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Possible Effect of Aromatic Plants and Essential Oils against COVID-19: Review of Their Antiviral Activity

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Authors' contributions

This work was carried out in collaboration of all authors. Authors PTM, DDT, DSTT and KTNN wrote the first draft of the manuscript. Authors EML, CLI, EMN, BZG, JTK and DTM collected information on plants bioactivity. Authors CMM, AM, SOM and GNB collected information on plant phytochemistry. All authors read and approved the final manuscript.

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ABSTRACT

Aim: Till now, no specific treatment is available for COVID-19. This work is carried out with the aim of verifying in the literature the antiviral properties of aromatic plants and essential oils that can justify their use against the causative agent of COVID-19, SARS-CoV-2.
Methodology: The literature review was based mainly on the usual databases such as PubMed, PubMed Central., Science Direct, SCIELO, DOAJ, Science alert, Semantic scholar and Google scholar.
Results: A survey of literature reveals that aromatic plants and their essential oils are active against a large number of viruses (Herpes virus-1, Herpes virus-2, HIV, Adeno virus, Hepatite B Virus, Enterovirus 71, JUNV, etc.) and even against SARS-CoV-1 which has 96% of the same genetic background with SARS-CoV-2.
Conclusion: Aromatic plants and their essential oils exhibit high antiviral activities against several types of viruses. This evidence stemming from several experimental studies means that some compounds derived from essential oils could act as inhibitors of COVID-19.
Molecular docking investigations and pharmacoinformatics of some compounds derived from essential oils with SARS-CoV-2 protease are in progress to identify the potential inhibitors of the virus.

Keywords: COVID-19; SARS-CoV-2; aromatic plants; essential oil; antiviral activity.

1. INTRODUCTION

Since December 2019, in China, a new coronavirus epidemic called the new coronavirus disease (COVID-19) has emerged. This new emerging disease is caused by severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) [1]. It quickly spread from China and became a pandemic that caused more than 630,000 deaths worldwide (situation on 25th July, 2020). Since then, the world has been racing to find an effective remedy for this virus, but so far no universally acceptable medicine or vaccine has been available to date. All approaches are therefore used to find a solution to this pandemic [2-3]. Meanwhile, Traditional Medicine has also been reported to be useful in the treatment of COVID-19 [4-6]. Furthermore, medicinal plants constitute an important source of molecules having various pharmacological properties including the antiviral potential, which can be useful for the search of a solution against COVID-19. According to the World Health Organization (WHO), more than 80% of African population uses traditional medicine to solve primary health problem. It has the advantage of being safe, effective, less expensive and less risky, with significantly reduced side effects compared to modern medicines [7-11].

Aromatic plants (AP) have been used since decades for the treatment of various ailments such as malaria, diabetes, mental disorders, cancer, hypertension, respiratory disorders etc. [12]. Aromatherapy is well known in Africa. Aromatic plants are boiled and stream inhaled to treat colds, coughs or flu. In fact, it is known that, aromatherapy can provide respiratory disinfection, decongestant and psychological benefits. Molecules that enter the nose or mouth pass to the lungs, and from there, to other parts of the body. They can reach the brain, affect the limbic system, which is linked to the emotions; the heart rate, breathing, memory, stress and hormone balance and then can have a subtle, yet holistic effect on the body [13-14]. Besides, Alamgeer et al. reported the use of aromatic plants in the treatment of respiratory disorders in Pakistan. Recently, it was reported the use of aromatic herbs to relieve the signs of COVID-19 in Africa [15].

Essential oils (EO) are the main active molecules in aromatic plants. They are mixtures of different lipophilic and volatile substances, such as monoterpenes, sesquiterpenes, and/or phenylpropanoids, and have a pleasant odor [16]. They possess various applications mainly in health, cosmetic, agriculture and food industries. Biological properties of essential oils include not only antimutagenic, anticancer, antioxidant, antiprotozoal activities but also anti-inflammatory, antimicrobial, immuno-modulatory and antiviral that can be useful in COVID-19 treatment [17]. In fact, many drugs that are on trials now are antiviral (Ribavirin, Remdesivir, Sofosbuvir, Galidesivir, Tenofovir, Lopinavir or Ritonavir etc.) or immuno-modulators (chloroquine) combine to antibiotics (e.g. azithromycin) [18].

