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LETTER TO THE EDITOR

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Phytotherapeutic options for the treatment of COVID-19: A concise viewpoint

In December 2019 in Wuhan city of China, a novel coronavirus emerged which was provisionally named as 2019-nCoV responsible for causing the Coronavirus Disease-2019 (COVID-19). As of May 2020, the WHO reported more than 4 million positive cases of COVID-19 all over the world.

Currently, no vaccine exists for the treatment of COVID-19 and limited therapeutic options are available (Li & De Clercq, 2020). For centuries, traditional medicines have been used to cure several diseases including viral infections (Ahmad et al., 2020). The phytotherapy-based approach to find new drugs have contributed as several plant species are a great source of modern medicines (Yaseen et al., 2019). Similarly, plant-derived active compounds have been studied as viral inhibitors for many years (Serkedjieva, Manolova, Zgórniak-Nowosielska, Zawilińska, & Grzybek, 1990). This study was aimed to briefly describe the potential use of ethno-medicinal research in searching new therapeutic options against COVID-19 and other coronaviruses and to provide some important directions to researcher for planning future studies. We have summarized various medicinal plants and their reported antiviral activities in Table 1. There is the possibility that studies on plant-derived compounds listed in Table 1 have been not carried according to more recent scientific qualitative standards for plant-derived products (Heinrich et al., 2020). For example, there is the possibility that high concentrations or doses have been used. The antiviral activities of medicinal plants have been mostly derived from laboratory studies (as clinical data are limited) and referred to multicomponent preparation of traditional medicines (Liu, Zhang, He, & Li, 2012). Similarly, the qualitative standards for reporting clinical trials in herbal medicine are not as rigorous as in the conventional pharmaceutical field (Williamson, Liu, & Izzo, 2020). In a study in 2012, it was reported that traditional herbal remedies along with Western medicines could help to improve symptoms, absorptions of pulmonary infiltrations, life-quality, and decrease corticosteroids uses in SARS patients (Liu et al., 2012).

The Traditional Chinese Medicines (TCM) were highly considered by Government of China in their campaign against COVID-19. To evaluate the safety and efficacy of treatments for COVID-19 patients, China launched more than 300 clinical trials on March 1, 2020. Among the total treatments, 16.5% (50 trials) were linked to the use TCM where 4.6% (14 cases) were linked to examine the combine use of Western medicine and TCM. Among the trials of TCM, 22 (7.3%) were launched to evaluate the efficacy of self-made herbal preparations including QingYi-4, Xin Guan-1 Formula and Xin Guan-2 Formula. The commercially available TCM products like Lian Hua Qing Wen capsules and Tan Re Qing injections were also studied in 14 (4.6%) trials (Yang et al., 2020). The therapeutic effects of TCM herbal remedies for the treatment of SARS coronavirus have also been published (Luo et al., 2020; Yang et al., 2020). Regardless the complex formulation of TCM, herbs such as *Scutellaria baicalensis* and *Glycyrrhiza glabra* were available in tested TCM preparations. The extracted baicalin and glycyrrhizin compounds from the mentioned herbs have in vitro evidences of anticoronaviral activity (Chen et al., 2004). The anti-coronavirus TCM remedies included plants such as *Lonicerae japonicae*, *Saposhnikovia divaricate*, *Forsythia Vahl*, and *Atractylodis macrocephalae* (Luo et al., 2020). This could identify new directions for future research.

For the treatment of coronavirus infections, two different research streams could be possibly followed to search useful phytotherapeutic compounds. One option is the herbal remedies that have potential preventive effects especially boosting the immune responses, that is, *Echinacea purpurea* and *Astragalus membranaceus* (Block & Mead, 2003). Astragals has been used in TCM herbal formulation against SARS (Liu et al., 2012). Immunomodulatory properties of polysaccharides and Uncaria tomentosa (from medicinal mushrooms) could also be used. The second option is the herbal remedies with therapeutic effects that have different antiviral mechanism of action. Regardless the etiology, clinical studies have proposed extract from plants, such as *Pelargonium sidoides* and *Sambucus nigra* to treat the infection of respiratory system (Agbabiaka, Guo, & Ernst, 2008; Hawkins, Baker, Cherry, & Dunne, 2019; Kalus et al., 2009). The anti-coronaviral activities of polyphenols and pelargonium has also been studied (Michaelis, Doerr, & Cinatl Jr, 2011; Weng et al., 2019). A set of compounds such as quercetin, kaempferol, and cryptotanshinone have been identified with anti-SARS-CoV action (Zhang, Wu, Zhang, Deng, & Peng, 2020). Active compounds derived from medicinal plants has different antiviral mechanisms, such as viral pentation inhibition, replication inhibition or inhibiting the SARS-3CLpro activity (Yang et al., 2020). Such studies can expand the area of plant-based products to be investigated in future experiments. Similarly, the phytotherapy can be useful in the management or prevention the adverse effects of conventional drugs (Yang et al., 2020).

Abbreviations: ADV, Aleutian disease virus; CMV, Cytomegalovirus; CVB, Coxsackie B virus; CXV, Cactus X virus; ESV, Espirito Santo virus; HBV, Hepatitis B virus; HIV, human immunodeficiency virus; HSV, Herpes simplex virus; JEV, Japanese encephalitis virus; KSHV, Kaposi sarcoma herpes virus; PV, polio virus; RSV, respiratory syncytial virus; SARS-CoV, severe acute respiratory syndrome coronavirus; VHSH, viral hemorrhagic septicemia virus; VSV, vesicular stomatitis virus; VV, vaccinia virus; VZV, varicella zoster virus.

