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RESEARCH ARTICLE

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Spices and herbs: Potential antiviral preventives and immunity boosters during COVID-19

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A severe acute respiratory syndrome is an unusual type of contagious pneumonia that is caused by SARS coronavirus. At present, the whole world is trying to combat this coronavirus disease and scientific communities are putting rigorous efforts to develop vaccines. However, there are only a few specific medical treatments for SARS-CoV-2. Apart from other public health measures taken to prevent this virus, we can boost our immunity with natural products. In this article, we have highlighted the potential of common spices and herbs as antiviral agents and immunity boosters. A questionnaire-based online survey has been conducted on home remedies during COVID-19 among a wide range of peoples (n-531) of different age groups (13--68 years) from various countries. According to the survey, 71.8% of people are taking kadha for combating infection and boosting immunity. Most people (86.1%) think that there is no side effect of kadha while 13.9% think vice versa. A total of 93.6% of people think that spices are helpful in curing coronavirus or other viral infection as well as boosting immunity. Most people are using tulsi drops, vitamin C, and chyawanprash for boosting their immunity. Therefore, we conclude from the survey and available literature that spices and herbs play a significant role against viral infections.

KEYWORDS
antiviral, bioactive compounds, coronavirus, herbs, immunity boosters, SARS-CoV-2, spices

1 | INTRODUCTION

In December 2019, the people of Wuhan city of the Hubei province of China were suffered from deadly "SARS-CoV-2" like pneumonia which was later named coronavirus disease (COVID-19) by the World Health Organization (WHO) (Wang, Wang, Ye, & Liu, 2020). The COVID-19 cases are increasing day by day, and there have been 37,423,660 confirmed cases of COVID-19 in more than 200 countries, including 1,074,817 deaths up to October 12, 2020. (https://covid19.who.int/). The WHO declared it initially a public health emergency of international concern and later pandemic where the COVID-19 symptoms include fever, sneezing, diarrhea, dry cough, malaise, respiratory distress, and shortness of breath. This virus (SARS-CoV-2) is a member of beta-coronavirus and is found similar to earlier coronavirus severe acute respiratory syndrome coronavirus (SARS-CoV) and the Middle East respiratory syndrome coronavirus (MERS-CoV), in its pathogenicity and clinical spectrum (Gurunathan et al., 2020).

Coronaviruses (CoV) (family: *Coronaviridae*) are enveloped viruses containing non-segmented, positive-stranded genomic RNA. These viruses are pleomorphic particles ranging from 80–220 nm in diameter. The genome size of coronaviruses ranges from 26–32 kilobases (MacLachlan & Dubovi, 2017). It has better genome sequence vis-à-vis to the SARS-CoV compared to MERS-CoV, but the amino acid sequence is different from the other coronavirus, especially in the region of 1ab polyprotein and S-protein or surface glycoprotein (Kannan, Ali, Sheeza, & Hemalatha, 2020). Their entire replication cycle takes place in the cytoplasm. Coronaviruses can cause several of diseases, including bronchitis, hepatitis, gastroenteritis, and even death in birds, humans, and other animals (Chafekar & Fielding, 2018). The coronavirus has been found to attack all types of people,

especially elderly patients having diabetes, hypertension, cerebral infarction, chronic bronchitis, Parkinson's disease, chronic obstructive pulmonary disease, cardiovascular disease, and cancer (Deng & Peng, 2020; Guan et al., 2020; Huang et al., 2020). Coronaviruses (CoVs) enter into the host cell through interaction between the S protein of the virus species and the receptor of the host cell. It will bind with the angiotensin-converting enzyme 2 receptor from the host cell to create a suitable habitation for viral replication (Walls et al., 2020).

Natural-derived compounds constantly become a worthy therapeutic alternative against several diseases, including viral infections, because they are innately better tolerated in the human body. According to a study, from 1940 to 2014, 49% of all small molecules approved by the U.S. Food and Drug Administration (FDA) were natural products or their derivates (Newman & Cragg, 2016).

Herbal exploration is continually performed, also to diminish coronavirus-related disease (Islam et al., 2020). Spices and herbs have been extensively studied globally due to their high antioxidant and antimicrobial activity in certain spices and their beneficial effects on humans. Spices contain many bioactive compounds that include flavonoids, phenolic compounds, sulfur-containing compounds, tannins, alkaloids, phenolic diterpenes, and so on (Devi, Umasanker, & Babu, 2012; Panpatil, Tattari, Kota, & Polasa, 2013; Patra, Jana, Mandal, & Bhattacharjee, 2016; Yashin, Yashin, Xia, & Nemzer, 2017). India has the recognized six systems of medicine, namely, Ayurveda, yoga, Unani, Siddha, naturopathy, and homeopathy (Ravishankar & Shukla, 2007). Ayurveda means the science of life, and it is not only considered as an ethnomedicine but also as a complete medical system for maintaining a healthy and happy living. In India, 20,000 plant species have been recorded, which are having medicinal value, but more than 500 traditional communities use only about 800 plant species for treating different diseases (Dev, 1997).

The outbreak of SARS-CoV-2 led to catastrophic events, as there was little specific treatment known to date for coronavirus. So there is a global need to search for the agents that can act against SARS-CoV-2 as a precautionary measure which boost our immunity during COVID-19. Ministry of AYUSH, India has released an advisory on Ayurveda's immunity promoting methods for self-care during the COVID-19 pandemic, which includes the use of spices such as turmeric, cumin, coriander, and garlic that are recommended in cooking. They have also advised taking drink herbal tea/decoction (kadha) made from basil, cinnamon, black pepper, ginger, and raisin once or twice in a day. Natural sugar or fresh lemon juice can be added to enhance the taste. Half teaspoon turmeric powder can be added to 150 mL hot milk (Golden Milk) which can be taken once or twice a day (https://www.ayush.gov.in/). This article summarizes the scientific studies on the antiviral activities of spices and herbs along with their derivatives, mechanism of action, and prospects for future studies along with the survey based analysis.

