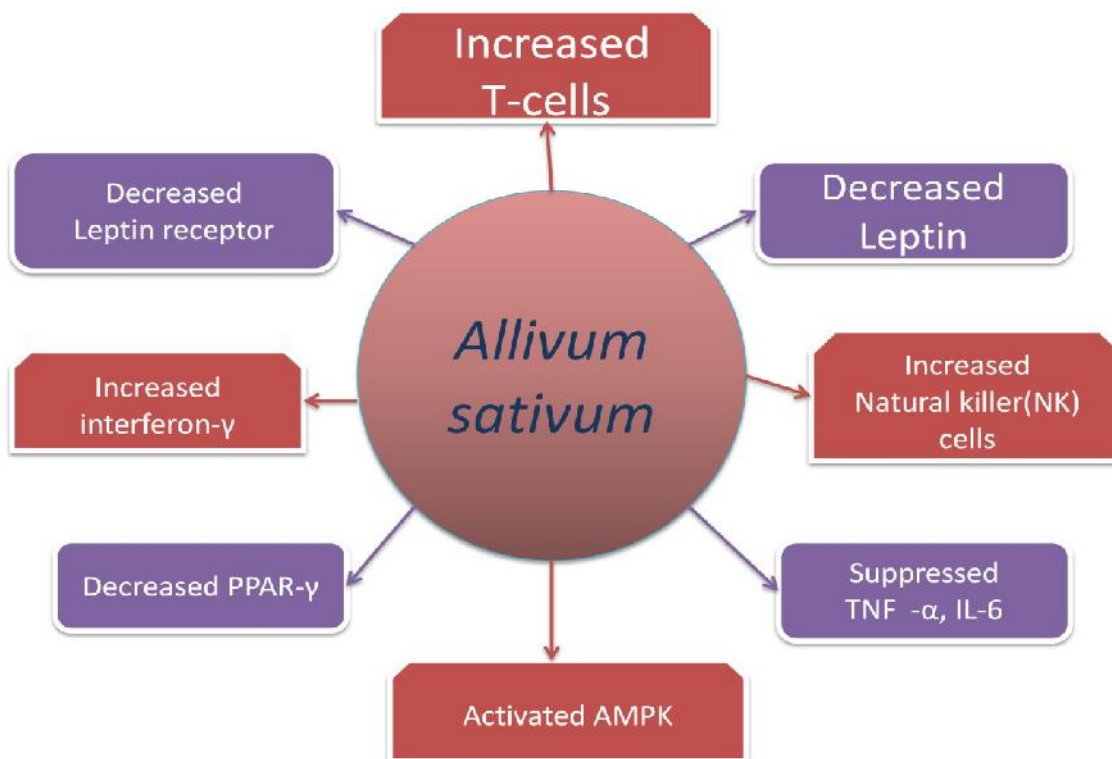


Fig 4. Effects of garlic on the immune system

Leptin is an anorexigenic hormone that signals the brain “not to eat”, therefore it causes appetite loss. An experiment was done on some participants who were allowed to eat salads and garlic bread. From this, it was found that the participants felt less hungry after consumption of salads compared to the garlic bread. So, it can be concluded that garlic increases the appetite (Donma MM and Donma O, 2020; Buckland NJ et al., 2013). Metabolism of leptin is assisted by alpha-melanocyte-stimulating hormone. Leptin decreases the appetite (Paudel KR et al., 2022), by stimulating the proopiomelanocortin (POMC), and cocaine amphetamine-regulated expression (CART) and simultaneously decreasing the agouti-related peptide (AgRP) and neuropeptide Y expression (NPY) (Buckland NJ et al., 2013) (Fig.5). The four neurons NPY, POMC, AgRP and CART are directly connected to the leptin. NPY and AgRP are considered as an orexigenic hormone, which increases appetite, whereas POMC and CART are anorexigenic and decrease appetite. The downregulation of some immune cells is brought about by constituents of garlic such as the decrease in expression of proinflammatory cytokines is influenced by alliin (Arreola R et al., 2015). Similarly, other