TABLE 1 Medicinal plants and reported antiviral compounds

S. No.	Plant name	Family	Active compounds	Effective against virus	References
1	*Plantago major* L.	Plantaginaceae	Caffeic acid, chlorogenic acid	HSV-I, HSV-II, ADV-III, and ADV-II	Nazarizadeh, Mikaili, Moloudizargari, Aghajanshakeri, & Javaherypour, 2013; Samuelsen, 2000
2	*Solanum torvum*	Solanaceae	Torvanol-A, Torvanol-H	HSV-I	Ikeda et al., 2000
3	*Euphorbia jokini*	*Euphorbiaceae*	Diterpenes, putranjivain A	HSV-II	Cheng et al., 2004
4	*Cassia javanica*	Caesalpiniaceae	Ent-epiafzel-echin(4a-8) epiafzelechin(EEE,S)	HSV-II	Kashiwada et al., 1990
5	*Melaleuca alternifolia*	Myrtaceae	Isoborneal	HSV-I	Hammer, Carson, & Riley, 2002
6	*Phylanthus amarus*	Phyllanthaceae	Elgic acid	HBV	Blumberg, Millman, Venkates, & Thyagarajan, 1990
7	*Bohmeria nivea*	Urticaceae		HBV	Chang, Huang, Yuan, Lai, & Hung, 2010
8	*Camellia sinensis*	Theaceae	Tannic acid, theaflavin 3 gallate, theaflavin-33-gallate	HIV, HCV, influenza	Oh et al., 2013
9	*Dryopteris crassirhizoma*	Dryopteridaceae	Kampferol	HIV	Min, Tomiyama, Nakamura, & Hattori, 2001
10	*Paeonia lactiflora*	Paeoniaceae	Penta-*o*-gallyl-βD-glucose	HBV	Lee, Lee, Jung, & Mar, 2006
11	*Verbescum thapsiforme*	Scrophulariaceae	Iridoid, phenyl thanoid	HSV-I, influenza A and B, H7N	Zgorniak-Nowosielska, Grzybek, Manolova, Serkedjieva, & Zawilińska, 1991
12	*Radix glycyrrhiza*	Fabaceae	Glycyrrhizin	Influenza, SARS-CoV	Fang et al., 2007; Yang, Islam, Wang, Li, & Chen, 2020
13	*Aesculus chinensis*	Sapindaceae	Flavonoids	RSV, influenza, rubella	Liu, Wang, Lee, Wang, & Du, 2008; Wei et al., 2004
14	*Melia azedarach*	Meliaceae	Meliacine, cinnamoyl dihydroxymeliacarpin	HSV-I and HSV-II, Junin virus, Sindbis virus, VSV, poliovirus, pseudorabies virus, tacaribe virus	Andrei, Coto, & de Torres, 1985; Andrei, Damonte, de Torres, & Coto, 1988; Andrei, Lampuri, Coto, & De Torres, 1986; Castilla, Barquero, Mersich, & Coto, 1998
15	*Humulus lupulus*	Cannabaceae	Xanthohumol	HSV and HIV	Wang, Ding, Liu, & Zheng, 2004
16	*Melissa officinalis*	Lamiaceae	Citral a, citral b, citronellal, monoterpenes, aldehydes, lemon balm oil	HSV	Cohen, Kucera, & Herrmann, 1964
17	*Prunella vulgari*	Lamiaceae	Rosmarinic acid, phenol like apigenin, luteolin derivatives	HIV	Yao, Wainberg, & Parniak, 1992
18	*Geum japonicum*	Rosaceae	Ursolic acid, maslinic acid	CMV	Yukawa et al., 1996
19	*Ocimum basilicum*	Lamiaceae	Ursolic acid (HSV-I), apigenin (HSV-II)	HSV-I and HSV-II	Yucharoen, Anuchapreeda, & Tragoolpua, 2011
20	*Glycyrrhiza glabra*	Fabaceae	Glycyrrhizic acid	VV, HSV, VSV, VZV, SARS-COV, KSHV, HIV-I HIV-II, and influenza virus	Fiore et al., 2008
21	*Stephania cepharantha*	Menispermaceae	Cepharathine	HSV-I, CVB-3, HIV, SARS-CoV	Ma et al., 2002
22	*Stylogne cauliflora*		Oligophenols are involved in antiviral activity	HCV	M Patil, Masand, & Prakash Gupta, 2016

(Continues)

TABLE 1 (Continued)

