

Plant-Based Approaches for Enhancing Immunity Against SARS-CoV-2 (COVID-19): A Review

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Abstract—When the new coronavirus spread worldwide, it triggered a massive health crisis unlike any before. Because no targeted medicines existed at first, scientists looked elsewhere for help. Plant remedies caught attention thanks to long-standing use in healing traditions across cultures. Systems like Ayurveda, Siddha, Unani, and Chinese herbal practice have relied on nature's chemistry for ages. These natural compounds often fight viruses, calm inflammation, protect cells, and balance immune responses. Attention turned sharply toward how such substances might block the virus responsible for the illness. The way it invades human cells involves spike proteins latching onto ACE2 receptors. Once inside, the pathogen copies itself using the host's machinery. Examining these steps reveals possible weak spots where plant molecules could interfere. This look explores those connections through the lens of botanical defenses and their active ingredients. It jumps right into how certain natural plants and their active parts - like flavonoids, alkaloids, terpenoids, glycosides, and polyphenols - can block viruses from entering cells, copying themselves, or sparking inflammation. Because these substances come from widely spread plant species, the document takes a close look at where they grow, what effects they have on the body, how they're used in real medical cases, and whether they're safe. Even though lab tests, animal experiments, and computer models show strong signs of fighting viruses, proof from big human trials is still thin. For that reason, deeper investigation, consistent methods, and proper testing in people are needed before we can fully trust treatments based on plants. When old healing traditions meet today's science, new paths could open up for finding virus-fighting drugs and getting ready for worldwide outbreaks.

Index Terms—Antiviral activity, COVID-19, Medicinal plants, Phytochemicals, SARS-CoV-2

I. INTRODUCTION

Background of COVID-19:

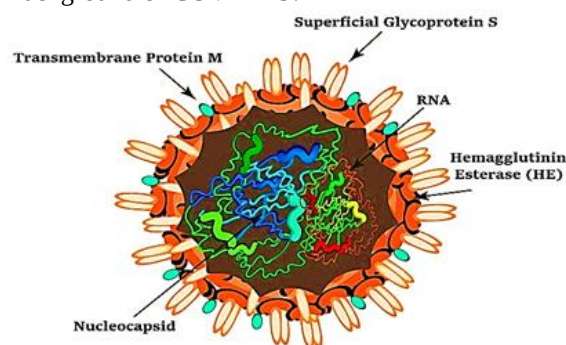


Fig.1 Structure of SARS- CoV- 2 Virus

Late in 2019, a new virus named SARS-CoV-2 appeared - soon circling the globe without pause. Health organizations quickly labeled it a pandemic due to how fast people began catching it. This germ is part of the Coronaviridae group, carrying its genetic code in a single strand of RNA. Wrapped around that core are key proteins: spike (S), membrane (M), envelope (E), plus nucleocapsid (N). Instead of just floating freely, these structures help shield and deliver the virus effectively. Notably, the spike protein acts like a key - it latches onto ACE2 receptors found on human cells. Because of this lock-and-key fit, infection begins once attachment occurs. Spreading easily from person to person, the pathogen overwhelmed systems before treatments existed. With no proven antivirals available at first, researchers turned elsewhere for answers. Finding different ways to respond became urgent when standard options fell short. For emphasis; do not underline.

Plant-Based Therapeutics Demand:

Back then, people turned to healing herbs because they offered strong natural benefits without harsh reactions. When the coronavirus spread worldwide, attention shifted again toward botanical remedies - not as replacements, but alongside usual care - to help bodies resist illness and lessen its impact. Ancient methods like Ayurveda, Siddha, and Unani pointed to specific plants - Tulsi, turmeric, ginger among them - for strengthening defenses and easing breathing troubles. With newer studies backing these uses, plant-derived substances began standing out as realistic options during the health crisis.