constituents induce some functions that reduce the effects of coronavirus on the immune system. The production of proinflammatory cytokines is also decreased by aged garlic extract (AGE). An experiment was done, where AGE was applied to the hypothalamus which showed a decrease in leptin (Amor S et al., 2019). The same experiment when done in the subcutaneous adipose tissue, causes a decrease in adipose weight and suppresses the gene expression of peroxisome proliferator-activated receptor gamma (PPAR- γ) and Leptin receptor (LepR). Adenosine monophosphate-activated protein kinase (AMPK) is stimulated by ABG, which in turn inhibits the transcriptional activity of PPAR- γ in liver cells (Sozio MS et al., 2011). The phosphorylation of acetyl CoA carboxylase is induced by AMPK. Due to this process, the enzyme gets inactivated which is needed in the conversion of acetyl CoA to malonyl CoA. Therefore, the inhibition of this process inhibits the production of fatty acids. AGE treatment is also a remedy for atherosclerosis and type 2 diabetes (Amor S et al., 2019; Sozio MS et al., 2011). This treatment could be helpful in treating co-morbid diseases. So, AGE treatment can be directly or indirectly beneficial for COVID-19.

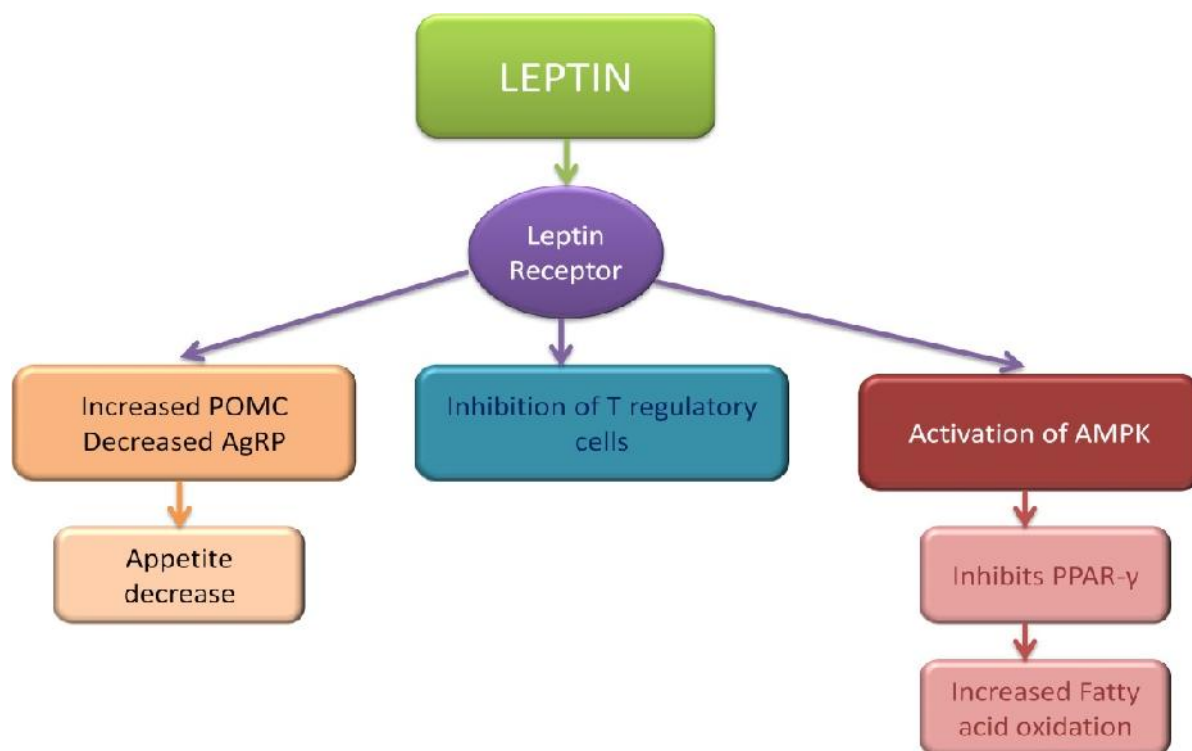


Fig 5. Effects of leptin on the immune system and regulation of appetite

4. Interaction of virus and constituents of garlic

The main reason behind the activation of the virus is the viral enzymes and proteins, which are responsible for the nourishment and growth of the virus. In recent research, the structure of Mpro, (also called as 3CL protease) a protease enzyme was observed. This enzyme is the main reason behind viral replication (Ashraf H et al., 2023) and the production of functional proteins. This is the key enzyme, which is responsible for the translation of the polypeptide (Khubber S et al., 2020). Mpro is a cysteine protease in which cysteine and histidine are present in its active center. This cysteine and histidine present in a combined form are known as catalytic dyad. Some catalytic dyad with a third residue, which is a buried water molecule, also occupies the same active site (Ullrich S and Nitsche C, 2020). From studies, it was found that this main protease is available in both, SARS-CoV-1 as well as SARS-CoV-2 but with a slight difference in the structural sequence. Both the viral sequences show 96% of similarity (Liu X and Wang XJ, 2020; Khubber S et al., 2020; Ullrich S and Nitsche C, 2020).

