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Review

Antibacterial and Antiviral Properties of *Coriandrum Sativum* and *Zingiber Officinale* against Human Respiratory Tract Related Bacterial and Viral Infections: A Review with a Focus on the Case of SARS-CoV

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Abstract

Phytochemical constituents in extracts from medicinal plants have been widely used since ancient times to treat microbial infections. *Coriandrum sativum* and *Zingiber officinale* are two of the main popular ingredients in traditional medicine recipes. Currently, these extracts are used to prevent Covid-19 infections. Therefore, this review describes the antimicrobial properties of coriander and ginger and how far it is suitable to use against bacterial and viral infections occurring in the human respiratory tract. For instance, the main phytochemical available in *C. sativum* is linalool, followed by terpinene, pinene, cymene, decenal, and camphor. Gingerol is the main constituent in *Z. officinale* followed by shogaols and paradols. Moreover, many research findings revealed that the extract from coriander and ginger can be used to control respiratory tract infected pathogens due to the antiviral and antibacterial properties of available phytochemicals. Therefore, it is very effective to use coriander and ginger to boost the immune system. Furthermore, scientific evidence has proved the effective antiviral properties of compounds present in coriander and ginger that have binding affinity to the proteins in the virus, blocking the virus's receptors and boosting the immunity to face the COVID-19 situation. In fact, the effectiveness of the antimicrobial activity of mixed extract of medicinal plant parts is better than that of individuals. Therefore, this will review the therapeutic characteristics of coriander and ginger extracts due to their various phytochemical activities.

Keywords: Respiratory tract infections, antibacterial properties, phytochemicals, COVID-19

Introduction

Since many decades ago, medicinal plants and their constituents have been utilized for disease control due to the properties of being anti-microbial, anti-diabetic, anti-inflammatory, antioxidant, and anti-tumor.[1] [2] Natural plants are suitable for traditional medicine since they have practical solutions to health problems, safety, and a lack of adverse reactions.[3] The World Health Organization (WHO) data revealed that 80% of the global population still consumes plant-based traditional medicinal treatments for the diseases they have in their daily lives.[4] [5] [6] Furthermore, the finding of research has revealed that 25% to 50% of existing pharmaceuticals are obtained from plants that have antimicrobial activities.[7] Moreover, most of them are secondary metabolites generated in plants, and they are accountable for the therapeutic activity of plants.[8] [9] The disease curing ability of these medicinal plants is principally due to the

existence of several phytochemical constituents such as essential oils, alkaloids, hydrocarbon, glycosides, nitrogen, fatty acids, gums, steroids, terpenoids, phenols, anthocyanins, tannins, resins, lignins, anthraquinone, coumarins, leucoanthocyanins, emodins, and saponins.[8] [10] [11] [12] Some of these secondary metabolites, such as alkaloids, terpenoids, flavonoids, and tannins have unique antimicrobial properties, and the secondary metabolites with these antimicrobial properties are generally categorized into three large molecular families: phenolic, terpenes, and alkaloids.[13] However, plants produce these secondary metabolites to obtain their safety through the defense mechanism, and they have been categorized as phytoanticipins, which activate as inhibitory compounds, or phytoalexins, which are obtained from precursors as a response to microbial attack. Those phytomedicines can be obtained from any part of the plant, like seeds, leaves, bark, and flowers. [8] [14] [15]

Ayurvedic medicine has recently begun paying attention to the properties of medicinal plants because of concerns about the side effects of western medicine. [16] [17] In conventional medicine, plant extracts and other parts obtained from plants have been used to treat microbial infections in the human respiratory tract. It has been reported that several plant-effective extracts have antibacterial and antiviral activity against various respiratory infections, inclusive of drug multi-resistance strains.[18] [19] *C. sativum, Z. officinale, Glycyrrhiza glabra, Cassia angustifolia, Valeriana wallichi, Asparagus racemosus, Boswellia serrata, Crocus sativus, Cyperus rotundus, Solanum indicum*, and *Terminalia arjuna* have been recorded based on their therapeutic importance.[20] In Sri Lanka, Ayurvedic medicines are used by about 60-70% of the rural population to cure and prevent diseases. Most traditional medicinal recipes were either verbally passed from generation to generation or noted down in the native tongue as usual in Sri Lanka. [21] Out of many traditional herbs, coriander and ginger take a special place in curing respiratory tract-based infections. For Sri Lankans, a drink made from coriander seeds is essential to treat flu and cold. Further, fresh ginger was also added to those drinks due to the property of relieving colds, coughs, and breathing difficulties. [22] Therefore, for these purposes, coriander and ginger are a must in Sri Lankan homes; the slightest throat irritation and a few sneezes are enough for a cup of the medicinal drink to be thrust into one's hand. Furthermore, coriander and ginger are the main ingredients in many Sri Lankan remedies used for respiratory tract infections, including 'Paspanguwa', an Ayurvedic medicine. [21] [22] Due to the Coronavirus disease 2019 (COVID-19), the consumption of coriander and ginger has been raised in many Asian countries, including Sri Lanka. Although those medicinal plants could not be a complementary preventive therapy for this pandemic, these treatments could be effective in enhancing the immunity of humans due to their therapeutic properties. [23]

Although the flowers, fruits, seeds, leave, and stems of coriander are commonly used as medicines, extraction of coriander seeds exists at the top level in healing herbs.[16] The coriander seed oil consists of 20 essential oils with highly effective antibacterial and antiviral activity.[15] Out of them, the most prevalent essential oil in coriander seed oil is linalool followed by geranyl acetate, ɣ - terpinene, α-pinene, anethol, and p-cymene.[24] [25] However, the antimicrobial action of coriander is still unclear.[26] Although the stem, rhizome, and leaves of ginger are used to treat flu, common cold, and headache-like respiratory tract infection-related disease symptoms,[27] [28] the most effective part of ginger is its rhizome. The major phytochemicals in the ginger rhizome are gingerols as the primary bioactive constituent with high flavonoid composition. [29] From ancient times, people used to drink coriander and ginger as traditional remedies to treat respiratory infections like cough, sore throat, fever, headache, nasal discharge, nasal

congestion, sneezing, runny nose, and nasal breathing. [30] Those typical symptoms are shown in COVID-19 patients also. There is no specific antiviral medication is still recommended for COVID-19 patients and much research is being carried out to develop a suitable vaccine. [31] Coriander and ginger could be used as dietary or supplementary therapy in the COVID-19 pandemic to prevent infection or strengthen immunity due to their antiviral properties. [32] Out of Ayurvedic medicinal plants, coriander and ginger play a significant role in Sri Lankans' day-to-day life. [21]