Based on the relevant clinical characteristics of the SARS-CoV-2 patients, the virus enters the

cell via angiotensin-converting enzyme-2 (ACE-2), leading to severe injury in the lungs (pneumonia) and dissemination of the virus to several other organs that may be infected in the course of illness. Pathophysiologically, the most important feature is that the pneumonia (an acute inflammatory lung injury), which itself varies depending on the disease severity level, but also alveolar damage that can precipitate acute respiratory distress syndrome (ARDS) uses a wide variety of biomolecules, mainly immunological in nature. The innate immune response is then to produce pro-inflammatory cytokines and chemokines to contain and stop the infection.

The main goal of this manuscript was to make a review on the antiviral properties of aromatic plants along with the essential oils.

2. METHODOLOGY

The literature review was made using the COVID-19 resources that have been made freely available to the scientific community (COVID-19 open research dataset https://pages.semanticscholar.org/coronavirus-research), as well as on the usual databases such as PubMed and Google scholar. The terms Aromatic plants, essential oils, antiviral activities and COVID-19 were used as keywords for the search. Finally, bibliographical references were made using bibliographical software "Mendeley".

3. RESULTS AND DISCUSSION

3.1 Results

3.1.1 Phytochemistry

Different antiviral activities of EO are attributable to the chemical composition of each EO. They are complex natural mixtures and their main constituents are responsible of their bioactivities. For instance, EO from eucalyptus, tea tree and thyme and their major monoterpene compounds namely γ-terpinene, δ-terpinene, α-pinene, *p*-cymene, terpinen-4-ol, α-terpineol, thymol, citral and 1,8-cineole were examined for their antiviral activity against herpes simplex virus type 1 (HSV-1) *In vitro* [19].

The yields of EO ranged from 1.5 to 3.5%. The chemical composition of many EO were reported depending on their ecological condition [20]. *Laurus nobilis* L. berry oil was characterized by the presence of β-ocimene (21.83%), 1,8-cineol (9.43%), α-pinene (3.67%), and β-pinene (2.14%) as major constituents while two interesting sesquiterpenes, i.e., eremanthin (3.65%) and dehydrocostuslactone (7.57%), were also identified. *Thuja orientalis* oil was characterized by 43 constituents (86.68% of the total oil) in which the main components were α-pinene (35.72%), d-3-carene (9.48%), and α-cedrol (9.55%). A total of 48 compounds (82.39% of the total oil) were identified in *Juniperus oxycedrus ssp*. oxycedrus berry oil. α-pinene (27.4%) and β-myrcene (18.9%) were the major constituents. Other identified compounds were α-phellandrene (7.1%), limonene (6.7%), epibicyclosesquiphellandrene (2.3%), and d-cadinene (2.2%). Forty-one components, representing 80.91% of the total, were identified in *Satureja. thymbra* oil, in which p-cymene (10.76%), α-pinene (10.15%), thymol (9.92%), sabinene (8.64%), γ-terpinene (7.56%), carvacrol (4.98%), trans-caryophyllene (3.67%), β-pinene (2.90%), and linalool (2.81%) were the main abundant compounds. *Cupressus sempervirens ssp*. pyramidalis oil was characterized by 19 components, representing 90.45% of the total oil. The main components were α-pinene (53.56%), α-terpinene (18.90%), thymol (3.84%), and terpinolene (3.15%). Twenty-six compounds were identified in *Salvia officinalis* (94.39% of the total oil) in which 1,8-cineol (43.62%), α-thujone (12.99%), sabinene (6.97%), camphor (5.71%), α-pinene (4.72%), α-humulene (3.41%), α-terpineol (3.18%), and β-pinene (3.01%) were identified as major compounds [21-22]. Fig. 1 displays different chemical structures of some major EO identified from aromatic plants having an antiviral activity.

3.1.2 Antiviral activity

The antiviral properties of EO of several plant extracts, responsible for their characteristic smell, have been described in recent years. Various viruses, including the human pathogen herpes simplex, have been shown to be very sensitive to the inhibitory activity of EO. These results support the potential use of EO from medicinal plants as agents for the treatment of viral infections and suggest the application of this type of natural products such as antiviral drugs [23].