In another research, it was found that the conserved part of the polypeptide is responsible for the formation of binding pockets (binding sites) for some drugs such as lopinavir/ritonavir. The conserved amino acids include Thr24, Asn28, and Asn119, which happen to be in active regions of the binding pocket (Liu X and Wang XJ, 2020; Zhang L et al., 2020). The conserved amino acids are not interrupted by any non-conserved amino acids in the binding pocket region rather they are very far from the conserved regions. Through computational mode, the position of amino acids was easily located. When molecular docking was done using lopinavir/ritonavir to SARS-CoV2, it was observed that Mpro showed high binding affinity to the binding pocket site, similar to the previous report found for SARS-CoV Mpro.

A prediction was made based on studies, that the amino acids Thr24, Thr26, and Asn119 are the main residues that form hydrogen bonds with the

lopinavir and ritonavir drugs. The residues form three hydrogen bonds with ritonavir and two hydrogen bonds with lopinavir, respectively (Liu X and Wang XJ, 2020; Khubber S et al., 2020).

Based on studies, it can be concluded that the formation of hydrogen bonds between the drug and the Mpro would prevent/hinder the function of SARS-CoV2. If the predicted drugs showed more hydrogen bonds with SARS-CoV-2 Mpro than lopinavir/ritonavir, the higher would be their mutation tolerance than lopinavir/ritonavir (Liu X and Wang XJ, 2020).

Synthetic drugs are usually effective against the pathogens, but there are some natural drugs that contain some phytochemicals that have inhibitory effects against pathogens. There are many plant products but garlic is one of them, whose constituents showed inhibition against Coronavirus. In a silico experiment, it was observed that seven organosulfur compounds of alliin were taken into account to inhibit the functions of Mpro of SARS-CoV2. The seven derived compounds of alliin that take part in this experiment are S-(allyl/ methyl/ethyl/propyl)-cysteine, S-propyl L-cysteine, and S-allylmercapto. Cysteine forms hydrogen bonds with protease enzymes to prevent it from functioning. Computational analysis has considered these compounds have antiviral potential to prevent COVID-19. Earlier, it was seen that Quercetin had prevented protease in SARS-CoV-1 during multiplication in host cells by blocking the viral attachment stage (Khubber S et al., 2020). A natural compound and a different form of Quercetin, Quercetin-3-galactoside was observed as a new class inhibitor against SARS-CoV 3CLpro through molecular docking as well as many assays such as Fluorescence resonance energy transfer (FRET) assay (Chen L et al., 2006). We learned about so many constituents present in garlic which are effective against COVID-19 as well as other diseases. But, this herbal drug or the constituents of garlic are only beneficial and will act effectively, when it is given at the correct amount. Otherwise, garlic could be toxic.

5. Side effects and Toxicity

Generally, the dosage comprises of 4g (one or two cloves) of raw garlic per day, one 300-mg dried garlic powder tablet two to three times per day, or 7.2 g of AGE per day for elderly persons (Tattelman E, 2005). In an experiment, female and male rats were supplemented with garlic at 300 and 600 mg for 21 days, and was reported that garlic caused delays in growth and affected the biological and histological parameters (Mikaili P et al., 2013). A study on garlic showed that its application results in mild inflammation, but it can cause skin reactions and deep chemical burns if applied under pressure bandage or poor wound or near secondary infection (Mikaili P et al., 2013). Garlic can be used in synergistic therapy to invade toxicity, and there is an elevation of antioxidant enzymes as well as antihypertensive and cardioprotective activities (El-Saber Batiha et al., 2020). Many trials were performed, experiments were done and some side effects such as insomnia, vomiting, dizziness, headache, nausea, heartburn, diarrhea, bloating, sweating, offensive body odor, and mild orthostatic hypotension were observed (El-Saber Batiha et al., 2020).