Studies have shown that the antimicrobial activity of mixed herbs is better than that of individuals. [33] [34] So the combined effect of coriander and ginger extract has better antibacterial and antiviral activity. The focus of this review is to illustrate the latest knowledge on the antibacterial and antiviral properties of coriander and ginger against microbial infections caused in the human respiratory tract. This will review the adequate consumption of coriander and ginger in this COVID-19 pandemic situation with laboratory evidence currently available. Furthermore, this will clearly explain the chemical constituents present in *C. sativum* and *Z. officinale* and the effectiveness of those traditional medicinal plants which people commonly use in day-to-day life to treat bacterial and viral infections related to the respiratory tract.

Bacterial and Viral Infections in the Human Respiratory Tract

The respiratory tract is a central entrance to the human body for microbial pathogens. Since, humans take about 20,000 breaths per day on average that approximately corresponds to 10,000 liters or ten cubic meters of air consisting of different microorganisms that can cause respiratory tract-based infections.[35] Microorganisms enter the upper respiratory tract by inhaling droplets and invading the mucosa.[36] Furthermore, microorganisms enter the lower respiratory tract by inhalation, aspiration, or hematogenous.[37] These entered bacteria initially colonize in the nasopharyngeal niche to cause respiratory disease,[38] and viruses fuse at the plasma membrane to enter the living organisms in the first phase and then, in the second phase, infect the other cells via cell-to-cell syncytia or fusion.[31] It has been reported that the human upper respiratory tract is a niche to the various communities of commensals and potentially pathogenic bacteria like *Streptococcus pneumoniae, Moraxella catarrhalis,* and *Staphylococcus aureus.* Also, pathogenic viruses like influenza viruses, adenoviruses, enteroviruses, respiratory syncytial viruses, parainfluenza viruses, and human coronaviruses commonly turn into pathogens in the human respiratory tract. [39] [38] When bacteria or virus infects the respiratory tract, sore throat, fever, neck swelling, coughing, sneezing, runny nose, and headaches like symptoms appear.

Bacteria and viruses cause various respiratory diseases. Among them, diphtheria is caused by *Corynebacterium diphtheriae* while showing sore throat, neck swelling, blockage of the respiratory passageway with membrane-like accumulations, and swollen glands in the neck. Otitis media is caused by *Streptococcus pneumoniae, Staphylococcus aureus*, and *Haemophilus influenza,* which cause symptoms of earache, fever, loss of balance, and fluid draining from the ear. [40] [109] Whooping cough (Pertussis) is also a common bacterial infection in the human respiratory tract caused by *Bordetella pertussis.* Tuberculosis is caused by *Mycobacterium tuberculosis* bacteria while showing symptoms of loss of appetite and loss of body weight, chills, night sweats, fever, and cough that lasts more than three weeks.[41] *Legionella pneumophila* bacteria cause Legionnaires disease (legionellosis), and high fever, lung consolidation, shortness of breath, muscle aches, headaches, and cough have been mentioned as the symptoms of Legionnaires disease.[42] Sore throat is another common bacterial infection in the respiratory tract caused by *Streptococcus pyogenes* while showing symptoms of pain in swallowing, fever, cough, runny nose,

sneezing, and headache.[43] Scarlet fever is caused by *Streptococcus pyogenes* and shows symptoms of fever (101 0F or higher), very red sore throat, whitish coating, swollen glands in the neck, 'Strawberry' tongue, a red skin rash, bright red skin in the crease of the underarm, elbow, and groin. Pneumonia shows symptoms like fever, shaking, chills, shortness of breath, consolidation of the lung, severe chest pain, and blood in the sputum. Bacterial pneumonia is caused by *Streptococcus pneumoniae,* and *Staphylococcus aureus*, and viral pneumonia are caused by influenza A, B viruses, human parainfluenza viruses (HPIV), and ratory syncytial viruses (RSV). Psittacosis disease is caused by *Chlamydia psittaci* while showing fever, dry cough, chest pain, headache, lung consolidation, and muscle aches. Q fever is caused by *Coxiella burnetii* while showing symptoms like fever and chills, headaches often behind the eyes, muscle pain, joint pain, and extreme fatigue. [44] Bronchitis is a common respiratory tract disease caused by the influenza virus, adenovirus, rhinovirus, respiratory syncytial virus, and coronavirus. Cough, fever, sputum production, dyspnea, hoarseness, wheezing, and chest pain have been reported as common symptoms of Bronchitis.[31] [32] [45] [46] Asthma is caused by Rhinovirus and the common cold virus while showing typical symptoms of difficulty breathing, wheezing, coughing, and chest tightness.[47] Common cold or nasopharyngitis is mainly caused by rhinovirus, a kind of picornavirus, and some other viruses including coronavirus, human parainfluenza viruses metapneumovirus, adenovirus, human respiratory syncytial virus, and enteroviruses caused same symptoms. Coughing, fevers, runny nose, and sore throat, like typical symptoms, appear in common cold or nasopharyngitis. [48] RNA viruses of the family Orthomyxoviridae cause Influenza, which shows common symptoms like fever, severe headache, chills, sore throat, coughing, muscle pains, and fatigue.

The Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) was found in Wuhan, Hubei province, China, during the recent outbreak of pneumonia in January 2020. [49] Middle-aged and older adults are mainly affected by SARS-CoV. As well as people with underlying diseases like diabetes, heart problems, hypertension, kidney problems, and obesity are also mainly affected by SARS-CoV. [50] COVID-19 has grown into a global pandemic respiratory illness. Fever, cough, general malaise, and muscle pain are the typical symptoms of COVID-19, as usual in other respiratory infections. This severe outbreak is spreading rapidly all over the world. Current studies have investigated those clinical conditions varied widely from asymptomatic to severe pneumonia. [51] These different types of respiratory tract-based bacterial and viral infections can be cured using medicinal plant treatments.

Medicinal Plant Treatments for Respiratory Tract-Based Diseases

The extracts from herbal plants are effective in treating respiratory disorders caused by microbes. Plant essential oils and their phytochemicals have the potential to inhibit the growth of an extensive variety of pathogens due to the secondary metabolites produced in various plant parts. [52] [53] The chemical constituents of plant extracts vary according to the species, stage of maturity, geographical location, way of extraction, and environmental factors. Since ancient times, Ayurvedic doctors have been using medicinal plants for respiratory tract-based diseases. In fact, according to Chinese medicine, respiratory tract-based disease; diphtheria was treated with an anti-diphtheria mixture processed based on old traditional prescriptions consisting of *Radix scrophulariae,* and *Fructus forsythiae*.[54] Oral administration of herbal medicines has investigated *Tongqiao huoxue* and *Tsumura saireito* decoctions, Erzhang decoctions, *Huanglong tonger* pills, and *Shenling baizhu* powder as medicinal plant treatments for Otitis media respiratory

disease.[55] The findings of Anupama, 2016 revealed that in Indian Ayurvedic medicine, medicinal plants like Tulsi leaves, Vasaka (Adulsa or Malabar nut), Brahmi (Bacopa), Talisadi churna, and Vasakasava had been used to treat whooping cough.[56] *Haemanthus albiflos, Clausena anisata*, and *Artemisia afra* like plants were used as medicine to treat Tuberculosis disease.[57] Marshmallow root, sage (*Salvia officinalis*), Echinacea, Licorice (*Glycyrrhiza glabra*) root, ginger root tea, cinnamon, lemon water, peppermint, and coconut oil like medicinal plant treatments were used to treat sore throat.[43] The results of the research have revealed that *Boesenbergia pandurata*, *Rhodomyrtus tomentosa*, and *Eleutherine Americana* had significant antibacterial effects against *Streptococcus pyogenes*.[58] Furthermore, *Erythrina senegalensis, Waltheria indica, Keetia hispida, Andira inermis, Combretum molle, Piliostigma thonningii,* and *Uapaca togoensis* like medicinal plants were used to treat Pneumococcal pneumonia respiratory disease.[59] [110] As mentioned in the current studies, *Hyoscyamus niger, Nigella sativa L., Verbascum thapsus, Citrus limon L., Justicia adhatoda, Allium sativum*, and *Althaea officinalis L.* like herbal plants could be used to treat Bronchitis viral disease.[23] [31] [45] [46] *Tylophora indica, Picrorrhiza kurroa,* and *Solanun xanthocarpum* like medicinal plants, were used to treat Asthma respiratory disorder.[47] The common cold is treated with *Allium sativum, Zingiber officinale, Allium cepa, Chamomilla recutita, Citrus limon, Tilia cordata, Echinacea purpurea,* and *Rubus idaeus* like medicinal plants.[48] [108] [111] *Andrographis paniculata, Eleutherococcus senticosus, Echinacea purpurea, Allium sativum, Sambucus nigra, Eucalyptus globulus, Hydrastis canadensis, Glycyrrhiza glabra, Althaea officinalis, Mentha piperita,* and *Ulmus fulva* like herbal plants are used to avoid viral infection of Influenza due to antiviral properties presence in those herbal plant parts (Table.1).

With the COVID-19 global pandemic situation, several studies have been conducted worldwide on medicinal plant treatment against SARS-CoV infection disease. As mentioned in many recent studies, various effective medicinal plant treatments are available worldwide to prevent SARS-CoV infection or strengthen immunity due to their antiviral properties. *Artemisia annua, Nyctanthes arbortristis, Andrographis paniculata, Withania somnifera, Aloe vera, Nigella sativa, Eckolina cava, Tinospora cordifolia, Isatis indigotica, Curcuma longa, Azadirachta indica, Pipper nigrum, Allium cepa,* and *Cannabis sativa* like herbal medicinal plants showed effective antiviral properties against SARS-CoV virus.[31] The finding of research has been further revealed that *Allium cepa, Allium sativum, Althea officinalis, Artemisia annua, Artemesia herba-alba Asso, Citrus limon, Commiphora myrrha, Eucalyptus globules, Nigella sativa, Glycyrrhiza glabra, Ocimum gratissimum, Malva sylvestris, Pimpinella anisum, Zingiber officinalis, Sambucus nigra,* and *Thymus vulgaris* like herbal medicinal plants showed antiviral effect against COVID-19.[23] Moreover, a study has been revealed the effectiveness of wide variety of herbal medicinal plants, *Aesculus hippocastanum, Allium ampeloprasum, Allium cepa, Brassica oleoracea, Bupleurum* spp., *Cassia tora, Cinnamomum verum, Curcuma* spp., *Camellia sinensis, Echinacea purpurea, Ginkgo biloba, Glycyrrhiza glabra, Heteromorpha arborescens*, and some other species of plants, including *Z. officinale* which used in various countries worldwide to treat COVID-19 global pandemic situations.[50] [113] Therefore, these extracts or phytoconstituents obtained from medicinal plants can be used to prevent and cure several diseases and give therapeutic effects with extended antimicrobial activity against different bacteria and viruses. From ancient times, people in Sri Lanka, most commonly used a medicinal drink called 'Paspanguwa', which contains *C. sativum*, *Z. officinale*, *Hedyotis corymbosa* ('Pathpadagam'), *Solanum xanthocarpum* ('Katuwelbatu'), and *Coscinium fenestratum* (false calumba/ 'Veniwalgata') as main ingredients.[34] In some instances, decoction and extract of other herbs such as *Piper longum* (long pepper/'Thippili'), *Evolvulus alsinoides* (Vishnukranthi), *Solanum melongena* (Thai eggplant),