Rocío et al. [24] showed that several compounds present in plants can inactivate a broad spectrum of animal viruses *in vitro*. The inhibitory effect of EO of *Lippia alba, Lippia origanoides, Oreganum vulgare* and *Artemisia vulgaris* on yellow fever

virus (YFV) was demonstrated. The CC_{50} values were below 100 µg/mL and MIC values were between 3.7 and 11.1 µg/mL. The mode of action appears to be a direct inactivation of the virus. For *Laurus nobilis,* EO were evaluated for their inhibitory activity against the replication of SARS-CoV-1 with an IC_{50} value of 120 µg/mL and a selectivity index (SI) of 4.16 and HSV-1 *in vitro* by visual scoring of the cytopathogenic effect induced by the virus after infection. *Laurus nobilis* oil showed activity against CoV-SARS. This oil was characterized by the presence of beta-ocimene, 1,8-cineol, α-pinene and beta-pinene as main constituents [25].

For the genus *Eucalyptus*, Ameur et al. showed that EO of *E. sideroxylon*, *E. lehmannii, E. leucoxylon* and *E. odorata* showed no inhibition of viral infection, while the most significant antiviral activity was demonstrated with EO of *E. sideroxylon*, *E. lehmannii, E. leucoxylon* and *E. odorata. bicostata* (IC_{50} = 0.7 - 4.8 mg/mL) and *E. astringens* (IC_{50} = 8.4 mg/mL), followed by EO of *E. cinerea* (IC_{50} = 102-131 mg/mL) and *E. maidennii* (IC_{50} = 136.5 - 233.5 mg/mL) [26]. EO of *E. cinerea* and *E. maidenii* showed an antiviral activity at a concentration of 150 mg/mL when incubated with cells. This activity was dose-dependent and the antiviral activity decreased with the diminution of EO concentration. The antiviral activity of aromatic plants on different type viruses and their major EO compounds is presented in the Table 1.