Garlic does not seem to affect drug metabolism, but recent reports on trials done on healthy participants showed inconsistent results. Garlic has an effect on the pharmacokinetics of protease inhibitors, as well as anticoagulants due to its antithrombotic properties (Rahman K and Lowe GM, 2006). The consumption of garlic has an ill effect, causing a decrease in coagulation of bleeding so it is normally advised that a patient undergoing surgery should not consume garlic at high doses 7 to 10 days earlier (Mikaili P et al., 2013). According to studies, it was reported that low consumption of garlic is innocuous, whereas the medicinal doses can cause mild gastrointestinal disorders, and high doses cause liver damage (Ried K and Fakler P, 2014; Almogren A et al., 2013).

6. Discussion

This review mainly focuses on the constituents of garlic and their functions in treating diseases,

especially COVID-19. From ancient times it has been popularly recognized as a traditional medicine for its therapeutic functions. This herbal spice has gained renewed interest due to its therapeutic effects in the prevention and treatment of various diseases. Recent studies and experiments on this herbal spice have unveiled a wide range of applications. Garlic contains sulfur-rich compounds including alliin, allicin, ajoenes, vinyldithiols, and sulfides which are considered as main constituents (He Z et al., 2023). These extracted compounds harbor many pharmacological activities such as antiviral, anti-inflammatory, anticarcinogenic, antioxidant, antidiabetic, renoprotective, anti-atherosclerotic, antibacterial, antifungal, antiprotozoal, and antihypertensive activities (Diantini A et al., 2023). Because of these effects, it helps in the prevention and treatment of various respiratory diseases (Giang T et al., 2023). Every compound present in garlic contributes to its anti-inflammatory effects (Diantini A et al., 2023). Each component of garlic possesses antioxidant properties.

So far, we have seen that the effective way to fight against COVID-19 is to boost our immune system. Studies emphasizing on immunomodulatory effects of garlic have reported an increase in the activity and number of cytokine suppressors, lymphocytes, natural killer cells, and macrophages and a decrease in leptin could boost the immune system. Therefore, it could be used as an alternative and effective way to fight against COVID-19. In COVID-19, mainly appetite decreases, to counteract that garlic could be used as it decreases the leptin hormone content (Paudel KR et al., 2022). This review also provides valuable information on Mpro and how the bioactive compounds of garlic bind to Mpro and inhibit its activity (Khubber S et al., 2020; Ashraf H et al., 2023). Mpro is the main protease enzyme, which is responsible for viral replication, viral protein production, and attachment to the host. This herbal spice could be used as an effective remedy, both synergistically as well as individually. Garlic has some side effects also if administered in high doses. Therefore, it is advised to use it properly for any medication or treatment of disease. Hence garlic has the

potential to ameliorate many diseases including COVID-19.