Justicia adhatoda (Pawatta), and *Piper nigrum* (black pepper) like plant parts were used as traditional remedies, to treat for the common symptoms of respiratory tract infections like cough, fever, sneezing, runny nose, nasal discharge, sore throat, nasal congestion, and nasal breathing.[60] In Sri Lanka, there has been increased consumption of coriander and ginger with the COVID-19 pandemic. It has been suggested that the coriander to Sri Lankans use as a highly effective immunity-boosting ingredient in the COVID-19 situation. The 'Ceylon Today' journal has informed the Sri Lankan people to use coriander as a beverage after boiling or add it to curries as curry powder ingredients to fight against corona viral infection. [61]

Table 1: Common bacterial and viral infections in the human respiratory tract and available medicinal plant treatments for them

Disease	**Bacterial or viral infection**	**Symptoms**	**Medicinal plant treatments**	**References**
Diphtheria	*Corynebacterium diphtheriae*	sore throat, neck swelling, blockage of the respiratory passageway with membrane-like accumulations, swollen glands in the neck	prescriptions consisting of *Radix scrophulariae*, *Fructus forsythia* according to the Chinese medicine	[54]
Otitis media	*Streptococcus pneumoniae, Haemophilus influenzae, Staphylococcus aureus*	earache, fever, loss of balance, fluid draining from the ear	*Tongqiao huoxue* and *Tsumura saireito* decoctions, Erzhang decoctions, *Huanglong tonger* pills, and *Shenling baizhu* powder	[55]
Whooping cough (Pertussis)	*Bordetella pertussis*	sneezing, mild coughing, runny nose, low fever, a rapid inrush of air following a paroxysm results in the high whooping cough	Tulsi leaves, Vasaka (Adulsa or Malabar nut), Brahmi (Bacopa), Talisadi churna, Vasakasava according to the Indian Ayurvedic medicine	[56] [62]
Tuberculosis	*Mycobacterium tuberculosis*	fever, loss of appetite and loss of weight, chills, night sweats, cough lasts more than three weeks.	*Clausena anisata*, *Haemanthus albiflos*, *Artemisia afra*	[34]
Legionnaires' disease (legionellosis)	*Legionella pneumophila*	high fever, lung consolidation, shortness of breath, muscle aches, headaches, cough	Cinnamon has been recorded to treat against *Legionella pneumophila*	[42]
Sore throat	*Streptococcus pyogenes*	pain and irritation in the throat when	Marshmallow root, peppermint, sage (*Salvia*	[43]

		swallowing, fever, cough, runny nose, sneezing, headache	*officinalis*) and Echinacea, Licorice (*Glycyrrhiza glabra*) root, lemon water, cinnamon, ginger root tea, coconut oil	
Scarlet fever	*Streptococcus pyogenes*	red sore throat, 'Strawberry' tongue, whitish coating, fever, red skin rash, swollen glands in the neck, bright red skin in the crease of the underarm, elbow, and groin	*Boesenbergia pandurata, Rhodomyrtus tomentosa, Eleutherine americana* have great antibacterial effects against *Streptococcus pyogenes*	[58]
Pneumonia	*Streptococcus pneumoniae, Staphylococcus aureus* Viral pneumonia is caused by influenza A, B viruses, human parainfluenza viruses (HPIV), and respiratory syncytial viruses (RSV)	fever, shaking chills, shortness of breath, consolidation of lung, severe chest pain, blood in the sputum	*Erythrina senegalensis, Waltheria indica, Piliostigma thonningii, Andira inermis, Keetia hispida, Uapaca togoensis, Combretum molle*	[59]
Psittacosis	*Chlamydia psittaci*	fever, dry cough, headache, muscle aches, chest pain, lung consolidation	-	[63]
Q fever	*Coxiella burnetii*	high fever and chills, headaches often behind eyes, muscle and joint pain, extreme fatigue	-	[44]
Bronchitis	Influenza virus, adenovirus, rhinovirus, respiratory syncytial virus, and coronavirus	cough, fever, sputum production, dyspnea, hoarseness, wheezing, and chest pain	*Hyoscyamus niger, Nigella sativa L., Verbascum thapsus, Citrus limon L., Justicia adhatoda, Allium sativum,* and *Althaea officinalis L.* can reduce influenza viral infection.	[23] [31] [45] [46]
Asthma	Rhinovirus, the common cold virus	difficulty in breathing, wheezing, coughing, chest tightness	*Tylophora indica, Picrorrhiza kurroa, Solanun xanthocarpum,*	[47]

Common cold / Nasopharyngitis	Rhinovirus, coronavirus, human parainfluenza viruses, metapneumovirus, adenovirus, human respiratory syncytial virus, enteroviruses	coughing, fever, runny nose, sore throat	*Allium sativum, Z. officinale, Allium cepa, Chamomilla recutita, Citrus x limon, Tilia cordata, Echinacea purpurea, Rubus idaeus*	[48]
Influenza	RNA viruses of the family Orthomyxoviridae	fever, severe headache, chills, sore throat, coughing, muscle pains, fatigue	*Andrographis paniculata, Eleutherococcus senticosus, Echinacea purpurea, Allium sativum, Sambucus nigra, Eucalyptus globulus, Hydrastis canadensis, Glycyrrhiza glabra, Althea officinalis, Mentha x piperita, Ulmus fulva*	[31]