II. MECHANISM OF SARS COV 2 INFECTION AND PLANT BASED IMMUNE RESPONSE

Viral Entry and Replication:

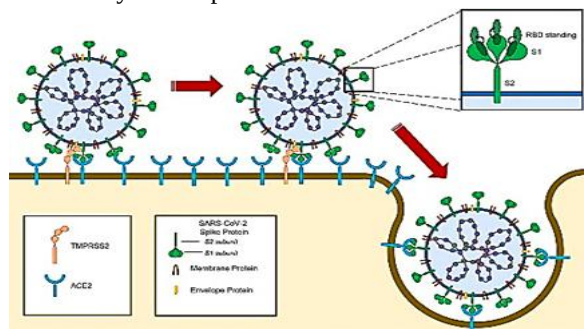


Fig.2 Mechanism of Viral Entry via ACE2 Receptor

The moment the virus enters, its spike protein grabs hold of ACE2 receptors sitting on human cells. Following that, host tools such as TMPSR2 tweak the setup so the invader can blend into the membrane and slide inside. Once past the barrier, the viral RNA spills out, hijacking what the cell normally does. From there, the outsider rewires activity to make endless copies along with new pieces for future invaders. These assembled particles exit one by one, jumping to nearby areas fast, pushing damage deeper into lung tissue. Out of nowhere, when the body struggles, immunity falters - chemical messages such as interleukins spill nonstop. This sudden rush, harsh and unyielding, risks overwhelming breathing ability, pulling systems down step by step. Extreme moments bring an unchecked flare-up; some name it a cytokine storm. Blood pathways suffer, air reaches tissues less easily. Failure spreads across vital areas unless steadied in time.

How Plant Chemicals Affect the Body's Defense:

Found in healing plants, phytochemicals act on their own to fight viruses, calm swelling, block damage from free radicals, besides balancing immunity. Their presence boosts how well the body defends itself, especially when facing threats like SARS-CoV-2. From roots and leaves come substances capable of disrupting key moments in a virus's timeline - opening doors for new ways to handle COVID-19. Quercetin stands out, just like curcumin, glycyrrhizin, kaempferol, along with catechins, each stepping in to slow down how viruses latch on, get inside, multiply, or build proteins. Some grab holds of parts of the virus - such as its outer spike tool, core enzyme 3CLpro, plus machinery for copying RNA - and halt spread within human cells.

Besides fighting viruses, plant chemicals play a key role in managing how the body's defense system behaves. When COVID-19 turns severe, it can trigger runaway inflammation - called cytokine storms - that may lead to breathing failure and harm multiple organs. These natural substances keep check on molecules like interleukins and TNF, dialing down swelling and protecting tissues. Though many plants offer support, turmeric delivers curcumin, which stands out by calming irritation and neutralizing harmful particles in cells. From licorice comes glycyrrhizin, a compound with virus-blocking traits and the ability to shape immune responses. Oxidative damage from infections meets resistance through quercetin, another shield found widely in nature. Immune cells work better when plant-based compounds step in, helping balance what happens inside our body's building blocks. With their gentle impact on systems plus a background rooted in nature, these substances show promise alongside treatments aimed at viruses like SARS-CoV-2.4

III. PLANT FEATURES WHERE IT GROWS AND HOW IT AFFECTS THE BODY:

From rainforests to warm dry zones, healing plants have long played a role in treating illness, especially within ancient practices like Ayurveda, Unani, Siddha, and Chinese herbal traditions. Instead of lab-made chemicals, many rely on substances pulled straight from leaves, roots, and bark - filled with elements such as flavonoids, alkaloids, terpenes, glycosides, and polyphenol-rich extracts. Because they fight viruses,

calm swelling, shield cells from damage, and help balance immune responses, these natural materials became more than just folklore during global outbreaks. With interest rising when hospitals overflowed, people turned again to plant-based remedies - not as replacements, but as quiet allies in staying well. Their strength lies not in modern labs alone, yet in centuries-old knowledge now backed by slow science.