S. No.	Plant name	Family	Active compounds	Effective against virus	References
23	*Pithecellobium clypearia*	Leguminosae	7-ogalloyltricetifavan 7,4-di-ogalloylricetifavan	HSV-I, HSV-II, Junin virus, HBV, tacaribe virus	Leung et al., 2006; Li, Leung, Yao, Ooi, & Ooi, 2006
24	*Humulus lupulus*	Cannabaceae	Xanthohumol	HIV	Wang et al., 2004
25	*Melissa officinalis*	Labiatae	Citral a, citral b,citronellal, monoterpenes, aldehydes, lemon balm oil	HSV	Allahverdiyev, Duran, Ozguven, & Koltas, 2004
26	*Prunella vulgaris*	Ericaceae	Rosmarinic acid, phenol like apigenin, luteolin derivatives	HSV-I	Xu, Lee, Lee, White, & Blay, 1999
27	*Geum japonicum*	Rosaceae	Triterpenes	HIV	Xu, Zeng, Wan, & Sim, 1996
28	*Ocimum basilicum*	Lamiaceae	Ursolic acid (HSV-I), apigenin (HSV-II)	HSV-I and HSV-II	Yucharoen et al., 2011
29	*Olea europea*	Oleaceae	Oleuropein, leaf extract	VHSH	Antunes et al., 2017
30	*Glycine max*	Leguminosae		ADV-I, CXV-B1	Müller et al., 2007
31	*Lycoris radiata*	Amaryllidaceae	Lycorine and alkaloids; 2αmethoxy-6-oethyloduline, 2αmethoxy-6-omethyloduline, trispherine	SARS-CoV, influenza	He et al., 2013
32	*Blumea laciniate*	Asteraceae	Polyphenols	RSV	Li, Ooi, Wang, But, & Ooi, 2004
33	*Geranium sanguineum*	Geraniaceae	Polyphenols	RSV, influenza	Chattopadhyay et al., 2009
34	*Phyllanthus nanus*	Euphorbiaceae		HBV	Lam et al., 2006
35	*Ardisia chinensis*	Primulaceae	Phenolics	HBV	Leung et al., 2006
36	*Alisma orientalis*	Alismataceae	25-anhydroanisol, 13b,17b-epoxyalisol, alisol b-23-acetate, alisol F24 acetate, alisol F	HBV	Jiang et al., 2006
37	*Acacia nilotica*	Fabaceae	Silybin, oxymatrine	HCV	Rehman, Ashfaq, Riaz, Javed, & Riazuddin, 2011
38	*Nerium indicum*	Apocynaceae	Caffeoylquinic acid, quercetin, luteolin-5o-rutinisid	Influenza, HIV,HSV	Farahani, 2014; Kitazato, Wang, & Kobayashi, 2007
39	*Elephantopus scabe*	Asteraceae	Polyphenols	RSV	Li, 2005
40	*Eleutherococcs senticosus*	Araliaceae	Ethanolic extract of roots	HRV, RSV, influenza virus A	Glatthaar-Saalmüller, Sacher, & Esperester, 2001
41	*Syzygium aromaticum*	Myrtaceae	Eugeniin	HSV-I, EBV	Carvalho, Andrade, de Sousa, & de Sousa, 2015; Kurokawa et al., 1998
42	*Azadiracta indica*	Meliaceae	Aqueous extract of leaves, azadiractin	Dengue virus	Parida, Upadhyay, Pandya, & Jana, 2002
43	*Momordia charantia*	Cucurbitaceae	Lectin MA30	Influenza	Ahmad, Javed, Rao, & Husnain, 2016
44	*Euphorbia segetalis*	Euphorbiaceae	Lupenone	HSV-I and HSV-II	Álvarez, Habtemariam, & Parra, 2015

(Continues)

TABLE 1 (Continued)

S. No.	Plant name	Family	Active compounds	Effective against virus	References
45	*Guazuma ulmifolia*	Malvaceae	Ethyl acetate extract	PV	Felipe et al., 2006
46	*Argimonia pilosa*	Rosaceae	Polyphenols	Influenza virus A and B	Shin, Lee, Park, & Seong, 2010
47	*Punica granatum*	Lythraceae	Polyphenols	HSV-I, norovirus	Živković et al., 2018
48	*Myrica rubra*	Myricaceae	Rodelphinidin-di-ogallate	HSV-I	Cheng et al., 2003
49	*Podophyllum peltatum*	Berberidaceae	Podohyllotoxin	Measles, HSV	Bedows & Hatfield, 1982
50	*Psiadia dentate*	Asteraceae	3-methylkaemfero	PV	Robin, Boustie, Amoros, & Girre, 1998
51	*Loranthus yadoriki*	Loranthaceae	Camp B,C	Coxsackie virus	Wang, Yang, Huang, Wen, & Liu, 2000
52	*Scutellaia baicalensis*	Lamiaceae	Isoscutellarein-8methyl ether (5,7,4trihydroxy-8methoxyflavone)	Influenza A	Nagai, Moriguchi, Suzuki, Tomimori, & Yamada, 1995
53	*Poncirus trifoliate*	Rutaceae	Flavonoids, coumarins, and triterpenoid	Influenza	Heo et al., 2018
54	*Dianella longifolia*	Asphodelaceae	Chrysophanic acid	PV	Semple, Pyke, Reynolds, & Flower, 2001
55	*Callophylum lanigerum*	Calophyllaceae	Calinode A-1, calonide B-4	HIV-I	Kashman et al., 1992
56	*Curcuma longa*	Zingiberaceae	Curcumin, curcuminoids	HIV-I, HBV, influenza	Zorofchian Moghadamtousi et al., 2014
57	*Dropteris crassirhizoma*	Dryopteridaceae	Dryocrassin ABBA, Extract, kaemferol acethylrhamnoside	Dengue virus	Maryam et al., 2020
58	*Scutellaria baicalensis*	Lamiaceae	Baicalin, isosceutellarei n-8-methylether, wagonin, oroxylin A	Influenza A and B, RSV, hepatitis B	Hour et al., 2013; Ma et al., 2002
59	*Urtica dioica*	Urticaceae	*n*-acethylglucosamine	HIV-I, HIV-II, influenza A	De Clercq, 2000; Rajbhandari et al., 2009
60	*Brazilian propolis*	Asteraceae	Moronic acid, kaemferol	HIV, influenza virus	Ito et al., 2001; Kai et al., 2014
61	*Artemisia annua L.*	Asteraceae	friedelan3-β-ol, artemetin, and quercetagetin 6,7,3′,4′-tetramethyl ether	SARS-CoV	Wang et al., 2007
62	*Lycoris radiate*	Amaryllidaceae	Lycorine, glycyrrhizin	SARS-CoV	Shahrajabian, Sun, Shen, & Cheng, 2020
63	*Glycyrrhiza uralensis*	Fabaceae		HIV, RSV, SARS-CoV	Hoever et al., 2005; Ma et al., 2002