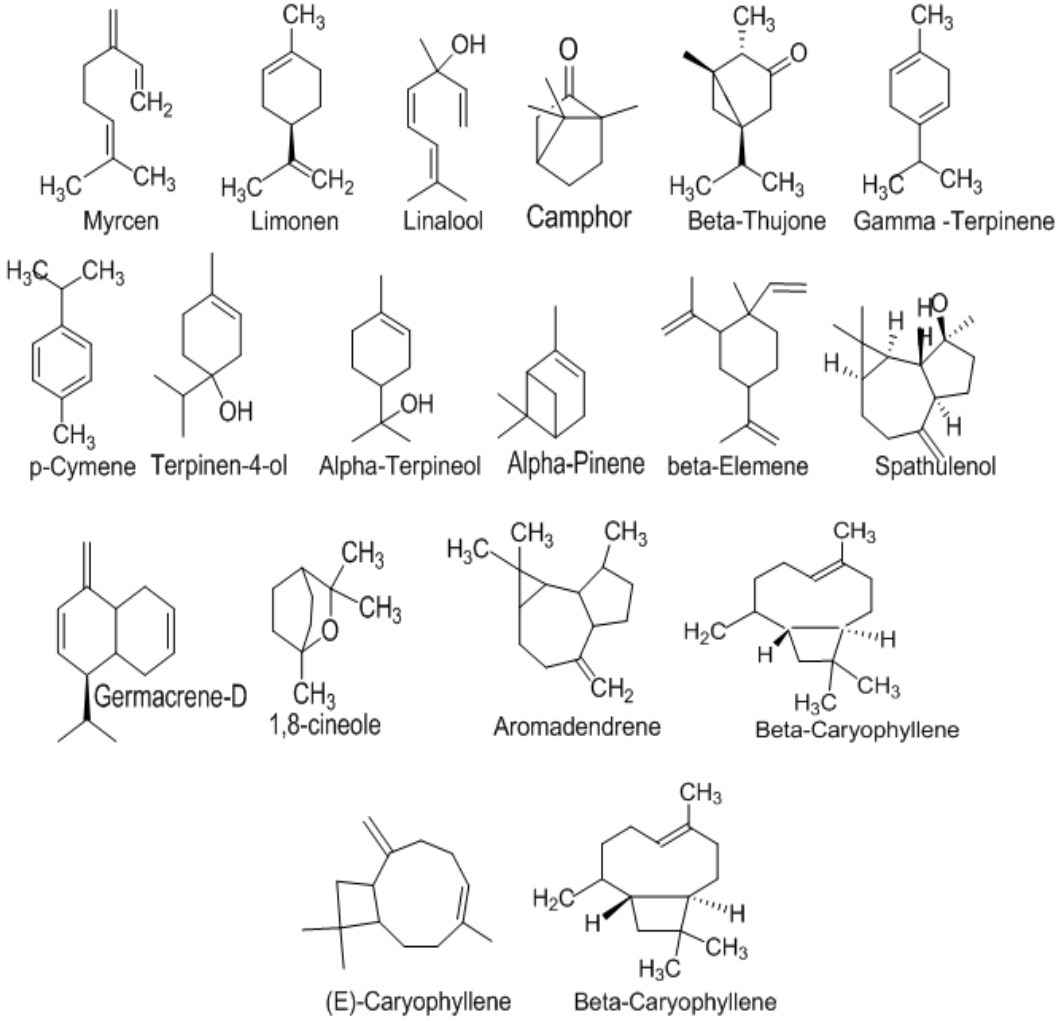

Fig. 1. Chemical structures of some major EO identified from aromatic plants having antiviral activity

Table 1. Aromatic plants, essential oils and antiviral activity

Plants (Family)	Viruses	Typical	Major compounds EO	Reference
Tetracera alnifolia Willd. (Dilleniaceae)	E7, E19	RNA non-	-	[27]
Terminalia ivorensis A.Chev. (Combretaceae)	E7, E19	enveloped viruses	δ-3-carene, α-pinene, β-caryophyllene, cedrol, terpinolene	[27-28]
Aloysia gratissima (Gillies & Hook.) Tronc. (Verbenaceae)	HSV-1/HSV-2	DNA enveloped viruses	1,8-cineole, sabinene, guaiol, bicyclogermacrene, germacrene B	[29-30]
Artemisia arborescens (Vaill.) L. (Compositae)			α-pinene, β-thujone, camphre , terpinen-4-ol, chamazulene	[31]
Artemisia douglasiana Besser ex Besser (Compositae)	HSV-1		Camphor, artemisia kenone, artemisia alcohol, α-thujone, 1,8-cineole	[29,32]
Cinnamonum verum (Lauraceae)			Eugenol, linalool, piperitone	[33]
Eucalyptus globulus Labill. (Myrtaceae)	HSV-1/HSV-2		1,8-cineole, isovaleraldehyde, spathulenol, α-terpineol, α-pinene	[34-35]
Eupatorium patens Philippi (Compositae)			(E)-caryophyllene, γ-muurolene, α-pinene, bicyclogermacrene, (z)-β-ocimene	[29,36]
Hyssopus officinalis L. (Lamiaceae)			Isopinocamphone, β-pinene, terpinen-4-ol,pinocarvone, carvacrol	[37-38]
Illicium verum Hook.f. (Schisandraceae)			Trans-anethole, 2-(1-cyclopentenyl)-furan, cis-anethole, γ-terpineol, limonene	[33,37]
Juniperus oxycedrus L. (Cupressaceae)			α-pinene, limonene, caryophyllene oxide, β-pinene, β-myrcene	[39]
Lavandula latifolia Medik. (Lamiaceae)	HSV-1		1,8-cineole, linalool, camphor, β-pinene, α-pinene	[40]
Leptospermum scoparium J.R.Forst. & G.Forst. (Myrtaceae)	HSV-1/HSV-2		β-Elemene, calamenene, linalool, α-selinene, α-cubebene	[41-42]
Matricaria recutita L. (Compositae)			α-bisabolol oxide, camphene, 1,8-cineole, camphor, limonene	[33,37]
Melaleuca alternifolia (Maiden & Betche) Cheel (Myrtaceae)			Terpinen-4-ol, α-terpinéol, α-pinène, α-terpinène, γ-terpinène, p-cymène, aromadendrène, β-caryophyllène, 1,8-cinéole	[34]
Mentha piperita L. (Lamiaceae)			Menthol, acétate de menthyle, menthone, acétate de néomenthyle	[43]
Origanum majorana L. (Lamiaceae)	HSV-1		Terpinen-4-ol, γ-terpinene, cis-sabinene hydrate, α-terpinene, α-terpineol	[40,44]