Phytochemical Compositions of Coriander and Ginger

Plants produce many secondary metabolites like alkaloids, terpenoids, tannins, and flavonoids which have antimicrobial activity.[64] Some simple bioactive phytochemicals like phenols and phenolic acids have been reported as effective chemical compounds against viruses, bacteria, and fungi.[7] [65] In fact, the antimicrobial activity of quinones results from protein inactivation, which leads to the deterioration of polypeptides in cell walls and enzymes that are bound to membranes.[66] Flavonoids are also recorded to be synthesized by plant parts to react to microbial infection,[67] and tannins also indirectly contribute to microbial inactivation by affecting microbial enzymes adhesins, and cell envelope transport proteins.[34] Furthermore, a research finding has been shown that terpenoids and alkaloids were active compounds against bacteria, viruses, and protozoa. Furthermore, plant essential oils have been proven to have a highly effective antibacterial and antiviral activity. [15]

Coriander is a member of the Apiaceae (Umbelliferae) family, and seeds of *C. sativum* are known as coriander as well as leaves are known as cilantro.[68] The main active constituents of *C. sativum* are essential oils and fatty oils, which can extract between 0.01 - 2.6% and 6.0 - 22.53%, respectively, from the ripe and dried coriander fruits.[25] [69] It has been reported that around fifty-three constituents in the essential oil of coriander have been identified, and these essential oils exhibit antimicrobial, antioxidant, free radical, antidiabetic, anticancer, and antimutagenic-like important properties.[24] [70] [112] Furthermore, the therapeutic potential of the antimicrobial effects of the essential oils has been proven highly effective against the bacterial and viral activity.[15] Furthermore, the coriander plant extract contains alkaloids and flavonoids, which have antimicrobial effects.[71] Linalool (coriandrol) is its principal constituent that mainly caused viral and bacterial inhibition.[72] The distilled oil contains around 65-70% of linalool, varying according to extract source.[73] Other main components are p-cymene (1.12%), geranyl anethol

(1.15%), ɣ - terpinene (4.17%), acetate (4.99%), and α-pinene (1.63%), [34] Other than those, it has been recorded that β-pinene, decenal, dodecanal, citronellal, citronellol, citral, camphor, cymene, geraniol, borneol, citronellyl acetate, α-cedrene, α-famesence, β-sesquiphell-andrene, and tetradecenal like phytochemicals also present in coriander.[24] [68] [74] Dodecanal, E-2- dodecanol, decanal, and E-2-decenol like compounds in coriander have been reported to have high antiviral properties.[75] Furthermore, heterocyclic compounds like furan and tetrahydrofuran derivatives, pyrazine, pyridine, isocoumarins, dihydrocoriandrin, coriandronsA-E, thiazole, digustilide phenolic acids, flavonoids, neochidilide, phthalides, and sterols are prevalent in *C. sativum.*[69] The main fatty acid content in coriander is petroselinic acid constituting 72.6% of all fatty acids.[76] [77]

Ginger, the rhizome of the *Z. officinale,* is concerned to be safe and used to treat various diseases.[78] According to the source of rhizomes, oil yield from ginger varies from 1% to 3%.[79] Ginger contains alkaloids, phenolic groups, steroids, and other critical bioactive molecules with medicinal effects like antimicrobial, antioxidation, and other pharmacological effects.[29] [80] [81] Although various studies have been identified gingerol, shagaol, zingerone-like compounds as the main component in the ginger extract, phytochemical compounds like propanediol, butanediol, and benzene dicarboxylic acid have been identified, which show antiviral activity in the aqueous ginger extract by two-dimensional gas chromatography-mass spectrometry (GC×GC-MS) analysis. Ginger's lyophilized extract has also been communicated as an antiviral agent against hepatitis C viral infection.[82] The difference in compounds identification in ginger extract and the aqueous ginger extract is due to the aqueous extraction method, which restricts the isolation of hydrophobic phytoconstituents.[83] While Zingiberene and its derivatives are the main volatile compounds of ginger, gingerols and their derivatives generate pharmacological activity of ginger.[84] However, Zingiberol is the principal aromatic agent of the rhizome.[29] [85] Furthermore, the gingerol, shogaols, and paradols, aromatic or pungent compounds in ginger powder's ethanolic extract, are identified as more active agents.[86] [87] Gingerols can be converted into shagaols due to heat processing or long storage period. Then shogaols can be converted into paradols after the hydrogenation process.[88] Ginger's essential oils and oleoresins exhibit significant antimicrobial and antioxidant activities.[81] Furthermore, a research finding has been revealed that ginger consists of alcohols, phenolic compounds, and its derivatives, aldehyde, ketones, sesquiterpenoids, monoterpenoids, and esters, which impart a broad antimicrobial spectrum against various microorganisms.[34] The primary sesquiterpene hydrocarbon in ginger is zingiberene (23.5%) followed by α-farnesene (12.0%), β-sesquiphellandrene (10.3%), and α-curcumene (5.5%). The primary monoterpene hydrocarbon is β-phellandrene (9.3%), followed by camphene (6.2%) and α-pinene (2.1%). Nerolidol (0.5%) and β-eudesmo (0.4%) are the most prevalent sesquiterpene alcohols. Geranial (6.4%) is the main oxygenated monoterpene compound followed by neral (3.7%), α-terpineol (0.5%), and linalool (0.3%) as recorded in current studies. [89] Moreover, bisacurone epoxide, eucalyptol, myrcene, heptan-2-ol, isoeugenol, and β-bisabolene, have been recorded as dominant constituents of ginger essential oil. [79] [90] The phytochemical composition indicated that powder obtain from ginger rhizome is high in saponins and low in tannin. Both essential and non-essential amino acids are also detected in ginger rhizome powder. [80]

Table 2: Summary of phytochemical composition of coriander

Phytochemical group	Compounds
Dominant Essential oils	linalool, p-cymene, geranyl anethol, ɣ - terpinene, acetate, and α-pinene
Others essential oils	β-pinene, decenal, dodecanal, citronellal, citronellol, citral, camphor, cymene, geraniol, borneol, citronellyl acetate, α-cedrene, α-famesence, β-sesquiphell-andrene, and tetradecenal
Heterocyclic compounds	furan and tetrahydrofuran derivatives, pyrazine, pyridine, isocoumarins, dihydrocoriandrin, coriandronsA-E, thiazole, digustilide phenolic acids, flavonoids, neochidilide, phthalides, and sterols
Main fatty acid	petroselinic acid