Fig.3 Ocimum sanctum (Tulsi)

From fields across India into parts of Southeast Asia, *Ocimum sanctum* - better known as Tulsi - grows widely. Valued deeply in Ayurvedic practice, it supports health through actions that adjust immunity, fight microbes, and reduce swelling. Inside the leaves hide natural compounds: eugenol stands out, alongside ursolic acid and rosmarinic acid, each playing a role in strengthening defenses and guarding lung pathways. Coughs quiet down, fevers ease, cold symptoms fade when people turn to drinks steeped from the herb, boiled extracts, or age-old healing mixtures rooted in tradition.



Fig.4 Zingiber officinale (Ginger)

From fields across India, China, and parts of Asia grows a well-known healing herb - ginger. Its power comes from substances like gingerols, shogaols, and zingerone. These bring antiviral strength, fight cell damage, calm swelling inside the body. When throats hurt or breathing feels tight, people often turn to this root. Nausea fades easier, movement of blood through vessels gets smoother too. Because it helps immunity work steadily, doctors sometimes include it during virus care, even with cases tied to COVID-19. Though small in appearance, its role in health remains deeply rooted.



Fig.5 Azadirachta indica (Neem)

From the Indian subcontinent comes a tree called *Azadirachta indica* - better known as neem - that's long been valued in traditional healing. Its strength lies in fighting microbes, viruses, fungi, yet calming inflammation too. Instead of just sitting idle, substances like nimbin, azadirachtin, and quercetin found in leaves, bark, and extracts actively slow down harmful organisms while supporting body defenses. While many plants offer remedies, this one stands apart through generations of use against rashes, high temperature, breathing trouble, and swelling-related illness. Though modern science examines it closely now, village healers relied on its reach long before labs existed.



Fig.6 Withania somnifera (Ashwagandha)

This plant called Withania somnifera, also known as Ashwagandha, plays a key role in traditional Indian healing. Found mostly across regions like India, the Middle East, and some areas of Africa, it grows wild in dry climates. Chemicals inside - such as

withanolides and alkaloids - support the body during tough physical or mental demands. Instead of just calming nerves, these compounds strengthen natural defenses and promote general well-being. Thanks to its ability to fight swelling and protect cells from damage, it helps people feeling constantly tired. Breathing problems sometimes ease when using this herb regularly over time. It may assist those dealing with weak responses from their immune system after catching viruses.

Among global hotspots for healing flora, India stands out - its ancient practices rooted deeply in nature's pharmacy. Thousands of plant types have long played roles in home remedies passed through generations. Scientific interest now grows, drawn by clues these plants may hold for tackling new viruses like SARS-CoV-2. Research findings, though quiet, point toward untapped possibilities hidden in leaf, root, and bark.

Table. Medicinal Plants and Their Pharmacological Activities Against SARS-CoV-2

Medicinal Plant	Major Phytochemical	Pharmacological Activity	Therapeutic Role Against SARS-CoV-2
Tulsi (<i>Ocimum sanctum</i>)	Eugenol	Immunomodulatory, Anti-inflammatory	Enhances immunity and respiratory protection
Ginger (<i>Zingiber officinale</i>)	Gingerol	Antiviral, Antioxidant	Reduces inflammation and viral activity
Neem (<i>Azadirachta indica</i>)	Nimbin	Antimicrobial, Antiviral	Inhibits microbial and viral growth
Ashwagandha (<i>Withania somnifera</i>)	Withanolides	Adaptogenic, Immunomodulatory	Strengthens immune response
Turmeric (<i>Curcuma longa</i>)	Curcumin	Anti-inflammatory, Antioxidant	Reduces cytokine storm and oxidative stress
Licorice (<i>Glycyrrhiza glabra</i>)	Glycyrrhizin	Antiviral, Immune-enhancing	Inhibits viral replication
Green Tea (<i>Camellia sinensis</i>)	Catechins	Antioxidant, Antiviral	Protects cells from oxidative damage

Pharmacological Activity:

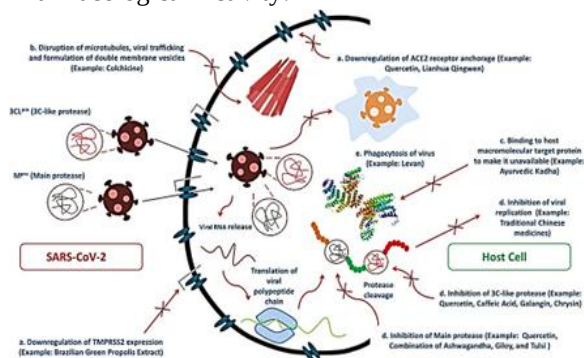


Fig.7 Interaction of Phytochemicals with Viral Targets

Some plant-based substances show wide-ranging effects that can help prevent or manage symptoms tied to COVID-19. Rather than acting on just one front, many herbal compounds engage multiple points in how viruses operate inside cells - while also supporting the body's own defenses. Through natural activity, they fight off viral spread, ease swelling, clear harmful molecules, block microbes, and fine-tune immunity - all useful traits when facing SARS-CoV-2. Because these agents work at several levels, their presence may slow down virus growth, lower excess inflammation, yet still shield organs from harm during serious illness.

Some plant chemicals - like quercetin, kaempferol, luteolin, and catechins - slow down coronaviruses by stopping them from sticking to cells, getting inside, or copying themselves. Because it messes with key virus tools needed to multiply, quercetin disrupts proteases and polymerases. Kaempferol, on the flip side, jams ion channels that help viruses escape infected cells. Alongside these actions, they calm inflammation and lower cell damage tied to serious cases of COVID-19.

From plants come compounds like berberine and glycyrrhizin, known to fight viruses while shaping how the body's defenses respond. Though different in origin, both influence inflammation - berberine quiets signals that drive swelling, helping immunity stay steady. Meanwhile, root extracts from licorice deliver glycyrrhizin, which blocks virus spread along with molecules tied to irritation. Turmeric holds terpenoids including curcumin, a substance able to neutralize harmful stress and calm excessive reactions within tissues. With its presence, surges of signaling proteins ease, lessening harm during infection; it also disrupts parts of viral machinery while supporting broader defense actions.

From root to remedy, ginger packs gingerols, shogaols, yet zingerone - each tackling viruses, bacteria, while calming oxidative stress and swelling. Because of these, breathing feels easier, redness fades, defenses grow sharper. On another note, Tulsi delivers eugenol alongside ursolic and rosmarinic acids, lifting the body's shield against lung-related bugs. Even so, Neem together with Ashwagandha steps in, bringing germ-fighting strength, balance under strain, plus immune fine-tuning when viruses strike.

Some plant chemicals latch onto virus parts like the spike protein or ACE2 receptor. Instead of ignoring them, they block key tools the virus needs - say, 3CLpro or its copying machine for RNA. Because of this interference, natural substances may stop viruses from getting into cells, multiplying, or building new proteins. Alongside calming inflammation, these compounds also assist body defenses. Together, that mix hints at how herbs might slow infections like SARS-CoV-2. Not every molecule works alone, yet their joint effect matters when facing new viral threats.

IV. TRADITIONAL MEDICINE USE IN THE COVID 19 PANDEMIC:

Old healing methods stepped into the spotlight when the virus spread, offering ways to support care through natural boosts to body defenses, easing breathing troubles, and maintaining wellness. Rather than modern drugs, traditions like Ayurveda, Siddha, Unani, and Chinese plant-based medicine leaned on long-used roots, blends, food habits, and daily routines to prevent or manage illness. With labs overwhelmed, public interest surged toward these age-old treatments due to signs they might fight viruses, calm swelling, reduce stress on cells, or balance immune response. Herbs like Tulsi, turmeric, and ginger have been part of Ayurvedic practice for supporting body defenses. With compounds found in these plants, reactions tied to swelling tend to ease up a bit. Black pepper joins them not just for flavor but for how it may assist absorption deep inside the system. Giloy sometimes shows up in simmered teas meant to steady vitality during stressful times. Even though some formulas gained attention only recently, roots of their use go way back. One such mix called Ayush Kwath moved into many homes when breathing felt tight for some people. Ashwagandha plays its role too - not loudly - but quietly helping balance stress signals across tissues.