Plants (Family)	Viruses	Typical	Major compounds EO	Reference
Pinus mugo Turra (Pinaceae)	HSV-1/HSV-2		Bornyl acetate, α-terpineol, (E)-caryophyllene, dehydroabietal, α-cadinol	[37,45]
Rosmarinus officinalis L. ((Lamiaceae)			α-pinene, camphene, camphor, verbenon, p-cymene	[33,37]
Santalum album L. (Santalaceae)			α-santalene, α-bergamotene, epi-β-santalene, β-santalene, γ-curcumene	[33,37]
Santolina insularis (Gennari ex Fiori) Arrigoni (Compositae)			β-phellandrene, myrcene, curcumene,	[46]
Tessaria absinthioides (Hook. & Arn.) DC. (Compositae)	HSV-1		Caryophyllene oxide, (E)-β-damascenone, γ-eudesmol, terpinen-4-ol	[29,36]
Thymus vulgaris L. (Lamiaceae)	HSV-1/HSV-2		Thymol, p-cymene, caryophyllene, α-pinene, β-myrcene	[33,37]
Origanum vulgare L. (Lamiaceae)	NDV	RNA enveloped virus	Caryophyllene, spathulenol, germacrene-D, α-terpineol, α-caryophyllene	[47-48]
Laurus nobilis L. (Lauraceae)	SARS-CoV	RNA enveloped virus	1,8-cineole, α-terpinyl acetate, sabinene, α-pinene, terpinen-4-ol	[39]
Lippia junelliana (Moldenke) Tronc. (Verbenaceae)	Junin virus	RNA enveloped virus	Piperitenone oxide, limonene, myrcenone, p-cymene, α-pinene	[29,36]
Lippia turbinata Griseb. (Verbenaceae)			Limonene, piperitenone oxide, 1,8-cineole, α-thujone, β-caryophyllene	
Ageratum conyzoides (L.) L. (Compositae)	E7, E19	RNA non-enveloped viruses	Precocene I, (E)-caryophyllene, γ-muurolene, bicyclogermacrene, α-humulene	[27]
Bryophyllum pinnatum (Lam.) Oken (Crassulaceae)			Nonanal, (E)-geranylacetone	[27,49]
Crinum jagus (J.Thomps.) Dandy (Amaryllidaceae)			β-ocimene, hexadecane, tetramethylpentadecane, phytol, hexacosane	[27,50]
Lippia multiflora Moldenke (Verbenaceae)			1,8-cineole, thymol, linalol, germacrene-D, p-cymene	[27,51]
Macaranga barteri Müll.Arg. (Euphorbiaceae)			Eremophilene, 6-epi-shyobunol, methyl salicylate, β-eudesmene, allo aromadendrene	[27]
Mondia whitei (Hook.f.) Skeels. (Apocynaceae)			(E)-2-hexen-1-ol, heptacosane, phytol, 1-hexanol, (E)-2-hexenal	[27]
Spondias mombin L. (Anacardiaceae)			Ethyl acetate, ethyl butyrate, ethyl hexanoate, hexyl butyrate, linalool	[27]
Ocimum basilicum L. (Lamiaceae)	Virus de l'herpès (HSV)	DNA enveloped virus	monoterpenoids (carvone, fenchone, geraniol, myrcene	[52]