2 | ANTIVIRAL PROPERTIES OF SPICES AND HERBS

Various medicinal plants/herbs are known as immunity boosters, namely, *Allium sativum* (garlic), *Tinosporacordifolia* (Giloy), *Ocimumbasilicum* (Tulsi), and so on (Singh, Tailang, & Mehta, 2016). Different spices such as clove, cinnamon, ginger, black pepper, and turmeric are known as immunity boosters along with their antiviral property (Sharma, Gupta, & Prasad, 2017; Shrivastava, 2020; Srivastava, Chaurasia, Khan, Dhand, & Verma, 2020). In this article, we have highlighted the antiviral potential of common spices and herbs mainly curcumin, cinnamon, ginger, clove, black pepper, garlic, neem, giloy, basil used during COVID-19 as depicted in Figure 1. Neem leaves contain various compounds such as zinc, quercetin, vitamin A, vitamin B1, vitamin B2, vitamin B6, vitamin C, vitamin E, and so on, which may boost immunity (Garba & Mungadi, 2019).

2.1 | *Curcuma longa* L. (turmeric)

Turmeric (*Curcuma longa L.*) belongs to the family of ginger (*Zingiberaceae*) and natively grows in India and Southeast Asia. Rhizomes of this plant contain several secondary metabolites including curcuminoids, sesquiterpenes, steroids, and polyphenol as major bioactive substances (Omosa, Midiwo, & Kuete, 2017). Curcumin is a natural polyphenol that is isolated for turmeric (*Curcuma longa*) and has been used from centuries as a traditional medicine in Asian countries to treat various disorders. Several studies have shown that the curcumin possesses some pharmacological properties such as anti-inflammatory, anti-angiogenic, and anti-neoplastic, without toxicity. Food Drug Administration (FDA) categorized it as "Generally Recognized as Safe." A dose of up to 12 g/day of curcumin was known to be safe for human consumption during the clinical trials without showing any side effects (Gupta, Patchva, & Aggarwal, 2013). Shrivastava (2020) reported that the dose of curcumin from 2,500 to 8,000 mg per day for 3 months showed no toxicity from curcumin. Curcumin is a dynamic antiviral that reduces the replication of viruses.

Antiviral activity of curcumin was observed against different viruses including hepatitis viruses, SARS coronavirus, influenza viruses, human immunodeficiency virus (HIV), herpes simplex virus, dengue virus, chikungunya virus, and so on, as listed in Table 1. Curcumin's antiviral activities can also be evidenced by its ability to regulate various molecular targets that contribute to various cellular events, such as transcription regulation, and the activation of cellular signaling pathways (Joe, Vijaykumar, & Lokesh, 2004). Curcumin's role in targeting various cellular pathways, further inhibiting the growth, and replication of viruses makes it an ideal candidate as an anti-viral drug. Utomo, Ikawati, and Meiyanto (2020), based on their molecular docking study, reported that the curcumin binds and inhibits the target receptors including SARS-CoV-2 protease, spike glycoprotein-RBD, and PD-ACE2, which are involved in virus infection.

2.2 | *Zingiber officinale* (ginger)

Ginger is one of the important medicinal plants which naturally occur in various countries. Ginger, *Zingiber officinale*, belongs to family