Abbreviations: ADV, Aleutian disease virus; CMV, Cytomegalovirus; CVB, Coxsackie B virus; CXV, Cactus X virus; HBV, Hepatitis B virus; HIV, human immunodeficiency virus; HSV, Herpes simplex virus; KSHV, Kaposi sarcoma herpes virus; SARS-CoV, severe acute respiratory syndrome coronavirus; PV, polio virus; RSV, respiratory syncytial virus; VHSH, viral hemorrhagic septicemia virus; VSV, vesicular stomatitis virus; VV, vaccinia virus.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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REFERENCES

Agbabiaka, T. B., Guo, R., & Ernst, E. (2008). Pelargonium sidoides for acute bronchitis: A systematic review and meta-analysis. *Phytomedicine*, *15*, 378–385.

Ahmad, A., Javed, M. R., Rao, A. Q., & Husnain, T. (2016). Designing and screening of universal drug from neem (*Azadirachta indica*) and standard drug chemicals against influenza virus nucleoprotein. *BMC Complementary and Alternative Medicine*, *16*, 519.

Ahmad, S., Zafar, M., Shinwari, S., Ahmad, M., Shinwari, Z. K., Sultana, S., & Butt, M. A. (2020). Ethno-medicinal plants and traditional knowledge linked to primary health care among the indigenous communities living in Western hilly slopes of Dera Ghazi Khan, Pakistan. *Pakistan Journal of Botany*, *52*, 519–530.

Allahverdiyev, A., Duran, N., Ozguven, M., & Koltas, S. (2004). Antiviral activity of the volatile oils of *Melissa officinalis* L. against herpes simplex virus type-2. *Phytomedicine*, *11*, 657–661.

Álvarez, Á. L., Habtemariam, S., & Parra, F. (2015). Inhibitory effects of lupene-derived pentacyclic triterpenoids from *Bursera simaruba* on HSV-1 and HSV-2 in vitro replication. *Natural Product Research*, *29*, 2322–2327.

Andrei, G., Coto, C., & de Torres, R. (1985). Antiviral activity and cytotoxicity assays of crude and partial purified extracts of *Melia azedarach* L. green leaves. *Revista Argentina de Microbiología*, *17*, 187–194.

Andrei, G., Lampuri, J., Coto, C., & De Torres, R. (1986). An antiviral factor from *Melia azedarach* L. prevents Tacaribe virus encephalitis in mice. *Experientia*, *42*, 843–845.

Andrei, G. M., Damonte, E. B., de Torres, R. A., & Coto, C. E. (1988). Induction of a refractory state to viral infection in mammalian cells by a plant inhibitor isolated from leaves of *Melia azedarach* L. *Antiviral Research*, *9*, 221–231.

Bedows, E., & Hatfield, G. (1982). An investigation of the antiviral activity of *Podophyllum peltatum*. *Journal of Natural Products*, *45*, 725–729.

Block, K. I., & Mead, M. N. (2003). Immune system effects of echinacea, ginseng, and astragalus: A review. *Integrative Cancer Therapies*, *2*, 247–267.

Blumberg, B., Millman, I., Venkates, P., & Thyagarajan, S. (1990). Hepatitis B virus and primary hepatocellular carcinoma: Treatment of HBV carriers with *Phyllanthus amarus*. *Vaccine*, *8*, S86–S92.

Carvalho, A. A., Andrade, L. N., de Sousa, É. B., & de Sousa, D. P. (2015). Antitumor phenylpropanoids found in essential oils. *BioMed Research International*, *2015*. https://doi.org/10.1155/2015/392674

Castilla, V., Barquero, A. A., Mersich, S. E., & Coto, C. E. (1998). In vitro anti-Junin virus activity of a peptide isolated from *Melia azedarach* L. leaves. *International Journal of Antimicrobial Agents*, *10*, 67–75.

Chang, J.-M., Huang, K.-L., Yuan, T. T.-T., Lai, Y.-K., & Hung, L.-M. (2010). The anti-hepatitis B virus activity of *Boehmeria nivea* extract in HBV-viremia SCID mice. *Evidence-Based Complementary and Alternative Medicine*, *7*, 189–195.

Chattopadhyay, D., Chawla-Sarkar, M., Chatterjee, T., Dey, R. S., Bag, P., Chakraborti, S., & Khan, M. T. H. (2009). Recent advancements for the evaluation of anti-viral activities of natural products. *New Biotechnology*, *25*, 347–368.

Chen, F., Chan, K. H., Jiang, Y., Kao, R. Y., Lu, H. T., Fan, K. W., … Yuen, K. Y. (2004). In vitro susceptibility of 10 clinical isolates of SARS coronavirus to selected antiviral compounds. *Journal of Clinical Virology*, *31*, 69–75.