Plants (Family)	Viruses	Typical	Major compounds EO	Reference
	Adénovirus (ADV)	DNA non-enveloped virus	and thujone), sesquiterpenoids (caryophyllene and farnesol),	[52]
	Coxsackie virus B1 (CVB1)	RNA non-enveloped virus	triterpenoid (ursolic acid) and flavonoid (apigenin). linalool, 1,8-cineole, β-farnesene, β-elemene and β-elemene	[52]
	Entérovirus 71 (EV71)	RNA non-enveloped virus		[52]
	HSV-2	DNA enveloped virus		[52]
	ADV-3	DNA Unwrapped virus		[52]
	Virus de l'hépatite B (VHB)	DNA enveloped virus		[52]
	ADV-3	DNA non-enveloped virus		[52]
Eucalyptus bicostata Maiden, Blakely & Simmonds (Myrtaceae)	Coxsakie virus B3	RNA non-enveloped virus	1,8-cineole, α-pinene, α-terpineol, globulol, aromadendrene	[26]
Eucalyptus astringens (Maiden) Maiden. (Myrtaceae)			α-pinene, 1,8-cineole, trans-pinocarveol, aromadendrene, globulol	[26,53]
Eucalyptus cinerea F.Muell. ex Benth. (Myrtaceae)			1,8-cineole, α-terpineol, limonene, p-cymene, γ-terpinene	[26,54]
Eucalyptus maidenii F.Muell. (Myrtaceae)			1,8-cineole, α-pinene, β-phellandrene, p-cymene, limonene	[26]
Eucalyptus caesia Benth. (Myrtaceae)	JUNV	RNA enveloped virus	1,8-cineol, p-cymene, γ-terpinene, α-pinen, terpinen-4-ol	[55]
Citrus limonum Risso (Rutaceae)	HSV-1	DNA enveloped virus	Limonene, β-pinene	[33]
Cymbopogon citratus (DC.) Stapf. (Poaceae)			Géranial, Néral, Myrcène	[40]
Heterothalamus alienus (Spreng.) Kuntze. (Compositae)	JUNV	RNA enveloped virus	β-pinene, sphatulenol, germacrene D	[56]
Artemisia kermanensis Podlech (Compositae)	HSV-1	DNA enveloped virus	p-menth-1,5-dien-8-ol, camphre, β-thujone	[52]

Legend: HSV = Herpes Simplex Virus (DNA virus); DEN = Dengue virus (RNA virus); NDV = Newcastle Disease Virus (DNA virus); SARS = Severe Acute Respiratory Syndrome; SARS-CoV = SARS- associated coronavirus (RNA virus); Junin virus (RNA virus), Adenovirus (ADV)