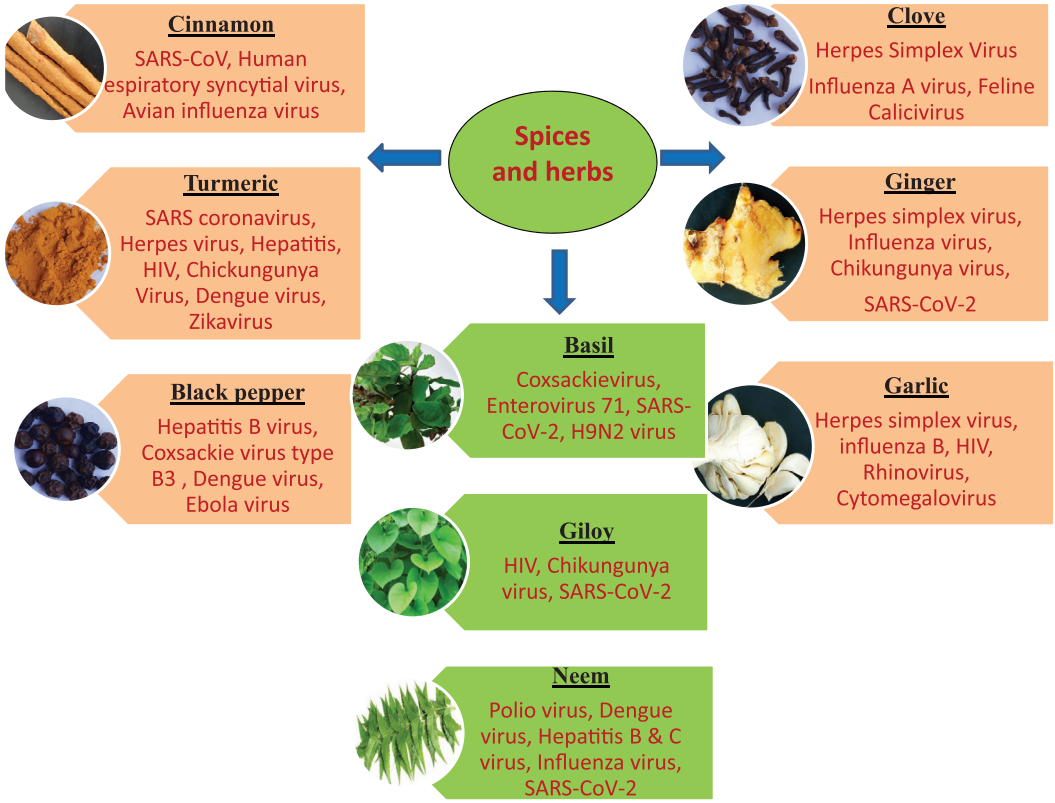

FIGURE 1 Common spices and herbs with antiviral properties [Colour figure can be viewed at wileyonlinelibrary.com]

TABLE 1 Antiviral properties and mechanism of action of Curcumin (bioactive compound from turmeric)

S. No.	Virus	Mechanism of action	References
1	SARS coronavirus	Replication and protease activity inhibitor	Wen et al., 2007
2	Herpes virus	Gene expression inhibitior	Kutluay, Doroghazi, Roemer, & Triezenberg, 2008
3	Hepatitis B virus	Replication inhibitor cccDNA inhibitor	Rechtman et al., 2010 Wei et al., 2017
4	Hepatitis C virus	Entry inhibitor	Anggakusuma et al., 2014
5	Human immunodeficiency virus	Protease inhibitor Integrase inhibitor Tat protein inhibitor	Balasubramanyam et al., 2004; Ali and Banerjea, 2016
6	Human papilloma virus	Gene expression inhibition	Maher et al., 2011; Mishra et al., 2015
7	Respiratory syncytial virus	Entry inhibitor replication and budding inhibition	Yang, Li, & Huang, 2016; Yang, Li, Li, Wang, & Huang, 2017
8	Chickun gunya virus	Entry inhibitor	Rhein et al., 2016 Mounce, Cesaro, Carrau, Vallet, & Vignuzzi, 2017
9	Dengue virus	Entry inhibitor Particle production Inhibition	Chen et al., 2013 Padilla, Rodríguez, Gonzales, Gallego-g, & Castaño-o, 2014
10	Zikavirus	Entry inhibitor	Mounce et al., 2017
11	Influenza A virus	Inhibitor of virus uptake, replication and particle production	Dai et al., 2018; Han, Xu, Guo, & Huang, 2018

Zingiberaceae and the other famous members of this plant family are turmeric, cardamom, and galangal. The plant is indigenous to South-east Asia and is cultivated in several countries including India. Ginger (*Zingiberofficinale*) is known as Sunthi in Ayurveda and the description of the plant appears in the old text like Charaka, Sushruta, Vagbhatta, and Chakra-dutta (Agrahari, Panda, Verma, Khan, & Darbari, 2015).

TABLE 2 Spices and herbs and their derivatives showing antiviral properties

Plant parts, extracts and compounds	Virus	Mechanism of action	Reference
Ginger			
ZingiberofficinaleRosc (ZOR) induced conditioned medium	Influenza A/Aichi/2/68 (Aichi) virus	Via macrophage activation leading to production of TNF-α.	Imanishi et al., 2006
Ginger essential oil	Herpes simplex virus	Disrupts virus envelope	Schnitzler, Koch, & Reichling, 2007
Aquatic extract of fresh ginger	Human respiratory syncytial virus	Blocking viral attachment and stimulate mucosal cells to secrete IFN-β	Chang, Wanga, Yeh, Shieh, & Chiang, 2013
Hydroethanolic extract of ginger	Influenza virus	—	Dorra, EL-Barrawy, Sallam, & Mahmoud, 2019
Aquatic extract of ginger	Chikungunya virus	Inhibition of cytopathic effect and cell viability	Sulochana, Jangra, Kundu, Yadav, & Kaushik, 2020
Bioactive compounds of ginger (gingerol, geraniol,shogaol, zingiberene, zingiberenol, zingerone)	SARS-CoV-2	Block the S protein from bindingto the ACE2 receptor or act as an inhibitor for MPro	Ahkam, Hermanto, Alamsyah, Aliyyah, & Fatchiyah, 2020
Cinnamon			
Procyanidins and butanol extract	SARS-CoV	Interference of clathrin-dependent endocytosis	Zhuanga et al., 2009
Water extract	Human respiratory syncytial virus	Inhibition of viral attachment and internalization	Yeh, Chang, Wang, Shieh, & Chiang, 2013
Silver nanoparticles of cinnamon bark	Avianinfluenza virus subtype H7N3	Interaction with viral genome and cellular factors or pathways of host cells required for viral replication	Fatima, Zaidi, Amraiz, & Afzal, 2016
Cinnamaldehyde	T2 bacteriophage	Inhibit the replication of T2 bacteriophage	Goldstein & Shumaker, 2019
Clove			
Eugeniin	Herpes simplex virus 1 and 2	Inhibiting DNA polymerase	Kurokawa et al., 1998
	Influenza A virus	—	
Eugenol		Inhibit viral replication and reducing infection	Reichling, Schnitzler, Suschke, & Saller, 2009
Clove extract	Feline calicivirus, a surrogate for human Norovirus	—	Aboubakr et al., 2016
Black pepper			
Amide alkaloid	Hepatitis B virus	Unclear	Hao et al., 2012
Extract	Coxsackie virus type B3	Cytopathic effect inhibition	Mair et al., 2016
Piperine	Dengue virus	Inhibit Methyltransferase	Nag & Chowdhury, 2020
	Ebola virus	VP35 interferon inhibitory domain	
Basil			
Ursolic acid	Coxsackievirus	Infection and replication inhibitor	Chiang, Ng, Cheng, Chiang, & Lin, 2005
	Enterovirus 71		
Essential oil and monoterpenes (camphor and 1,8-cineol)	Bovine viral diarrhoea virus	Viral particle inhibitor	Kubiça, Alves, Weiblen, & Lovato, 2014
Crude extract and terpenoid	H9N2 virus	—	Ghoke et al., 2018
Rosmarinic acid, Oleanolic acid, Ursolic acid and Methyl eugenol	SARS-CoV-2	Main protease	Kumar, 2020