During the pandemic, people in China turned to ancient healing practices just as much as hospital care. Fever, coughing, tiredness, yet trouble breathing - these symptoms saw some relief through plant-based remedies like Lianhua Qingwen and Qingfei Paidu soup. Mixing old ways with new science seemed to speed up healing while softening how hard the illness hit. Elsewhere, Unani healers along with Siddha experts leaned on leafy blends meant to fight germs and boost inner strength. Nature's pharmacy became a quiet partner in staying resilient when sickness spread. Now more than ever, people around the world have turned to age-old healing practices during the health crisis. Because of that shift, blending ancestral plant-based treatments with current lab-driven science has gained attention. Some herbs long trusted for lung-related conditions are under scrutiny using drug analysis methods, protein interaction models, and human testing - just to see how well they might fight the virus behind COVID-19. Even so, these natural options aren't meant to swap out today's antiviral

drugs. Instead, they could play a supportive role - perhaps boosting body defenses, calming swelling, or helping patients bounce back faster. For any of this to work safely within mainstream clinics, solid proof, uniform preparation standards, and real-world medical assessments must come first.

V. CLINICAL EVIDENCE AND THERAPEUTIC APPLICATIONS OF PHYTOCHEMICALS

Even if much of the work on plant substances fighting SARS-CoV-2 happens in labs or computer models, a few have moved into human trials. Because they show promise, things like quercetin, black seed, and green bee glue are being watched closely. Since early results point to shorter illness and milder signs, scientists keep tracking how these affect people with COVID-19. Their power likely comes from stopping viruses, calming damage from oxidation, and tuning immune responses just right. One plant compound getting attention is quercetin - it can block viruses from entering cells, slow their spread, plus calm swelling in the body.

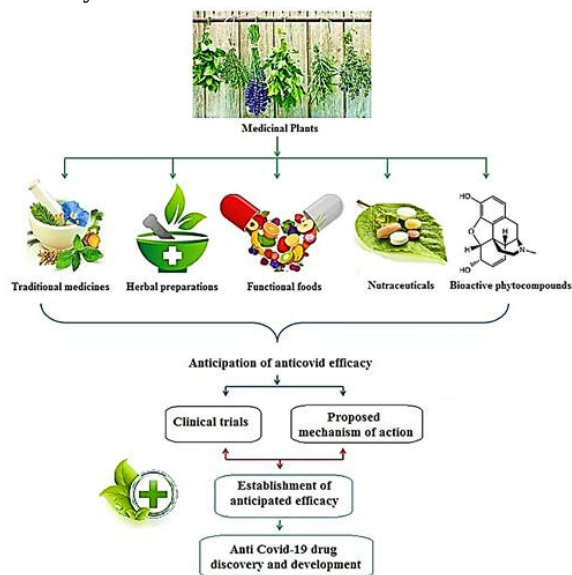


Fig.8 Plant-Based Drug Development Pathway Against COVID-19

Not far behind comes *Nigella sativa*, long used for lung-related illnesses, known to strengthen how the body fights off invaders. From tree sap collected by bees emerges propolis, a sticky substance that helps immunity and shows signs of stopping the virus linked to COVID-19.

Most people turned to plant blends passed down through old healing practices when the outbreak hit. Blends like tulsi mixed with ginger, turmeric tied in, along with cinnamon, became common choices. The idea behind them? Strengthening the body's defenses while possibly lowering how bad symptoms get. Instead of one single active part driving results, it is many elements teaming up inside these mixtures. Their combined force creates stronger impacts than any alone could manage.

Even though results look promising, big randomized studies are still few. Doses differ, formulas change, people respond in their own way - making consistent treatments hard to set. Because of that, more work must happen before plant-based medicines fit reliably into regular care.