Cheng, H.-Y., Lin, T.-C., Ishimaru, K., Yang, C.-M., Wang, K.-C., & Lin, C.-C. (2003). In vitro antiviral activity of prodelphinidin B-2 3, 3′-di-O-gallate from *Myrica rubra*. *Planta Medica*, *69*, 953–956.

Cheng, H.-Y., Lin, T.-C., Yang, C.-M., Wang, K.-C., Lin, L.-T., & Lin, C.-C. (2004). Putranjivain A from Euphorbia jolkini inhibits both virus entry and late stage replication of herpes simplex virus type 2 in vitro. *Journal of Antimicrobial Chemotherapy*, *53*, 577–583.

Cohen, R. A., Kucera, L. S., & Herrmann, E. C., Jr. (1964). Antiviral activity of *Melissa officinalis* (Lemon Balm) extract. *Proceedings of the Society for Experimental Biology and Medicine*, *117*, 431–434.

De Clercq, E. (2000). Current lead natural products for the chemotherapy of human immunodeficiency virus (HIV) infection. *Medicinal Research Reviews*, *20*, 323–349.

Fang, B.-H., Qiu, L.-C., Chen, J.-X., Chen, L.-Z., Zeng, Z.-L., & Chen, Z.-L. (2007). The anti-influenza H9N2 virus effects of active compounds from Radix Glycyrrhizae. *Guangdong Agricultural Sciences*, *03*, 3. http://en.cnki.com.cn/Journal_en/D-D000-GDNY-2007-03.htm

Farahani, M. (2014). Anti-herpes simplex virus effect of Camellia sinesis, Echiumamoenum and *Nerium oleander*. *Journal of Applied & Environmental Microbiology*, *2*, 102–105.

Felipe, A. M. M., Rincão, V. P., Benati, F. J., Linhares, R. E. C., Galina, K. J., De Toledo, C. E. M., … Nozawa, C. (2006). Antiviral effect of Guazuma ulmifolia and *Stryphnodendron adstringens* on poliovirus and bovine herpesvirus. *Biological and Pharmaceutical Bulletin*, *29*, 1092–1095.

Fiore, C., Eisenhut, M., Krausse, R., Ragazzi, E., Pellati, D., Armanini, D., & Bielenberg, J. (2008). Antiviral effects of Glycyrrhiza species. *Phytotherapy Research: An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural Product Derivatives*, *22*, 141–148.

Glatthaar-Saalmüller, B., Sacher, F., & Esperester, A. (2001). Antiviral activity of an extract derived from roots of *Eleutherococcus senticosus*. *Antiviral Research*, *50*, 223–228.

Hammer, K., Carson, C., & Riley, T. (2002). In vitro activity of Melaleuca alternifolia (tea tree) oil against dermatophytes and other filamentous fungi. *Journal of Antimicrobial Chemotherapy*, *50*, 195–199.

Hawkins, J., Baker, C., Cherry, L., & Dunne, E. (2019). Black elderberry (*Sambucus nigra*) supplementation effectively treats upper respiratory symptoms: A meta-analysis of randomized, controlled clinical trials. *Complementary Therapies in Medicine*, *42*, 361–365.

He, J., Qi, W. B., Wang, L., Tian, J., Jiao, P. R., Liu, G. Q., … Liao, M. (2013). Amaryllidaceae alkaloids inhibit nuclear-to-cytoplasmic export of ribonucleoprotein (RNP) complex of highly pathogenic avian influenza virus H5N1. *Influenza and Other Respiratory Viruses*, *7*, 922–931.

Heinrich, M., Appendino, G., Efferth, T., Fürst, R., Izzo, A. A., Kayser, O., … Viljoen, A. (2020). Best practice in research – Overcoming common challenges in phytopharmacological research. *Journal of Ethnopharmacology*, *246*, 112230.

Heo, Y., Cho, Y., Ju, K., Cho, H., Park, K. H., Choi, H., … Kim, Y. B. (2018). Antiviral activity of *Poncirus trifoliata* seed extract against oseltamivir-resistant influenza virus. *Journal of Microbiology*, *56*, 586–592.

Hoever, G., Baltina, L., Michaelis, M., Kondratenko, R., Baltina, L., Tolstikov, G. A., … Cinatl, J. (2005). Antiviral activity of glycyrrhizic acid derivatives against SARS– coronavirus. *Journal of Medicinal Chemistry*, *48*, 1256–1259.

Hour, M.-J., Huang, S.-H., Chang, C.-Y., Lin, Y.-K., Wang, C.-Y., Chang, Y.-S., & Lin, C.-W. (2013). Baicalein, ethyl acetate, and chloroform extracts of Scutellaria baicalensis inhibit the neuraminidase activity of pandemic 2009 H1N1 and seasonal influenza a viruses. *Evidence-Based Complementary and Alternative Medicine*, *2013*. https://doi.org/10.1155/2013/750803

Ikeda, T., Ando, J., Miyazono, A., Zhu, X. H., Tsumagari, H., Nohara, T., … Uyeda, M. (2000). Anti-herpes virus activity of solanum steroidal glycosides. *Biological and Pharmaceutical Bulletin*, *23*, 363–364.

Ito, J., Chang, F.-R., Wang, H.-K., Park, Y. K., Ikegaki, M., Kilgore, N., & Lee, K.-H. (2001). Anti-AIDS agents. 48. Anti-HIV activity of moronic acid derivatives and the new melliferone-related triterpenoid isolated from Brazilian propolis. *Journal of Natural Products*, *64*, 1278–1281.