Table 3: Summary of Phytochemical composition of Ginger

Phytochemical group	Compounds
Main volatile compounds	gingerol, shagaol, zingerone
Primary sesquiterpene hydrocarbons present	Zingiberene followed by α-farnesene, β-sesquiphellandrene, and α-curcumene
The primary monoterpene hydrocarbon	β-phellandrene, followed by camphene (6.2%) and α-pinene
The most prevalent sesquiterpene alcohols	Nerolidol and β-eudesmo
The main oxygenated monoterpene compounds	Geranial followed by neral, α-terpineol, and linalool
Dominant constituents of ginger essential oil	bisacurone epoxide, eucalyptol, myrcene, heptan-2-ol, isoeugenol, and β-bisabolene,

The Therapeutic Effect of Coriander And Ginger on Respiratory Tract Infected Bacteria and Viruses

Among Sri Lankans, almost a niggling litany of mothers and elders swear by the goodness of a liquid brewed from coriander seeds with ginger rhizomes to beat the cold and flu. [22] Furthermore, when looking at the Sri Lankan traditional medicine recipes, coriander and ginger play a significant role in their therapeutic characteristics. Those traditional remedies are popular due to minimal side effects from consuming remedies. The effectiveness of the antimicrobial inhibition of mixed spices is better than individuals. So the combined effect of coriander and ginger extract has better antibacterial and antiviral activities. [34] However, there are no fixed formulae because the dosage and combinations of plant medicines are customized according to the physiology of the disease. [21]

Studies have shown that coriander oil is an antibacterial and antiviral agent due to phytochemicals like linalool. Nevertheless, it has been recorded that the inhibition of coriander essential oil is greater than the activity of its principal constituent, linalool. Therefore, it has been revealed that antimicrobial inhibition is due to complicated interactions between individual compounds that cause to total inhibition and not only because of linalool. [26] According to some findings, the hot aqueous extracts and long soak (72 hours) of

the coriander plants have lost antibacterial properties, while cold aqueous extract for 24 hours shows a higher inhibitory effect. On the other hand, plant parts like stems, and leaves did not show antibacterial properties, and only the seed oil of coriander has a vigorous antimicrobial activity. Furthermore, the findings of research have been revealed that the ethanolic extract of coriander seeds inhibited all types of tested bacteria.[16] Moreover, it has been investigated that hexane and aqueous extracts exhibit antiviral activity compared to methanol extract in the experiment to test the HSV-1 inhibition of coriander seeds extract.[91] Therefore, it is vital to concern about the plant part, extraction method, and soaking time to take maximum therapeutic effects of these herbal medicine extracts. Coriander oil inhibits pathogenic bacteria associated with foodborne diseases and nosocomial infections. It has been reported that coriander oil has no adverse effects or toxicity, and it is considered safe for human consumption.[77] The references proved that the essential oil extracted from coriander shows antibacterial and antifungal activities against twenty-five genera of bacteria and one fungal species.[92] As mentioned in research findings, the antibacterial effect of coriander extract is steady at high temperatures and has the optimum antibacterial activity at pH 6 with 2.0% NaCl concentration.[25] The antibacterial properties of *C. sativum* has been reported against both gram-positive and negative bacteria.[93] [94] [95] The antimicrobial effects of the extracts are due to those secondary metabolites,[71] and these phytochemicals can effectively control gram-positive, negative bacteria and viruses which infect the respiratory tract. Most of the gram-negative strains and *S. aureus* strains were inhibited by coriander oil, and they were unable to regrow in a fresh culturing medium.[26] Furthermore, the coriander essential oil primarily damages bacteria's cell membrane, which causes cell death.[26] In fact, the antibacterial inhibition of coriander oil against *Salmonella typhimurium, Enterobacter agglomerans, Listeria monocytogenes, Escherichia coli, Staphylococcus aureus, Staphylococcus pyogenes, Serratia grimesii, Bacillus subtilis, Stenotropomonas maltophilia, Enterococcus faecalis, Penicillum expansum, Klebsiella pneumoniae, Bacillus megaterium, Yersinia enterocolitica, Pseudomonas aeruginosa*, and *Escherichia cloaca* has been reported.[72] [77] [96] Gram-positive strains like *Bacillus cereus*, *Staphylococcus aureus, Enterococcus faecalis,* clinical *Staphylococcus aureus* isolate, and clinical methicillin-resistant *S. aureus* isolates also have been inhibited by coriander seeds oil.[26] According to a current study, methanol extraction of coriander has shown a wide range of antibacterial activity on various bacterial strains. Furthermore, hexane extract also displayed antibacterial effects on gram-positive (*S. pyogenes, S. epidermidis, S. aureus*) and gram-negative (*Pseudomonas aeruginosa, Escherichia coli*) bacteria. [106] However, methanol extract has higher antibacterial activity than hexane extract. [25] [97] However, it has been investigated that coriander oil does not affect *Bacillus cereus* and *Enterococcus faecalis*. [26]