VI. TOXICOLOGY AND SAFETY CONSIDERATIONS

Plants used in medicine carry a reputation for being gentle, mostly due to where they come from and how long people have relied on them across healing traditions like Ayurveda, Unani, Siddha, and Chinese practices. Centuries of human experience show many herbs were taken regularly when lungs struggled, swelling appeared, or immunity acted up. Still, whether these botanicals help - without harm - rests heavily on how much is used, how they're made ready, how clean they are, and how well they're checked for consistency. Even though substances from nature tend to upset the body less than lab-made pills, too much or careless usage can bring trouble: poison-like effects, rashes, stomach pain, hurt livers, or clashes with standard medicines.

Some plant chemicals might slow down how medicines are processed in the body, changing how they work or making side effects more likely. When certain herb supplements are taken over time, they can change how liver enzymes break down medications - sometimes causing dangerous mix-ups. Instead of helping, tainted herbs carrying pollutants like pesticides or heavy metals could do harm due to poor quality control. Where a plant grows - its soil type, weather patterns, region - affects how strong its natural compounds become. Even when harvested and how long it's stored plays a role in how potent those ingredients remain. One wrong shift in these elements can tilt how well herbal treatments work. That change

might alter how the body responds to plant medicine. So, checks must happen - consistency matters, safety counts, testing proves necessary. Without clear standards, using herbs against SARS-CoV-2 stays risky. Every batch needs verification before reaching patients.

Limits and Medical Testing:

Even so, lab tests and computer models show some promise for plant compounds fighting viruses, reducing inflammation, or boosting immunity related to SARS-CoV-2. Yet much of what we know comes from cells in dishes, animals, or simulations - not people. Because of that gap, drawing firm conclusions about real-world benefits stays out of reach. Without broad human trials run at scale, proof for using herbal remedies in treating COVID-19 keeps falling short.

How a substance is removed from a plant, where the plant comes from, how it's mixed into medicine, how much people take, and who takes it - these factors shift how treatments work. Yet another thing: research often looks at single chemicals instead of whole herb blends, so matching findings between trials gets tricky. Approvals for natural remedies demand proof on whether they help, if they harm, how body processes them, and what happens over time - all details still missing for plenty of botanicals.

For these reasons, large-scale medical testing using carefully planned studies must confirm how safe certain plant compounds are when fighting SARS-CoV-2 - alongside their best dose levels, absorption rates, and healing potential. Just as vital? Making sure every method used to extract and prepare them stays uniform so results stay dependable across different tests. When old remedies meet today's science - not just theory but real lab work - it could build a stronger path toward trustworthy treatments rooted in nature for viruses now and later.

VII. PLANT-BASED COVID-19 TREATMENTS WHAT LIES AHEAD:

Looking into plant-made substances offers fresh paths in finding drugs that fight SARS-CoV-2. Because their chemicals differ so much in shape, herbs bring wide-ranging actions in living systems. Though lab work took many directions, blocking how the virus gets in, spreads, or triggers swelling became key goals. Since old healing practices hold hidden clues, teaming them

up with today's methods makes sense. Instead of ignoring nature's pharmacy, science now digs deeper into what plants can truly do.

Lately, computers have helped scientists look faster at how natural plant substances might fight the coronavirus. Instead of only testing in labs, researchers now simulate how these chemicals behave using tools like AI and digital models. One method slides molecules into virus structures on screen - a bit like solving puzzles blindfolded. Thanks to this, spotting which ones stick well to key parts of the virus takes far less time than before. Think spike protein, 3CLpro, enzymes that act like scissors for viral replication. Tools such as virtual screening dig through thousands without touching a test tube. Quercetin, found in apples and onions, shows it holds tight in simulations. Curcumin, from turmeric, behaves similarly, even if real-world results lag behind. Glycyrrhizin, from licorice root, slips neatly into certain pockets of the virus machinery. So do catechins - yes, those green tea antioxidants. Even with anolides, lesser-known players from ashwagandha, appear to bind strongly. All of this points not to cures but clues - quiet signals worth checking further.