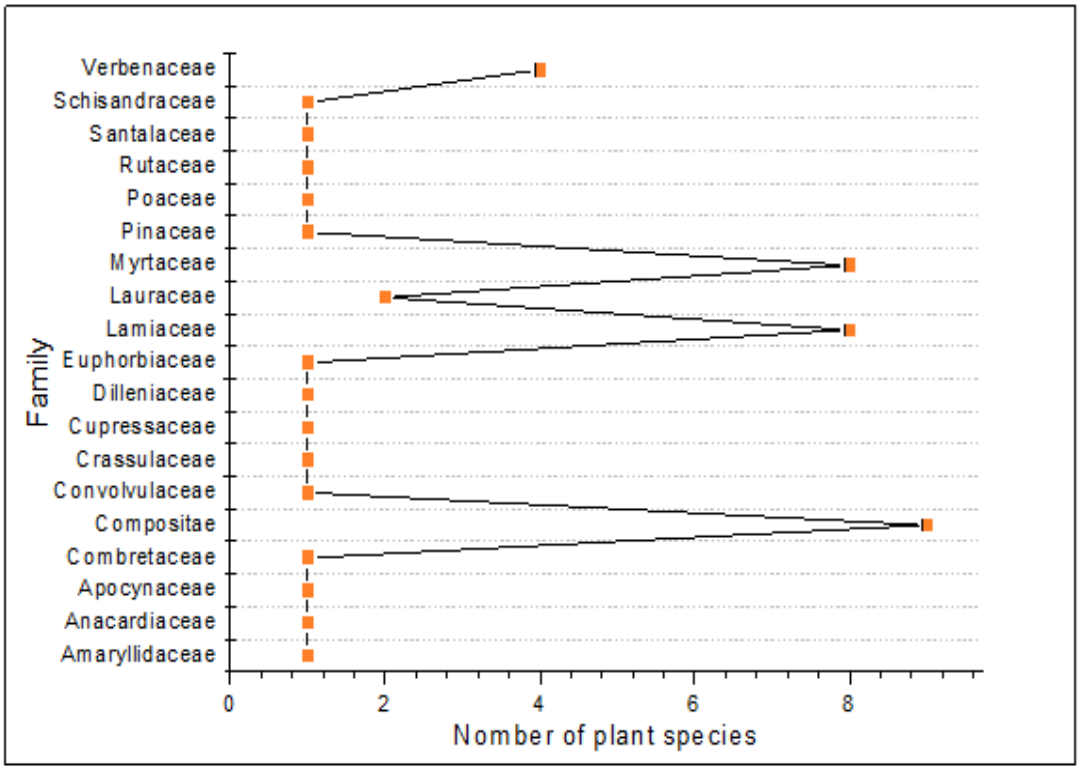

Fig. 2. Different families identified and their specific richness

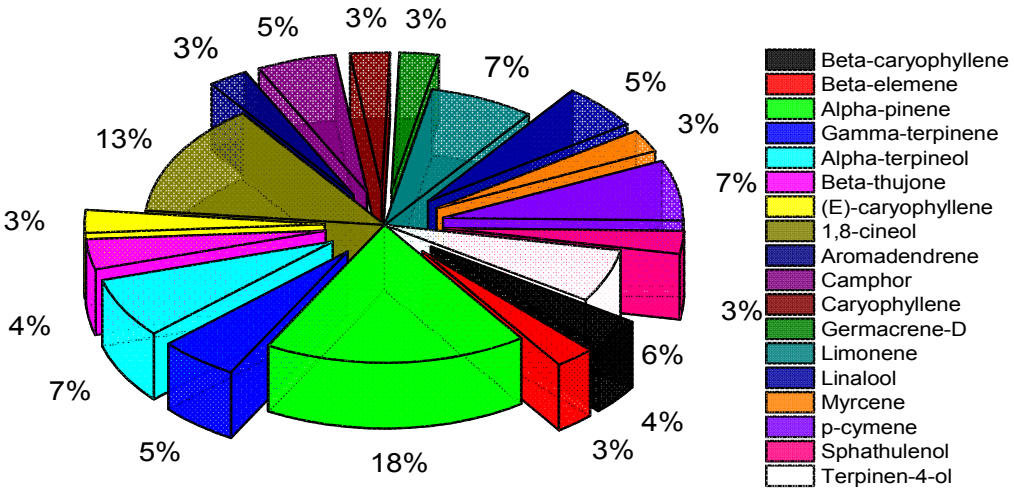

Fig. 3. Rate of major essential oil compounds from antiviral aromatic plants concentration of essential oils in the majority of antiviral aromatic plants

Fig. 2 illustrates different families identified and their specific richness.

As shown in the Fig. 2, tree botanical families out of the 19 possess 64.4% of listed species. These specific families are the following: Compositae (20%), Lamiaceae (17.7%), Myrtaceae (17.7%) and Verbenaceae (8.8%).

Fig. 3 shows major EO compounds antiviral aromatic plants.

It emerges from this Fig. 3 that among EO identified in antiviral aromatic plants, 18 compounds are in the majority with a predominance of α-pinène (18%) followed respectively by 1,8-cineol (13%), α-terpineol, limonene and p-cymène (7% to each), Terpinen-4-ol (6%), ϒ-terpinène, camphor and linalool (5% to each), β-thujone and β-caryophyllene (4%). (E)-Caryophyllene, aromadendrene, caryophyllene, germacrene-D, Myrcene, sphathulenol and β-elemene in the last position with at least 3% to each.

3.2 Discussion

COVID-19 is an emerging infectious disease with highly variable clinical expression similar to that of common respiratory diseases [1]. At a time when COVID-19 is raging throughout humanity, causing loss of human lives and when the prospect of developing a new drug in the short and medium term is not feasible due to numerous constraints, thus it is urgent to find an alternative solution to this major public health problem in order to save lives. To this end, fumigation with aromatic plants is one of the alternative therapeutic means to be encouraged in Africa where more than 80% of the population uses medicinal and aromatic plants for treatment [8,10-11,15]. In fact, the scientific evidence regarding the effects of EO on RNA and/or DNA viruses is very numerous and well documented [17,23]. Since the most important cause of COVID-19 related deaths is respiratory failure which is due to pneumonia and that the main reason that causes morbidity and mortality in SARS-CoV-2 patients is the overproduction of proinflammatory cytokines, molecules that act *via* anti-inflammatory mechanism of action are potential therapeutic agents since they can inhibit several proinflammatory cytokines. As stated above, Winska et al have reported the anti-inflammatory activity of EO.