Financial support & sponsorship: None

Conflicts of Interest: None

References

- Almogren A, Shakoor Z, Adam MH. Garlic and onion sensitization among Saudi patients screened for food allergy: a hospital based study. 2013. Afr Health Sci. 13(3):689-693.
- Amor, S., González-Hedström, D., Martín-Carro, B., Inarejos-García, A. M., Almodóvar, P., Prodanov, M., García-Villalón, A. L., and Granada, M. 2019. Beneficial Effects of an Aged Black Garlic Extract in the Metabolic and Vascular Alterations Induced by a High Fat/Sucrose Diet in Male Rats. *Nutrients*. 11(1):153
- Arreola, R., Quintero-Fabián, S., López-Roa, R. I., Flores-Gutiérrez, E. O., Reyes-Grajeda, J. P., Carrera-Quintanar, L., and Ortuño-Sahagún, D. 2015. Immunomodulation and anti-inflammatory effects of garlic compounds. *J Immunol Res*. 2015:401630.
- Ashraf H, Dilshad E, Afsar T, Almajwal A, Shafique H, and Razak S. 2023. Molecular Screening of Bioactive Compounds of Garlic for Therapeutic Effects against COVID-19. *Biomedicines*. 11(2):643.
- Bayan, L., Koulivand, P. H., and Gorji, A. 2014. Garlic: a review of potential therapeutic effects. *Avicenna J Phytomed*. 4(1):1-14.
- Buckland, N. J., Finlayson, G., and Hetherington, M. M. 2013. Slimming starters. Intake of a diet-congruent food reduces meal intake in active dieters. *Appetite*. 71:430-437.
- Chakraborty, D., and Majumder, A. 2020. Garlic (Lahsun) – An Immunity Booster Against SARS-CoV-2. *BioResToday*. 2(8):755-757.
- Chen, G., Wu, D., Guo, W., Cao, Y., Huang, D., Wang, H., Wang, T., Zhang, X., Chen, H., Yu, H., Zhang, X., Zhang, M., Wu, S., Song, J., Chen, T., Han, M., Li, S., Luo, X., Zhao, J., and Ning, Q. 2020. Clinical and immunological features of severe and moderate coronavirus disease 2019. *J Clin Invest*. 130(5):2620-2629
- Chen, L., Li, J., Luo, C., Liu, H., Xu, W., Chen, G., Liew, O. W., Zhu, W., Puah, C. M., Shen, X., and Jiang, H. 2006. Binding interaction of quercetin-3-beta-galactoside and its synthetic derivatives with SARS-CoV 3CL (pro): structure-activity relationship studies reveal salient pharmacophore features. *Bioorg Med Chem*. 14(24):8295-8306.
- Colunga Biancatelli, R. M. L., Berrill, M., Catravas, J. D., and Marik, P. E. 2020. Quercetin and Vitamin C: An Experimental, Synergistic Therapy for the Prevention and Treatment of SARS-CoV-2 Related Disease (COVID-19). *Front Immunol*. 11:1451
- Diantini, A., Febriyanti, R. M., and Levita, J. 2023. Efficacy and Safety of Add-On Plant-Based Drugs for COVID-19 Patients: A Review of the Randomized Control Trials. *Infect Drug Resist*. 16:3879-3891
- Donma, M. M., and Donma, O. 2020. The effects of allium sativum on immunity within the scope of COVID-19 infection. *Med Hypotheses*. 144:109934.
- El-Saber Batiha, G., Magdy Beshbishy, A., G Wasef, L., Elewa, Y. H. A., A Al-Sagan, A., Abd El-Hack, M. E., Taha, A. E., M Abd-Elhakim, Y., and Prasad Devkota, H. 2020. Chemical Constituents and Pharmacological Activities of Garlic (*Allium sativum* L.): A Review. *Nutrients*. 12(3):872.
- Fauquet, C. M., and Fargette, D. 2005. International Committee on Taxonomy of Viruses and the 3,142 unassigned species. *Virology*. 2:64
- Giang, T. V., Hoa, L. N. M., Hien, T. T., Cuong, Q. D., Cap, N. T., Lam Vuong, N., and Thach, P. N. 2023. Traditional Vietnamese Medicine Containing Garlic Extract for Patients With Non-severe COVID-19: A Phase-II, Double-Blind, Randomized Controlled Trial. *Cureus*. 15(7):e42484