Beside number crunching, lab tests now back many herbal remedies from ancient Indian and Chinese healing systems. Tulsi, ginger, turmeric, Ashwagandha, neem, or black cumin - mixes with these often-slow viruses, calm swelling, balance immunity. Old wisdom paired with new science could mean cheaper care, especially where hospitals lack funds, medicine hard to reach. Plants might handle several problems at once: virus spread, body heat, cell damage, uneven defenses - not just one piece.

Even though plants show real promise as medicine, big hurdles stand in the way of doctors using them regularly. Different ways of growing, picking, and processing herbs lead to uneven results - this messes with how well they work and whether they're safe. Extraction methods aren't uniform across labs, formulas shift between batches, doses often guess rather than measure. Much of what we know comes from petri dishes, mice, or computer simulations - not people walking into clinics. Real proof on absorption, movement through the body, effectiveness, and effects over time still hides behind missing human trials. Until solid data fills those gaps, trust stays shaky at best.

Getting official permission for herbal treatments still means showing lots of proof - on safety, consistent

production methods, purity checks, and whether they actually work. One stumbling block? Some natural compounds like curcumin do not get absorbed well by the body, making them less useful in real medical settings. Yet new progress in biological engineering, tiny-scale tech, and smarter ways to deliver medicine is slowly solving issues around how long these substances last inside us, how much enters the bloodstream, and how strong their effects can be. Tiny carrier structures, protective shells around active ingredients, or mixing different remedies together might just push plant-based healing agents into stronger performance territory.

VIII. CONCLUSION

From nature's pharmacy comes a quiet strength against viruses like SARS-CoV-2 - plants offer real tools, not magic fixes. Their active compounds work in many ways, sometimes easing harm caused by infections. Instead of one single effect, they bring layers of support through how they interact with cells. Because of this, certain herbs show potential in lowering serious outcomes tied to respiratory illness. Though science moves slowly here, early signs point toward meaningful roles in health defense. Each plant holds unique chemistry, shaped by environment and genetics. While lab-made drugs dominate headlines, roots, leaves, and bark quietly contribute valuable molecules

- Antiviral activity
- Anti-inflammatory effects
- Antioxidant properties
- Immunomodulatory functions
- Antimicrobial potential

Some plant-based substances can interfere at several points in how a virus spreads - blocking it from sticking to cells, getting inside, copying itself, or triggering harmful inflammation - which helps explain their role in backing up the body's defenses during COVID-19. Compounds like flavonoids, alkaloids, terpenoids, polyphenols, and glycosides show clear signs of balancing immunity while reducing harm from too much internal stress and swelling. Back then, when the world was dealing with lockdowns, old healing ways stepped up. Not just background noise - Ayurveda, Siddha, Unani, and Chinese traditional medicine offered plant-based options. Instead of

waiting, people turned to herbs said to support breathing and boost resistance. Among the most reached-for plants were:

- Tulsi (*Ocimum sanctum*)
- Ginger (*Zingiber officinale*)
- Ashwagandha (*Withania somnifera*)
- Neem (*Azadirachta indica*)

Now more than ever, labs are turning to ancient remedies for clues. Because science can now test old claims with new tools. When molecules fit together like puzzle pieces, researchers notice which ones come from plants. These fits sometimes block viruses from spreading inside cells. Even tiny carriers made in factories work better when they mimic natural structures. Some of those structures arrive exactly where needed in the body. What once grew in remote regions is now studied under microscopes. Each discovery links forest wisdom with lab precision. Not every herb works, yet a few shows real promise. Where tradition led, technology now follows.

Even so, good results from lab tests, animal research, and computer models still face hurdles - like these ones

- Lack of standardized formulations
- Limited large-scale clinical trials
- Variability in dosage and extraction methods
- Insufficient long-term safety data
- Complex regulatory approval processes

Only after strict clinical testing, safety checks, and consistent quality control can herbal medicines become common in real-world treatment. Still, plants and their natural compounds hold strong promise for creating treatments that are effective, low-cost, and available to many. Because ancient healing wisdom joined with today's science could play a key role in finding new drugs, strengthening health systems worldwide, and standing ready when unknown viruses appear.

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