TABLE 2 (Continued)

Plant parts, extracts and compounds	Virus	Mechanism of action	Reference
Garlic			
Sulfur constituents	Coxsackie virus species, herpes simplex virus types 1 and 2, influenza B	—	Tsai et al., 1985
Ajoene, Allyl alcohol and diallyl disulfide	HIV	Inhibiting the integrin dependent processes	Tatarintsev et al., 1992
Allicin	Common cold virus (rhinovirus)	Reaction with thiol groups of various enzymes, e.g., alcohol dehydrogenase	Ankri & Mirelman, 1999
Allitridin	Cytomegalovirus	Treg amplification	Zhen et al., 2006
Extract of garlic	Newcastle disease virus	Blocking of attachment of virus to the cell receptors	Harazem, Rahman, & Kenawy, 2019
Neem			
NIM-76	Polio virus	Inhibits viral multiplication	Sai Ram et al., 2000
Aqueous extract	Dengue virus type-2	Inhibits viral multiplication	Parida, Upadhyay, Pandya, & Jana, 2002
Bark extract	Herpes simplex virus type-1	Block HSV-1 entry into cells	Tiwari, Darmani, Yue, & Shukla, 2009
Water extracted polysaccharides	Bovine herpes virus type-1 (BoHV-1)	Inhibits virus adsorption to the cell	Saha et al., 2010
3-Deacetyl-3-cinnamoyl azadirachtin	Hepatitis C virus (HCV)	Inhibitor against NS3/4A protease	Ashfaq, Jalil, & UlQamar, 2016
Nimbaflavone, Rutin, and Hyperoside	Influenza virus	Interaction with nucleoprotein	Ahmad, Javed, Rao, & Husnain, 2016
Chloroformic leaf extracts	Foot and mouth disease virus	—	Younus et al., 2016
Bark extract	Newcastle disease virus (NDV)	—	Mahmood, Amir, Abbas, Aslam, & Rafique, 2018
Azadirachtin	Hepatitis B virus	Interaction with HBV polymerase	Parvez et al., 2018
Neem terpenoids	SARS-CoV-2	Inhibitor of membrane and envelop	Borkotoky & Banerjee, 2020
Giloy			
Ethanol extract	HIV	HIV protease inhibitors	Rege & Chowdhary, 2014
Silver nanoparticles	Chikungunya virus	Inhibition on cytopathic effect	Sharma et al., 2019
Tinosponone	SARS-CoV-2	Inhibitor of main protease (3CL pro)	Krupanidhi et al., 2020
Tinocordiside	SARS-CoV-2	Inhibitor of main protease	Shree et al., 2020

Zanjabeel (*Zingiberofficinale*) is a famous herbal drug in the conventional Unani system of medicine (Bashir & Afrin, 2019).

Ginger is a rich source of bioactive compounds such as phenolic groups, alkaloids, and steroids, which have medicinal effect. The chief aromatic agent of the rhizome is the zingiberol with analogues such as the shogoals, paradol, and zingerone. In addition to the main bioactive compounds, ginger also contains other sub-compounds such as 4-gingerol, 6-gingerol, 8-gingerol, 10-gingerols, 6-shogaols, and 14-shogaols (Ali, Blunde, Tanira, & Nemmar, 2008; US Report, 2013). They are reported to demonstrate antiemetic, antipyretic, analgesic, antiarthritic, and anti-inflammatory activities.

It has been proven by many studies that the ginger and its bioactive compounds showed effective antiviral activity against SARS-CoV-2, Influenza virus, Herpes simplex virus, Human respiratory syncytial virus, Chikungunya virus, and so on as shown in Table 2 (Admas, 2020; Dorra et al., 2019; Imanishi et al., 2006; Sulochana et al., 2020). Antiviral activity of lyophilized juice extracted from *Zingiber officinale* has been studied on the hepatitis C virus at varying concentrations from 5–200 μg/mL. They found that 100 μg/mL dose was effective, which inhibits virus replication that was monitored by amplification of viral RNA segments (Wahab, Adawi, & Demellawy, 2009).

Ahkam et al. (2020) studied the potential of a few bioactive compounds, namely, gingerenone A, gingerol, geraniol, shogaol, zingiberene, zingiberenol, and zingerone from Ginger as anti-SARS-CoV-2 for their interaction to spike and main protease (Mpro) protein based on molecular docking study. They found that the bioactive compounds of ginger block the spike (S) protein from binding to the ACE2 receptor or act as an inhibitor for MPro. The S protein is

responsible for SARS-CoV-2 entry during the infection which binds with angiotensin-converting enzyme 2 (ACE2) receptor from the host cell to generate an appropriate environment for viral replication (Walls et al., 2020). Main Protease (MPro) is accountable for processing the poly-proteins pp1a and pp1ab during viral replication (Hilgenfeld, 2014).