Volatile oils, alkaloids, phenols, and high oleoresin are the compounds resulting in high therapeutic characteristics in ginger. [29] [107] Ginger extract has high antimicrobial activity and inhibition activity due to the chemical properties of ginger. It has been reported that the ethyl acetate, n-hexane, and soxhlet extract of the ginger rhizomes could be utilized to treat bacterial infections, colic, and dyspepsia. These extracts could also treat the common cold, heart diseases, lung diseases, hypercholesterolemia, and digestive disorders. The terpenoids are effective in pharmacology due to their relationship with compounds such as vitamin A. [27] Bioactive compounds like shagaols, zingerone, paradols, and gingerols are accountable for the “burning” effect sensed in the mouth because those could not quickly vaporize. [29] In conventional medicine, ginger is considerably consumed to treat headaches, colds, and nausea. In Ayurveda and Western medicine, ginger is used to treat arthritis, muscular discomfort, and rheumatic disorders.[98] Antibacterial

compounds inhibit the growth of multidrug-resistant bacterial strains in ginger by influencing membrane integrity and inhibiting biofilm evolution.[99] Some studies have shown that components in ginger essential oil affect the expression of some genes associated with bacterial energy metabolism, cell membrane-associated proteins coding, tricarboxylic acid cycle, and DNA metabolism.[100] Hexane, ethanol, ethyl acetate like solvents, and water can be used for ginger extraction. All extracts are tested for antibacterial action and bacterial growth inhibition activity except water.[27] Ginger showed dose-dependent antibacterial activity towards both gram-positive and negative bacteria; *Staphylococcus aureus, Bacillus megaterium, Pseudomonas aeruginosa*, *Pseudomonas fluorescens, Listeria monocytogenes, Escherichia coli, Streptococcus pyogenes, Salmonella typhimurium, Streptococcus mutans, Shigella flexneri, Bacillus subtilis, Acinetobacter baumannii*, and *Candida albicans*. [81] [101] [102] [103] It has been investigated that extracts from ginger roots by ethyl acetate, n-hexane, and soxhlet extracts have antibacterial activities against *Staphylococcus epidermidis*, *Coliform bacillus*, and *Streptococcus viridans* while water extract did not exhibit antibacterial activity on them.[27] The ginger essential oil has more significant antibacterial inhibition against gram-positive bacteria than gram-negative ones.[79] It has been reported that gingers extract exhibited various degrees of antibacterial effect towards the bacterial species, *Shigella* sp., *Aeromonas sobria, Serratia marcescens, Morganella morganii, Coliform bacilli, Salmonella enteric, Klebsiella oxytoca, Porphyromonas endodontalis, Prevotella intermedia*, and *Citrobacter freundii.*[103]

Coriander has been reported to have an antiviral effect on the hepatitis A virus (HAV).[75] It has been reported that hepatitis C virus (HCV) also could be inhibited by lyophilized juice extract of ginger effectively by affecting the level of α-fetoprotien and markers related to the role of the liver like aspartate aminotransferase and alanine aminotransferase.[82] [88] It has been revealed that aqueous extract of ginger shows antiviral activity against feline calicivirus used as a human norovirus surrogate.[83] Also, the antiviral activity of ginger has been proven against the influenza virus.[104] Dodecanal, E-2- dodecanol, decanal, and E-2- decenol present in coriander show inhibition against viruses like dengue and middle east respiratory syndrome (MERS) coronavirus. Those viruses are consistent with various proteins, which are most effectively binding with compounds present in coriander. Therefore, coriander can effectively inhibit those viruses. The E-2- dodecanol compound showed the highest binding affinity to structural proteins of those viruses, and the chemical compound decanal had the highest binding capacity to non-structural proteins of those viruses. [75] Therefore, this binding affinity to proteins in viruses could effectively inhibit the coronavirus by coriander in this pandemic situation. Linalool present in coriander also has been reported as an immune enhancer. Therefore, immune-enhancing properties are also beneficial to face this COVID-19 situation. Fresh ginger is said to inhibit viral attachment and internalization of human respiratory syncytial virus (HRSV) in both human upper and lower respiratory tract cell lines. [114] [115] [116] Mucosal cells are stimulated by the high concentration of fresh ginger to secrete interferon- β (INF-β) that positively contribute to avoiding infections. Due to this property, ginger could be effectively used to treat the common cold and flu-like respiratory infections. However, dry ginger has not been reported to be as effective as fresh ginger. [105] The coronavirus could infect human cells containing ACE2 (Angiotensin-Converting Enzyme 2) receptors and proteases like the TMPRSS2 (Transmembrane Serine protease 2), including nose, oral mucosa, small intestine, lungs, nasopharynx, heart, and kidneys. Ginger has been reported to inhibit the growth of the coronavirus by blocking the receptor of SARS-CoV-2/TMPRSS2 due to antiviral properties present in gingerol-like phytochemical compounds. [50] Therefore, after concerning

these antiviral properties present in both coriander and ginger, the combination of those herbal extracts could be effectively used to inhibit the coronavirus. The compounds present in those herbal extracts can bind to the proteins in the virus, have the ability to block the receptors of the virus, and also have the ability to enhance immunity. Therefore, coriander and ginger can be effectively used to face this global pandemic situation. Moreover, the research scientists have an excellent opportunity to develop very effective antibiotics or dietary supplements with those herbal extracts since they do not have adverse side effects. Furthermore, researchers have to do studies to determine the most effective extraction method of phytochemical constituents from those herbal medicinal plants. Moreover, researchers can develop filtration methods to filter out only the effective photochemical compounds from herbal extracts. Moreover, hand sanitizers, and face masks embedded with those antimicrobial compounds, like preventive methods, can be developed using those antimicrobial compounds available in the herbal medicinal plants to face this global pandemic. Further studies can be performed to regulate the other medicinal effects of those herbal extracts, drugs, and medicines that could be developed without side effects.

Furthermore, it can be suggested to carry on more research studies to identify the other mechanism of inhibition activity of coronavirus by those herbal extracts. In vitro or in vivo experiments need to be verified to determine the effectiveness of coriander and ginger against coronavirus. Therefore, considering the side effects of vaccination, a very effective and safe preventive or immune-enhancing treatment could be developed with herbal medicinal plant parts to face this global pandemic situation.