- He, Z., Yuan, J., Zhang, Y., Li, R., Mo, M., Wang, Y., and Ti, H. 2023. Recent advances towards natural plants as potential inhibitors of SARS-Cov-2 targets. *Pharm Biol.* 61(1):1186-1210.
- Kaye, A. D., De Witt, B. J., Anwar, M., Smith, D. E., Feng, C. J., Kadowitz, P. J., and Nossaman, B. D. 2000. Analysis of responses of garlic derivatives in the pulmonary vascular bed of the rat. *J Appl Physiol* 89(1):353-358.
- Khubber, S., Hashemifesharaki, R., Mohammadi, M., and Gharibzahedi, S. M. T. 2020. Garlic (*Allium sativum* L.): a potential unique therapeutic food rich in organosulfur and flavonoid compounds to fight with COVID-19. *Nutr J.* 19(1):124.
- Liu, X., and Wang, X. J. 2020. Potential inhibitors against 2019-nCoV coronavirus M protease from clinically approved medicines. *J Genet Genomics.* 47(2):119-121
- Mikaili, P., Maadirad, S., Moloudizargari, M., Aghajanshakeri, S., and Sarahroodi, S. 2013. Therapeutic uses and pharmacological properties of garlic, shallot, and their biologically active compounds. *Iran J Basic Med Sci.* 16(10):1031-1048.
- Paudel, K. R., Patel, V., Vishwas, S., Gupta, S., Sharma, S., Chan, Y., Jha, N. K., Shrestha, J., Imran, M., Panth, N., Shukla, S. D., Jha, S. K., Devkota, H. P., Warkiani, M. E., Singh, S. K., Ali, M. K., Gupta, G., Chellappan, D. K., Hansbro, P. M., and Dua, K. 2022. Nutraceuticals and COVID-19: A mechanistic approach toward attenuating the disease complications. *J Food Biochem.* 46(12):e14445.
- Qin, C., Zhou, L., Hu, Z., Zhang, S., Yang, S., Tao, Y., Xie, C., Ma, K., Shang, K., Wang, W., and Tian, D. S. 2020. Dysregulation of Immune Response in Patients With Coronavirus 2019 (COVID-19) in Wuhan, China. *Clin Infect Dis.* 71(15):762-768.
- Rahman, K., and Lowe, G. M. 2006. Garlic and cardiovascular disease: a critical review. *J Nutr.* 136(3 Suppl):736S-740S.
- Rahman K. 2001. Historical perspective on garlic and cardiovascular disease. *J Nutr.* 131(3s):977S-9S.
- Rahman, M. S. 2007. Allicin and Other Functional Active Components in Garlic: Health Benefits and Bioavailability. *International J. Food Properties* 10 (2): 245–68.
- Ried, K., and Fakler, P. 2014. Potential of garlic (*Allium sativum*) in lowering high blood pressure: mechanisms of action and clinical relevance. *Integr Blood Press Control.* 7:71-82.
- Ryu, J. H., and Kang, D. 2017. Physicochemical Properties, Biological Activity, Health Benefits, and General Limitations of Aged Black Garlic: A Review. *Molecules.* 22(6):919.
- Sozio, M. S., Lu, C., Zeng, Y., Liangpunsakul, S., and Crabb, D. W. 2011. Activated AMPK inhibits PPAR- α and PPAR- γ transcriptional activity in hepatoma cells. *Am J Physiol Gastrointest Liver Physiol.* 301(4):G739-G747.
- Tattelman E. 2005. Health effects of garlic. *Am Fam Physician.* 72(1):103-106.
- Ullrich, S., and Nitsche, C. 2020. The SARS-CoV-2 main protease as drug target. *Bioorg Med Chem Lett.* 30(17):127377
- Wang, Y., Wang, Y., Chen, Y., and Qin, Q. 2020. Unique epidemiological and clinical features of the emerging 2019 novel coronavirus pneumonia (COVID-19) implicate special control measures. *J Med Virol.* 92(6):568-576.
- Wang, F., Nie, J., Wang, H., Zhao, Q., Xiong, Y., Deng, L., Song, S., Ma, Z., Mo, P., and Zhang, Y. 2020. Characteristics of Peripheral Lymphocyte Subset Alteration in COVID-19 Pneumonia. *J Infect Dis.* 221(11):1762-1769.
- Wu, W., Li, R., Li, X., He, J., Jiang, S., Liu, S., and Yang, J. 2015. Quercetin as an Antiviral Agent Inhibits Influenza A Virus (IAV) Entry. *Viruses.* 8(1):6.
- Zeng, Y., Li, Y., Yang, J., Pu, X., Du, J., Yang, X., Yang, T., and Yang, S. 2017. Therapeutic Role of Functional Components in Alliums for Preventive

Chronic Disease in Human Being. Evid Based Complement Alternat Med. 2017:9402849.

Zhang, L., Lin, D., Sun, X., Curth, U., Drosten, C., Sauerhering, L., Becker, S., Rox, K., and Hilgenfeld, R. 2020. Crystal structure of SARS-CoV-2 main protease provides a basis for design of improved -ketoamide inhibitors. Science. 368(6489):409-412

Access this Article in Online	
	Website: www.ijcrims.com
	Subject: Herbal Medicine
Quick Response Code	
DOI: 10.22192/ijcrms.2024.10.06.002	

[How to cite this article:](#)

Ankita Pal, Fatema Calcuttawala. (2024). Garlic: a potential traditional herbal medicine to combat COVID-19. Int. J. Curr. Res. Med. Sci. 10(6): 5-17.

DOI: <http://dx.doi.org/10.22192/ijcrms.2024.10.06.002>