2.3 | *Cinnamomum cassia* (cinnanon)

Cinnamomum cassia is an aromatic tree species belonging to the *Lauraceae* family. Cinnamon has been prominently used in traditional Chinese, Indian, Persian, and Unani medicine for a long time. Cinnamon has been used as a popular spice by different countries around the world for thousands of years. Cinnamon is obtained from the bark of its young branches which is widely used all around the world as a daily condiment. It can be also used as a material for medical products and has high economic value. It is used for several conditions such as; flatulence, amenorrhea, diarrhea, toothache, fever, leukorrhea, common cold, and headache. It has also been reported that the regular use of cinnamon averts throat infections (Hajimonfarednejad et al., 2018).

Ojagh, Rezaei, Razavi, and Hosseini (2012) reported that the bark of cinnamon contains 21 chemical compounds, which include cinnamaldehyde (60.41%) and eugenol (3.19%), which have an antibacterial effect. Several scientific studies have shown the antimicrobial, antiviral, antifungal, antioxidant, antihypertensive, antidiabetic, antitumor, gastroprotective, and immunomodulatory effects of cinnamon (Shen et al., 2012). According to a study, a higher dose of cinnamon (100 mg/kg) drastically increased the phagocytic index, serum immunoglobulin levels, and antibody titer, while its low dose (10 mg/kg) improved serum immunoglobulin levels only. So, the higher dose increases both cell-mediated and humoral immunity, whereas the low dose showed an effect only on humoral immunity (Niphade, Asad, Chandrakala, Toppo, & Deshmukh, 2009).

Moshaverinia, Rastegarfar, Moattari, and Lavaee (2020) studied the effect of hydro alcoholic extract of cinnamon on herpes simplex virus-1. They found that the hydroalcoholic extract of cinnamon was effective in reducing the viral titer of HSV-1 by prevention of viral attachment to cells.

2.4 | *Syzygium aromaticum* (clove)

Clove (*Syzygiumaromaticum*), belonging to the family *Myrtaceae*, is globally used in medicine as an antiseptic against contagious diseases due to the antimicrobial activities against oral bacteria. Clove is also used in the food industry due to its antimicrobial activities for increasing shelf-life. FDA has confirmed the safety of clove buds, clove oil, eugenol, and oleoresins as a food supplement (Vijayasteltar, Nair, Maliakel, Kuttan, & Krishnakumar, 2016). The WHO has given the acceptable daily uptake of clove in humans is 2.5 mg/kg body weight (Ogunwande et al., 2005).

Clove has main phenolic compounds such as flavonoids, hidroxicinamic acids, hidroxibenzoic acids, and hidroxiphenylpropens. The main bioactive component of clove is eugenol (Neveu et al., 2010). Eugenol exhibits broad antimicrobial activities against both Gram-positive, Gram-negative, and acid-fact bacteria, as well as fungi. Cloves are well known also for their antiemetic (relieves nausea and vomiting) and carminative properties. Eugeniin, a compound isolated from the herbal extracts of *S. aromaticum*, and *Geum japonicum*, was identified as anti-Herpes Simplex Virus compound at 5 μg/mL concentration. The inhibitory action of eugeniin is on the viral DNA synthesis by acting as a selective inhibitor of the HSV-1 DNA polymerase and eugenol on viral replication and reducing infection (Kurokawa et al., 1998; Reichling et al., 2009).

2.5 | *Piper nigrum* (black pepper)

Piper is a member of family *Piperaceae* and famous as the king of spices due to its pungent smell. Black pepper is grown in many tropical regions like Brazil, Indonesia, and India. *Piper nigrum* has significant biological properties and its bioactive compounds are used medicine, preservative, and perfumery. Piperine, a dynamic alkaloid of black pepper, is widely used in the as conventional system of medicine (Ayurveda, Siddha, Unani, and Tibetan). It contains major pungent alkaloid piperine (1-peperoyl piperidine) which is known to possess many interesting pharmacological properties such as antihypertensive, anti-Alzheimer's, antidepressant, antiplatelets, anti-inflammatory, antioxidant, antipyretic, antitumor, antiasthmatic, analgesic, antimicrobial, and so on (Damanhouri & Ahmad, 2014; Jafri et al., 2019; Tiwari, Mahadik, & Gabhe, 2020; Yoo et al., 2019).

Priya and Saravana (2017) evaluated the antiviral activity of *Piper nigrum*in chloroform and methanolic extracts against vesicular stomatitis virus (an enteric virus) and human parainfluenza virus on human cell lines. They found that the anti-viral activity of *Piper nigrum* is higher in chloroform extract due to the presence of higher content ofalkaloids. According to molecular docking based study, it has been found that piperine could inhibit methyltransferase of Dengue virus and VP35 interferon inhibitory domain of Ebola virus comparative to commercial antiviral Ribavirin (Nag & Chowdhury, 2020). Rajagopal, Byran, Jupudi, and Vadivelan (2020) in a docking based study reported that the bioactive compounds from black pepper such as piperdardiine and piperanine are considerably active against COVID-19, which can be further used for its treatment.

2.6 | *Ocimum basilicum* L. (basil)

Ocimum basilicum L. (OB) is a popular medicinal herb of the family *Labiatae* which is also known as Sweet basil. The essential oils of these plant materials have been used extensively in food, perfumery, dental and oral products for many years. Basil is a natural spice that possesses antimicrobial activities as many studies have reported. The essential oils of OB have been reported to show activity against a

wide range of bacteria, fungi, and parasites. The different components of OB are used as remedies for treating disorders such as viral ocular, respiratory, and hepatic infections. *Ocimum basilicum* has been reported to contain several of interesting compounds, such as monoterpenoids (carvone, cineole, fenchone, geraniol, linalool, myrcene, and thujone), sesquiterpenoids (caryophyllene and farnesol), triterpenoid (ursolic acid), and flavonoid (apigenin) (Chiang et al., 2005).