Jiang, Z.-Y., Zhang, X.-M., Zhang, F.-X., Liu, N., Zhao, F., Zhou, J., & Chen, J.-J. (2006). A new triterpene and anti-hepatitis B virus active compounds from Alisma orientalis. *Planta Medica*, *72*, 951–954.

Kai, H., Obuchi, M., Yoshida, H., Watanabe, W., Tsutsumi, S., Park, Y. K., … Kurokawa, M. (2014). In vitro and in vivo anti-influenza virus activities of flavonoids and related compounds as components of Brazilian propolis (AF-08). *Journal of Functional Foods*, *8*, 214–223.

Kalus, U., Grigorov, A., Kadecki, O., Jansen, J.-P., Kiesewetter, H., & Radtke, H. (2009). *Cistus incanus* (CYSTUS052) for treating patients with infection of the upper respiratory tract: A prospective, randomised, placebo-controlled clinical study. *Antiviral Research*, *84*, 267–271.

Kashiwada, Y., Iizuka, H., Yoshioka, K., Chen, R.-F., Nonaka, G.-i., & Nishioka, I. (1990). Tannins and related compounds. XCIII: Occurrence of Enantiomeric Proanthocyanidins in the Leguminosae plants, *Cassia fistula* L. and *C. javanica* L. *Chemical and Pharmaceutical Bulletin*, *38*, 888–893.

Kashman, Y., Gustafson, K. R., Fuller, R. W., Cardellina, J. H., McMahon, J. B., Currens, M. J., … Boyd, M. R. (1992). The calanolides, a novel HIV-inhibitory class of coumarin derivatives from the tropical rainforest tree, Calophyllum lanigerum. *Journal of Medicinal Chemistry*, *35*, 2735–2743.

Kitazato, K., Wang, Y., & Kobayashi, N. (2007). Viral infectious disease and natural products with antiviral activity. *Drug Discoveries & therapeutics*, *1*, 14–22.

Kurokawa, M., Hozumi, T., Basnet, P., Nakano, M., Kadota, S., Namba, T., … Shiraki, K. (1998). Purification and characterization of Eugeniin as an anti-herpesvirus compound from Geum japonicum and *Syzygium aromaticum*. *Journal of Pharmacology and Experimental Therapeutics*, *284*, 728–735.

Lam, W. Y., Leung, K. T., Law, P. T. W., Lee, S. M. Y., Chan, H. L. Y., Fung, K. P., … Waye, M. M. Y. (2006). Antiviral effect of Phyllanthus nanus ethanolic extract against hepatitis B virus (HBV) by expression microarray analysis. *Journal of Cellular Biochemistry*, *97*, 795–812.

Lee, S.-J., Lee, H.-K., Jung, M.-K., & Mar, W. (2006). In vitro antiviral activity of 1, 2, 3, 4, 6-penta-O-galloyl-β-D-glucose against hepatitis B virus. *Biological and Pharmaceutical Bulletin*, *29*, 2131–2134.

Leung, K., Chiu, L. C., Lam, W., Li, Y., Sun, S. S., & Ooi, V. E. (2006). In vitro antiviral activities of Chinese medicinal herbs against duck hepatitis B virus. *Phytotherapy Research: An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural Product Derivatives*, *20*, 911–914.

Li, G., & De, C. E. (2020). Therapeutic options for the 2019 novel coronavirus (2019-nCoV). *Nature Reviews Drug Discovery*, *19*(3), 149–150. http://dx.doi.org/10.1038/d41573-020-00016-0.

Li, Y. (2005). Antiviral Screening of Medicinal Herbs Traditionally Used in South China. *Antiviral agents from selected Chinese herbal medicines*, 1st, 1st, 43–50). ProQuest Information and Learning Company 300 North Zeeb Road P.O. Box 1346 Ann Arbor, MI 48106-134: The Chinese University of Hong Kong (Hong Kong). https://search.proquest.com/openview/60a3ba8059f9aeaee53e0f93db0a79c4/1?pq-origsite=gscholar&cbl=18750&diss=y.

Li, Y., Leung, K.-T., Yao, F., Ooi, L. S., & Ooi, V. E. (2006). Antiviral flavans from the leaves of Pithecellobium c lypearia. *Journal of Natural Products*, *69*, 833–835.

Li, Y., Ooi, L. S., Wang, H., But, P. P., & Ooi, V. E. (2004). Antiviral activities of medicinal herbs traditionally used in southern mainland China. *Phytotherapy Research: An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural Product Derivatives*, *18*, 718–722.

Liu, A.-L., Wang, H.-D., Lee, S. M., Wang, Y.-T., & Du, G.-H. (2008). Structure-activity relationship of flavonoids as influenza virus neuraminidase inhibitors and their in vitro anti-viral activities. *Bioorganic & Medicinal Chemistry*, *16*, 7141–7147.

Liu, X., Zhang, M., He, L., & Li, Y. (2012). Chinese herbs combined with Western medicine for severe acute respiratory syndrome (SARS). *Cochrane Database of Systematic Reviews*, (12). https://www.cochranelibrary.com/cdsr/doi/10.1002/14651858.CD004882.pub3/epdf/full.