Table 4: Summary of the therapeutic effects of coriander

Form of therapeutic compound/ extracts	**Therapeutic effects**
	Antibacterial properties
Coriander essential oil	• an antibacterial and antiviral agent • inhibits pathogenic bacteria associated with foodborne diseases and nosocomial infections • antibacterial and antifungal activities against twenty-five genera of bacteria and one fungal species. • the gram-negative strains and *S. aureus* strains were inhibited and they were unable to regrow in a fresh culturing medium • primarily damages bacteria's cell membrane, which causes cell death • antibacterial inhibition against *Salmonella typhimurium, Enterobacter agglomerans, Listeria monocytogenes, Escherichia coli, Staphylococcus aureus, Streptococcus pyogenes, Serratia grimesii, Bacillus subtilis, Stenotropomonas maltophilia, Enterococcus faecalis, Penicillum expansum, Klebsiella pneumoniae, Bacillus megaterium, Yersinia enterocolitica, Pseudomonas aeruginosa*, and *Escherichia cloaca.* • Gram-positive strains like *Bacillus cereus*, *Staphylococcus aureus, Enterococcus faecalis*, clinical *Staphylococcus aureus* isolate, and clinical methicillin-resistant *S. aureus* isolates also have been inhibited • does not affect *Bacillus cereus* and *Enterococcus faecalis*

Methanol extraction of coriander	• a wide range of antibacterial activity on various bacterial strains. Furthermore, • methanol extract has higher antibacterial activity than hexane extract
Hexane extracts	• exhibit antiviral activity in the experiment to test the HSV-1 • antibacterial effects on gram-positive (*S. pyogenes, S.epidermidis, S.aureus*) and gram-negative (*Pseudomonas aeruginosa, Escherichia coli*) bacteria
Ethanolic extract of coriander seeds	• inhibited many types of bacteria.
	Antiviral properties
Coriander as an antiviral compound	• antiviral effect on the hepatitis A virus (HAV). • Linalool present in coriander has been reported as an immune enhancer • Dodecanal, E-2- dodecanol, decanal, and E-2- decenol present in coriander show • inhibition against viruses like dengue and middle east respiratory syndrome (MERS) coronavirus

Table 5: Summary of the therapeutic effects of Ginger

Form of therapeutic compound/ extracts	**Therapeutic effects**
	Antibacterial properties
Ginger as an antibacterial compound	• to treat headaches, colds, and nausea. • In Ayurveda and Western medicine, ginger is used to treat arthritis, muscular discomfort, and rheumatic disorders. • inhibit the growth of multidrug-resistant bacterial strains in ginger by influencing membrane integrity and inhibiting biofilm evolution. • dose-dependent antibacterial activity towards both gram-positive and negative bacteria; *S. aureus, B. megaterium, P. aeruginosa*, *P. fluorescens, L. monocytogenes, E. coli, S. pyogenes, S. typhimurium, S. mutans, Shigella flexneri, B. subtilis, Acinetobacter baumannii*, and *Candida albicans*. • various degrees of antibacterial effect towards the bacterial species, *Shigella* sp., *Aeromonas sobria, Serratia marcescens, Morganella morganii, Coliform bacilli, Salmonella enteric, Klebsiella oxytoca, Porphyromonas endodontalis, Prevotella intermedia*, and *Citrobacter freundii.*
Components in ginger essential oil	• affect the expression of some genes associated with bacterial energy metabolism, cell membrane-associated proteins coding, tricarboxylic

	acid cycle, and DNA metabolism. • more significant antibacterial inhibition against gram-positive bacteria than gram-negative ones
Ethyl acetate, n-hexane, and soxhlet extract of the ginger rhizomes	• utilize to treat bacterial infections, colic, and dyspepsia. • To treat the common cold, heart diseases, lung diseases, hypercholesterolemia, and digestive disorders. • antibacterial activities against *Staphylococcus epidermidis*, *Coliform bacillus*, and *Streptococcus viridans*
Water extract	• did not exhibit antibacterial activity on them
Bioactive compounds like shagaols, zingerone, paradols, and gingerols	• accountable for the "burning" effect sensed in the mouth • not quickly vaporize.
	Antiviral properties
Ginger as an antiviral compound	• hepatitis C virus (HCV) also could be inhibited by lyophilized juice extract • aqueous extract shows antiviral activity against feline calicivirus used as a human norovirus surrogate • antiviral activity has been proven against the influenza virus. • to inhibit viral attachment and internalization of human respiratory syncytial virus (HRSV) in both human upper and lower respiratory tract cell lines • inhibit the growth of the coronavirus by blocking the receptor of SARS-CoV-2/TMPRSS2 due to antiviral properties present in gingerol-like phytochemical compounds

Conclusion

When the respiratory tract is infected by any pathogenic bacteria or virus, sore throat, fever, neck swelling, coughing, sneezing, runny nose, headaches, shortness of breath, and loss of appetite like any typical symptom will appear. The extract from the seed oil of *C. sativum* and rhizome of *Z. officinale* can be used to treat respiratory tract-related microbial diseases due to these extractions having antibacterial and antiviral properties. Coriander and ginger consist of essential oil, alkaloids, tannins, terpenoids, and flavonoids with antiviral and antibacterial activities. Furthermore, linalool is the major phytochemical in *C. sativum* followed by terpinene, pinene, cymene, decenal, and camphor as well as, gingerol is the main phytochemical in *Z. officinale* followed by shogaols and paradols. While each of these phytochemicals

provides antimicrobial activity against respiratory tract-based pathogens, the collection of these phytochemicals has a high curing ability due to complicated interactions that occurred among these phytochemicals. Since, in the modern world, cytotoxic drugs are most commonly used as immunostimulants and immunomodulators with various side effects, plant-derived compounds and extracts are potential candidates due to their lower cytotoxicity and higher bioavailability. Therefore, a beverage or dietary supplement made with coriander and ginger is an effective immune-enhancing drink for daily usage as a solution for various bacterial and viral infections, including the COVID-19 global pandemic situation. This will be adequate protection against COVID-19 disease because these natural medicines have hardly any or no side effects. Also, there is laboratory evidence to prove the effective antiviral properties of compounds present in those herbal extracts that can the proteins in viruses, block the virus's receptors, and enhance the immunity to face the COVID-19 situation.

Conflicts of Interest

The authors state that there is no conflict of interest. The authors alone are responsible for the content of this review paper.

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