Numerous studies showed that the aqueous and methanol extract of leaf and seed oil of basil enhances immune response by increasing T-helper and natural killer cells, lymphocyte count, phagocytic activity, neutrophil count, antibody titer, and so on against the variety of infection as a defense mechanism (Jamshidi & Cohen, 2017; Pattanayak, Behera, Das, & Panda, 2010; Vasudevan, Kashyap, & Sharma, 1999).

Ursolic acid has been reported to inhibit viral infections of herpes simplex virus (HSV)-1 and human immunodeficiency virus (HIV), as well as tumor growth (Nonotny, Vachalkova, & Biggs, 2001). Extracts and selected purified components of OB showed a broad spectrum of anti-DNA and RNA virus activities also. Three phytochemical compounds of tulsi, namely, vicenin, sorientin 4'-O-glucoside 2''-O-p-hydroxy-benzoagte, and ursolic acid showed inhibition of main protease of SARS-CoV-2 in a molecular docking study (Shree et al., 2020).

2.7 | *Allium sativum* L. (garlic)

Allium sativum L. (Garlic) family *Liliaceae* is originally from Asia but it is also cultivated in other countries, namely, China, North Africa (Egypt), Europe, and Mexico. It has been used as a medicinal agent from thousands of years. This plant is a bulb growing to 25–70 cm with flowers used as a spice and flavoring agent for foods. Garlic is having high nutritive value, improves taste of food, and also helps indigestion. Garlic is having a wide range of pharmacological effects with low toxicity such as anthelmintics, anti-inflammatory, antioxidant, antifungal, and so on (Alam, Hoq, & Uddin, 2016).

Allicin (diallyl-dithiosulfinate), which is produced by the garlic enzyme alliinase from the alliin, has been known for wide-antifungal and antiviral activities. The decreasing order of the compounds having virucidal activity in garlic was ajoene, allicin, allyl methyl thiosulfanate, and methyl allyl thiosulfanate (Gebreyohannes & Gebreyohannes, 2013). Antiviral activity of garlic extract has been studied against influenza virus A/H1N1 in cell culture and it was found that it inhibits the virus penetration and proliferation in cell culture (Mehrbod, Amini, & Tavassoti-Kheiri, 2009). The garlic extract showed inhibitory activity on infectious bronchitis virus (IBV-a coronavirus) in the chicken embryo (Shojai, Langeroudi, Karimi, Barin, & Sadri, 2016).

2.8 | *Azadirachta indica* (neem)

The neem tree botanically referred to as *Azadirachta indica* is a fast-growing evergreen herb belonging to the family *Meliaceae*. The Indian origin traditional medicinal plant neem has been used to treat several acute and chronic diseases in different parts of Asia and Africa from the ancient period. All parts of the neem tree such as seeds, roots, leaves, flowers, and bark have been used in traditional medicine as household remedies against various human ailments. They exhibit insecticidal, antimicrobial, larvicidal, antimalarial, antibacterial, antiviral, and spermicidal effects (Gupta et al., 2013).

Different terpenoids isolated from the bark of this herb include nimbin, nimbidin, nimbolide, limonoids, β-sistosterol, 6-desacetylnimbinene, nimbione, margocin, quercetin, and so on (Alzohairy, 2016). A compound from the extract of neem leaves called "hyperoside" possesses showed potential as a universal drug against influenza strains due to its free radical scavenging property. Hyperoside compound from neem leaf extract along with the chemical drugs LGH, Naproxen, BMS-885838, and BMS-883559 showed best results with conserved residues of nucleoprotein of influenza virus (Ahmad et al., 2016). The neem is an extraordinary plant and United Nations has declared neem as the "tree of the 21st century" (United Nations Environment Programme, 2012).

Due to its already proven antiviral properties and effectiveness, many scientists have started research on neem for discovering drugs against SARS-COV-2. Natural bioactive compounds, namely, methyl eugenol, oleanolic acid, and ursolic acid extracted from tulsi and neem act as inhibitors against SARS-CoV-2. These bioactive compounds function as effective inhibitors of SARS-CoV-2 by binding to the spike glycoprotein, RNA polymerase, and/or its protease which results in the prevention of both viral attachment and replication (Kumar, 2020). Approximately 20 compounds isolated from neem leaves extract showed high binding affinity against COVID-19 main protease protein which is the key protein for viral replication (Subramanian, 2020). Muralikumar, Ramakrishnamacharya, and Seshachalam (2020) screened ligands from Nimba and Amrita (*A. indica* and *T. cordifolia*) known as Nimbamritam in silico to evaluate anti-SARS-CoV-2 activity. They found that the ligand interacted and inhibited the residues of spike protease or Mpro protease of SARS-CoV-2.

2.9 | Tinospora cordifolia (giloy)

Tinospora cordifolia (giloy) is a member of the family of *Menispermaceae* and is usually found in Asian counties like India, Sri Lanka, Myanmar, and China. It is a medicinal plant native to India commonly called Guduchiand used in Ayurvedic formulations as a medicine to treat several diseases. Due to its medicinal importance, *T. cordifolia* has been highly exploited for commercial purposes and used as an effective medicine for therapies against several diseases such as jaundice, urinary disorder, skin diseases, diabetes, anemia, inflammation, allergic condition, and so on (Kumar, 2020; Sonkamble & Kamble, 2015). Different parts of *T. cordifolia*, such as leaves, stem, root, flower, seed, and so on, have all the above mentioned pharmacological activities. This plant is also used in Ayurvedic "Rasayanas" to improve the immune system and the body's resistance against infections.