Luo, H., Q-l, T., Y-x, S., S-b, L., Yang, M., Robinson, N., & J-p, L. (2020). Can Chinese medicine be used for prevention of corona virus disease 2019 (COVID-19)? A review of historical classics, research evidence and current prevention programs. *Chinese Journal of Integrative Medicine*, *26*(4), 243–250.

M Patil, V., Masand, N., & Prakash Gupta, S. (2016). HCV inhibitors: Role of compounds from botanical sources. *Current Topics in Medicinal Chemistry*, *16*, 1402–1409.

Ma, C. M., Nakamura, N., Miyashiro, H., Hattori, M., Komatsu, K., Kawahata, T., & Otake, T. (2002). Screening of Chinese and Mongolian herbal drugs for anti-human immunodeficiency virus type 1 (HIV-1) activity. *Phytotherapy Research: An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural Product Derivatives*, *16*(2), 186–189. https://doi.org/10.1002/ptr.922.

Ma, S.-C., du, J., But, P. P. H., Deng, X. L., Zhang, Y. W., Ooi, V. E. C., … Lee, S. F. (2002). Antiviral Chinese medicinal herbs against respiratory syncytial virus. *Journal of Ethnopharmacology*, *79*, 205–211.

Maryam, M., Te, K. K., Wong, F. C., Chai, T. T., Gary, K., & Gan, S. C. (2020). Antiviral activity of traditional Chinese medicinal plants Dryopteris crassirhizoma and *Morus alba* against dengue virus. *Journal of Integrative Agriculture*, *19*, 1085–1096.

Michaelis, M., Doerr, H. W., & Cinatl, J., Jr. (2011). Investigation of the influence of EPs® 7630, a herbal drug preparation from Pelargonium sidoides, on replication of a broad panel of respiratory viruses. *Phytomedicine*, *18*, 384–386.

Micol, V., Caturla, N., Pérez-Fons, L., Más, V., Pérez, L., & Estepa, A. 2005 The olive leaf extract exhibits antiviral activity against viral haemorrhagic septicaemia rhabdovirus (VHSV). *Antiviral research*, 66 (2–3), 129–136.

Min, B.-S., Tomiyama, M., Nakamura, N., & Hattori, M. (2001). Kaempferol acetylrhamnosides from the rhizome of Dryopteris crassirhizoma and their inhibitory effects on three different activities of human immunodeficiency virus-1 reverse transcriptase. *Chemical and Pharmaceutical Bulletin*, *49*, 546–550.

Müller, V., Chávez, J. H., Reginatto, F. H., Zucolotto, S. M., Niero, R., Navarro, D., … Simões, C. M. O. (2007). Evaluation of antiviral activity of South American plant extracts against herpes simplex virus type 1 and rabies virus. *Phytotherapy Research*, *21*, 970–974.

Nagai, T., Moriguchi, R., Suzuki, Y., Tomimori, T., & Yamada, H. (1995). Mode of action of the anti-influenza virus activity of plant flavonoid, 5, 7, 4′-trihydroxy-8-methoxyflavone, from the roots of Scutellaria baicalensis. *Antiviral Research*, *26*, 11–25.

Nazarizadeh, A., Mikaili, P., Moloudizargari, M., Aghajanshakeri, S., & Javaherypour, S. (2013). Therapeutic uses and pharmacological properties of *Plantago major* L. and its active constituents. *Journal of Basic and Applied Scientific Research*, *3*, 212–221.

Oh, E.-G., Kim, K. L., Shin, S. B., Son, K. T., Lee, H. J., Kim, T. H., … Kim, J. H. (2013). Antiviral activity of green tea catechins against feline calicivirus as a surrogate for norovirus. *Food Science and Biotechnology*, *22*, 593–598.

Parida, M., Upadhyay, C., Pandya, G., & Jana, A. (2002). Inhibitory potential of neem (*Azadirachta indica* Juss) leaves on dengue virus type-2 replication. *Journal of Ethnopharmacology*, *79*, 273–278.

Rajbhandari, M., Mentel, R., Jha, P. K., Chaudhary, R. P., Bhattarai, S., Gewali, M. B., … Lindequist, U. (2009). Antiviral activity of some plants used in Nepalese traditional medicine. *Evidence-Based Complementary and Alternative Medicine*, *6*, 517–522.

Rehman, S., Ashfaq, U. A., Riaz, S., Javed, T., & Riazuddin, S. (2011). Antiviral activity of *Acacia nilotica* against hepatitis C virus in liver infected cells. *Virology Journal*, *8*, 220.

Robin, V., Boustie, J., Amoros, M., & Girre, L. (1998). In-vitro antiviral activity of seven psiadia species, Asteraceae: Isolation of two antipoliovirus flavonoids from Psiadia dentata. *Pharmacy and Pharmacology Communications*, *4*, 61–64.

Samuelsen, A. B. (2000). The traditional uses, chemical constituents and biological activities of *Plantago major* L. *A Review Journal of Ethnopharmacology*, *71*, 1–21.

Semple, S. J., Pyke, S. M., Reynolds, G. D., & Flower, R. L. (2001). In vitro antiviral activity of the anthraquinone chrysophanic acid against poliovirus. *Antiviral Research*, *49*, 169–178.

Serkedjieva, J., Manolova, N., Zgórniak-Nowosielska, I., Zawilińska, B., & Grzybek, J. (1990). Antiviral activity of the infusion (SHS-174) from flowers of *Sambucus nigra* L., aerial parts of *Hypericum perforatum* L., and roots of *Saponaria officinalis* L. against influenza and herpes simplex viruses. *Phytotherapy Research*, *4*, 97–100.