Pruthvish and Gopinatha (2018) reported that the crude extract of dry stem of *T. cordifolia* showed antiviral activity against herpes simplex virus which was evaluated by MTT assay. Chowdhury (2020) evaluated the five phytoconstituents of *T. cordifolia* (giloy), namely, berberine, b-sitosterol, coline, tetrahydropalmatine, and octacosanol using molecular dynamics approach. She found that berberine can regulate 3CLpro protein's function by inhibition and subsequently control viral replication. Tinocordiside, one of the phytochemicals of giloy, showed inhibition of main protease of SARS-CoV-2 in a molecular docking study (Shree et al., 2020). Berberine, Isocolumbin, Magnoflorine, and Tinocordiside compounds isolated from Giloy showed high binding efficacy against all the four key SARS-CoV-2 target surface glycoprotein (6VSB), receptor-binding domain (6M0J), RNA dependent RNA polymerase (6M71), and main protease (6Y84) involved in virus attachment and replication (Sagar & Kumar, 2020).

3 | METHODOLOGY

A questionnaire based online survey has been conducted on home remedies during COVID-19 among people (n-531) of different age groups varying from 13–68 years from countries namely India, United Kingdom, and United States. This survey has covered 17 states (Maharashtra, Tamil Nadu, Rajasthan, Arunachal Pradesh, Gujarat, Uttar Pradesh, Madhya Pradesh, Bihar, Himachal Pradesh, Haryana, Telangana, Assam, Kerala, Punjab, Uttarakhand, Chhatisgarh, and Manipur) and two Union territories of India (Delhi and Chandigarh) which include overall 124 cities.

4 | RESULTS

Out of 531 people who have participated in the survey, 26.6% of people were tested for COVID-19 in which 7.8% of people were found positive as shown in Figure 2a. In the survey, we found that people are boosting their immunity in various ways apart from using sanitizers and wearing masks. Most people (93.6%) think that Indian spices and home remedies are helpful in the treatment of coronavirus or other viral infection as well as boosting immunity.

According to the survey, 71.8% of people are taking kadha (basil, cinnamon, black pepper, ginger, and raisin) prescribed by Ayush Ministry, India as shown in Figure 2b. Many people (52.4%) are taking kadha only one time in a day while 24.1% of people are taking kadha two times in a day. People (68.8%) are using ginger, clove, dalchini, black pepper, and tulsi in their kadha. Mostly people (86.1%) think that there is no side effect of kadha, while 13.9% think and experience the side effects of kadha, that is, acidity in the stomach, heartburn, constipation, diarrhea ulcers in mouth, and high blood pressure (especially in senior citizens). According to Ayurveda, if we take kadha in excess, then it can create problems; otherwise there are no side effects.

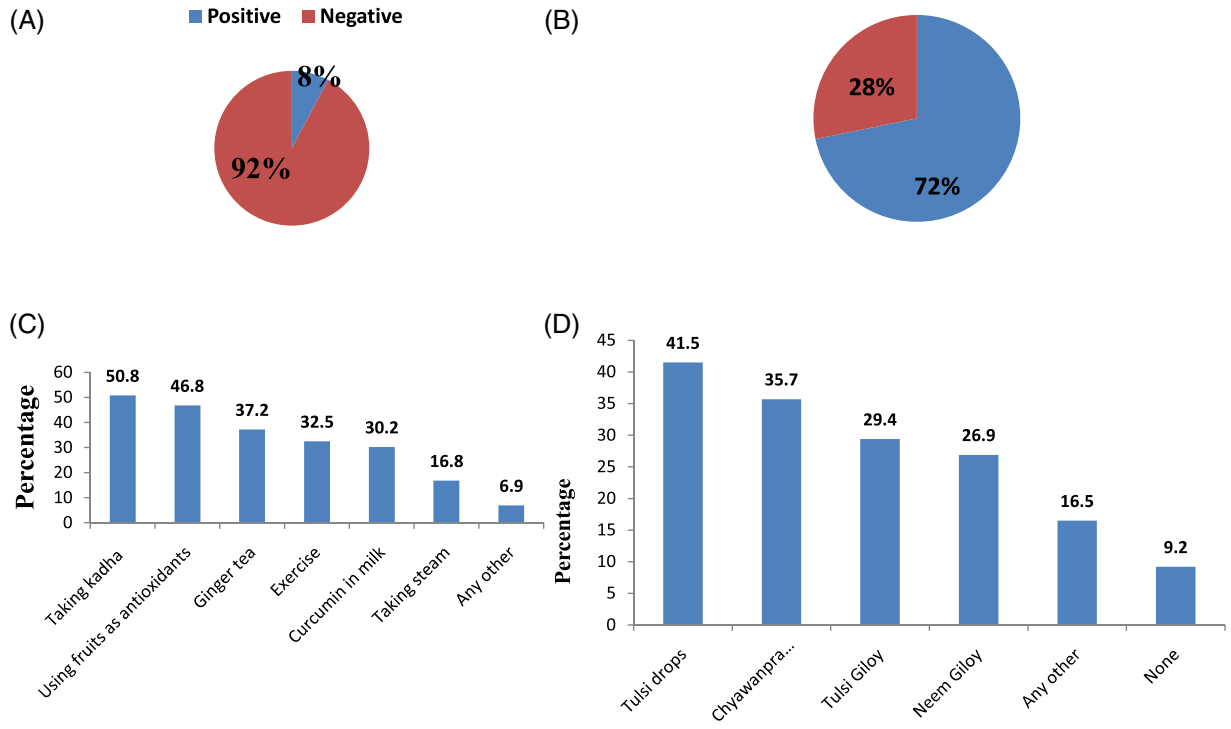

FIGURE 2 Survey Analysis on home remedies during COVID-19. (a) Coronavirus positive cases. (b) Percentage of people taking kadha. (c) Methods of boosting immunity. (d) Natural immunity boosting products [Colour figure can be viewed at wileyonlinelibrary.com]

People (83.1%) are boosting immunity by taking Amla/lemon or other fruits as a rich source of vitamin C. Vitamin C is an antioxidant that serves as an enzyme cofactor for various biochemical and physiological processes in humans (Ngo, Ripper, Cantley, & Yun, 2019). Mostly people are using tulsi drops, chyawanprash, tulsigiloy, and neemgiloy (41.5, 35.7, 29.4, and 26.9%, respectively) for boosting their immunity. Chyawanprash is an Indian Ayurvedic health supplement that is prepared by approximately 50 herbs and spices showing immunity boosting as well as antioxidant properties (Sharma et al., 2019).

5 | DISCUSSION

The coronavirus disease is highly transmittable with no effective antiviral therapy to combat the infection (Guan et al., 2020). However, in our study, we highlighted the role of spices and herbs in the treatment of COVID-19. The survey has been conducted to identify the various home remedies used during COVID-19, which include many spices and herbs.

As per our survey data, most people are taking kadha only one time a day and they are using ginger, clove, cinnamon, black pepper, and tulsi as main ingredients in kadha. We have analyzed that cinnamon, black pepper, tulsi, and turmeric play vital role against SARS-CoV-2 (COVID-19) as well as other viral infections, which was also supported by some other recent studies mentioned in Tables 1 and 2. Our findings were also well supported by Rastogi, Pandey, and Singh (2020), who proposed the use of *Tinospora cordifolia* (Giloy), *Zingiber officinale* (Ginger), *Curcuma longa* (Curcumin), and *Ocimum sanctum* (Tulsi) due to their antiviral property. Shrivastava (2020) reported that tulsi leaves increase the level of helper T cells as well as natural killer cells, which helps fight against viral infection. Tulsi is being used for curing pain, pneumonia, diarrhea, cough, and fever of ancient times, which are the common symptoms of COVID-19 (Goothy et al., 2020). Black pepper provides relaxation from sinusitis and nasal congestion, which are the most common symptoms of COVID-19 (Pathak & Khandelwal, 2007). Quercetin, a flavonoid present in black pepper, improves the body's immunity constantly due to its antiviral properties (Yao et al., 2017). Our findings were also well supported by Rajagopal et al. (2020) who recommended the consumption of black pepper and ginger in a daily diet, as it may be helpful in the prevention of coronavirus. According to our survey, people (83.1%) are boosting immunity by taking Amla/lemon or other fruits as a rich source of vitamin C for boosting their immunity. Arandomized controlled trial to carry out in the USA in 167 patients with sepsis-related ARDS indicated that uptake of ~15 g/day of vitamin C for 4 days may decrease mortality in these patients (Flower et al., 2020). A randomized, controlled clinical trial was also performed on patients with confirmed SARS-CoV-2 infection in the ICU at three hospitals in Hubei, China. They have given high-dose intravenous vitamin C, that is, 12 g of vitamin C/50 mL every 12 h for 7 days and found that the high-dose intravenous vitamin C may provide a defensive effect without any side effects in critically COVID-19 patients (Zhang et al., 2020). Utomo et al. (2020) reported that the *Citrus sp.* exhibits the best prospective as an inhibitor to the development of the SARS-CoV-2.

According to ASSOCHAM, India dipstick study spices export from India went up by 23% during COVID-19 (June 2020) compared with the same month of 2019. Major Indian spices that are transported abroad include pepper, ginger, turmeric, coriander, cumin, fennel, fenugreek, nutmeg, spice oils cardamom, and mint products. The main countries where the spices are being imported include the United States, United Kingdom, Germany, France, Italy, Canada, Australia, UAE, Iran, Singapore, China, and Bangladesh, which shows that the world is benefitted by the magical spices of India.

6 | CONCLUSIONS

In the current pandemic scenario, precautions and boosting immunity are one of the best choices to get away from COVID-19 infection. As per our study, we conclude that the uses of spices and herbs may play a significant role against viral infections. We have analyzed that cinnamon, black pepper, basil, and turmeric play a vital role against SARS-CoV-2 (COVID-19) as well as other viral infections, which was also supported by some other recent studies. In India, people are using spices as well as herbs from ancient times due to their taste, antiviral, antimicrobial, antioxidant, and immunity-boosting properties. Since ages Indians are habitual of taking these natural products that have conferred immunity in the Indian population, which probably is the major cause for low mortality in India. However, the excessive use of spices and herbs may cause various side effects, namely, acidity in the stomach, heartburn, constipation, diarrhea ulcers in the mouth, high blood pressure, and so on. Therefore, detailed studies about the bioactive compounds present in common Indian herb and spices and their effectiveness and mode of action against lethal viruses need to be explored.

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CONFLICT OF INTEREST

The authors do not have a conflict of interest.

AUTHOR CONTRIBUTIONS

Dr. Namita Ashish Singh conceived, conducted, and analyzed the questionnaire results of the survey. Dr. Pradeep Kumar was involved in questionnaire analysis, review and editing. The original draft was written by Jyoti, while Dr. Naresh Kumar was involved in the review and editing of the manuscript.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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