Shahrajabian, M. H., Sun, W., Shen, H., & Cheng, Q. (2020). Chinese herbal medicine for SARS and SARS-CoV-2 treatment and prevention, encouraging using herbal medicine for COVID-19 outbreak. *Acta Agriculturae Scandinavica, Section B—Soil & Plant Science*, *70*(05), 437–443.

Shin, W. J., Lee, K. H., Park, M. H., & Seong, B. L. (2010). Broad-spectrum antiviral effect of Agrimonia pilosa extract on influenza viruses. *Microbiology and Immunology*, *54*, 11–19.

Wang, Q., Ding, Z.-H., Liu, J.-K., & Zheng, Y.-T. (2004). Xanthohumol, a novel anti-HIV-1 agent purified from hops *Humulus lupulus*. *Antiviral Research*, *64*, 189–194.

Wang, S.-Q., Du, Q.-S., Zhao, K., Li, A.-X., Wei, D.-Q., & Chou, K.-C. (2007). Virtual screening for finding natural inhibitor against cathepsin-L for SARS therapy. *Amino Acids*, *33*, 129–135.

Wang, Z., Yang, Z., Huang, T., Wen, L., & Liu, Y. (2000). Experimental research on inhibitory effect of alcohol extracts from Loranthus yadoriki Sieb. On coxsackie B3 virus. *Zhongguo Zhong Yao Za Zhi = Zhongguo Zhongyao Zazhi = China Journal of Chinese Materia Medica*, *25*, 685–687.

Wei, F., Ma, S.-C., Ma, L.-Y., But, P. P.-H., Lin, R.-C., & Khan, I. A. (2004). Antiviral flavonoids from the seeds of Aesculus chinensis. *Journal of Natural Products*, *67*, 650–653.

Weng, J.-R., Lin, C. S., Lai, H. C., Lin, Y. P., Wang, C. Y., Tsai, Y. C., … Lin, C. W. (2019). Antiviral activity of Sambucus FormosanaNakai ethanol extract and related phenolic acid constituents against human coronavirus NL63. *Virus Research*, *273*, 197767.

Williamson, E. M., Liu, X., & Izzo, A. A. (2020). Trends in use, pharmacology, and clinical applications of emerging herbal nutraceuticals. *British Journal of Pharmacology*, *177*(6), 1227–1240.

Xu, H.-X., Lee, S. H., Lee, S. F., White, R. L., & Blay, J. (1999). Isolation and characterization of an anti-HSV polysaccharide from *Prunella vulgaris*. *Antiviral Research*, *44*, 43–54.

Xu, H.-X., Zeng, F.-Q., Wan, M., & Sim, K.-Y. (1996). Anti-HIV triterpene acids from Geum japonicum. *Journal of Natural Products*, *59*, 643–645.

Yang, Y., Islam, M. S., Wang, J., Li, Y., & Chen, X. (2020). Traditional Chinese medicine in the treatment of patients infected with 2019-new coronavirus (SARS-CoV-2): A review and perspective. *International Journal of Biological Sciences*, *16*, 1708–1717.

Yao, X.-J., Wainberg, M. A., & Parniak, M. A. (1992). Mechanism of inhibition of HIV-1 infection in vitro by purified extract of *Prunella vulgaris*. *Virology*, *187*, 56–62.

Yaseen, G., Ahmad, M., Shinwari, S., Potter, D., Zafar, M., Zhang, G., … Sultana, S. (2019). Medicinal plant diversity used for livelihood of public health in deserts and arid regions of Sindh-Pakistan. *Pakistan Journal of Botany*, *51*, 657–679.

Yucharoen, R., Anuchapreeda, S., & Tragoolpua, Y. (2011). Anti-herpes simplex virus activity of extracts from the culinary herbs *Ocimum sanctum* L., Ocimum basilicum L. and *Ocimum americanum* L. *African Journal of Biotechnology*, *10*, 860–866.

Yukawa, T. A., Kurokawa, M., Sato, H., Yoshida, Y., Kageyama, S., Hasegawa, T., … Shiraki, K. (1996). Prophylactic treatment of cytomegalovirus infection with traditional herbs. *Antiviral Research*, *32*, 63–70.

Zgorniak-Nowosielska, I., Grzybek, J., Manolova, N., Serkedjieva, J., & Zawilińska, B. (1991). Antiviral activity of Flos verbasci infusion against influenza and herpes simplex viruses. *Archivum Immunologiae et Therapiae Experimentalis*, *39*, 103–108.

Zhang, D.-h., Wu, K.-l., Zhang, X., Deng, S.-q., & Peng, B. (2020). In silico screening of Chinese herbal medicines with the potential to directly inhibit 2019 novel coronavirus. *Journal of Integrative Medicine*, *18*, 152–158.

Živković, I., Šavikin, K., Zdunić, G., Živković, J., Bigović, D., Menković, N., & Radin, D. (2018). Antiviral activity of medicinal plants extracts against foodborne norovirus. *Lekovite Sirovine*, *38*, 31–34.

Zorofchian Moghadamtousi, S., Abdul Kadir, H., Hassandarvish, P., Tajik, H., Abubakar, S., & Zandi, K. (2014). A review on antibacterial, antiviral, and antifungal activity of curcumin. *BioMed Research International*, *2014*(1), 1–12. https://www.hindawi.com/journals/bmri/