EO molecules were also reported to interact with the viral life cycle, such as the viral entry, replication, assembly, and release, as well as targeting virus–host through specific or noncovalent interactions such as hydrogen bonds, π/π and van der Waals interactions [57-59]. Among aromatic plant species, *Ocimum basilicum* that is widely distributed in DRC possess antiviral activities against DNA viruses likeHSV, ADV and hepatitis B virus and RNA viruses (coxsackievirus B1 (CVB1) as well as enterovirus 71 (EV71)). Others aromatic plant species belonging to the *Lippia, Eucalyptus* and *Artemisia* have antiviral activities [19,25]. Loizzo et al. reported the inhibitory activity of *Laurus nobilis* EO against SARS-CoV which has 96% of the same genetic background as SARS-CoV-2 [39]. This revealed that naturally occurring EO chemo-types containing beta-ocimene, 1,8-cineole, alpha-pinene and beta-pinene being the main constituents could act as therapeutic agents against SARS-CoV-2's main protease, the causative agent of COVID-19.

4. CONCLUSION

The present study was carried out with the aim of documenting the antiviral properties of aromatic plant species which can justify their use against SARS-CoV-2. Many scientific evidences revealed that EO display bioactivity against RNA and/or DNA viruses. Thus, the present review proposes the development of antiCOVID-19 alternative based-method of relevance using reverse pharmacology approach. Molecular docking investigations and pharmacoinformatics of some naturally occurring EO chemo-types against SARS-CoV-2 proteases are in progress in order to identify the potential inhibitors.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Fei Z, Ting Y, Ronghui D, Guohui F, Ying L, Zhibo L, et al. Clinical course and risk factors for mortality of adult in patients with

COVID-19 in Wuhan, China: A retrospect-tive cohort study. The Lancet. 2020;395: 1054-1062.
Available:doi.org/10.1016/S0140-6736(20)30566-3

2. Mpiana PT, Ngbolua KN, Tshibangu DST, Kilembe JT, Gbolo BZ, Mwanangombo DT, et al. Identification of potential inhibitors of SARS-CoV-2 main protease from *Aloe vera* compounds: A molecular docking study. Chemical Physics Letters. 2020; 754:137751.
Available:doi.org/10.1016/j.cplett.2020.137751
3. Mbadiko CM, Inkoto CL, Gbolo BZ, Lengbiye EM, Kilembe JT, Matondo A, et al. A mini review on the phytochemistry, toxicology and antiviral activity of some medically interesting *Zingiberaceae* species. Journal of Complementary and Alternative Medical Research. 2020;9(4): 44-56.
Available:doi.org/10.9734/jocamr/2020/v9i430150
4. Li-sheng W, Yi-ru W, Da-wei Y, Qing-quan L. A review of the 2019 novel coronavirus (COVID-19) based on current evidence. International Journal of Antimicrobial Agents; 2020.
DOI: https://doi.org/10.1016/j.ijantimicag.-2020.105948
5. Ngbolua KN, Mbadiko CM, Matondo A, Bongo GN, Inkoto CL, Gbolo BZ, et al. Review on ethno-botany, virucidal activity, phytochemistry and toxicology of *Solanum* genus: Potential bio-resources for the therapeutic management of COVID-19. European Journal of Nutrition and Food Safety. 2020;12(7):35-48.
DOI: 10.9734/EJNFS/2020/v12i730246
6. Mpiana PT, Ngbolua KN, Tshibangu DST, Kilembe JT, Gbolo ZB, Mwanangombo DT, et al. *Aloe vera* (L.) Burm. F. as a potential anti COVID-19 plant: A minireview of its antiviral activity. European Journal of Medicinal Plants. 2020;31(8):86-93.
DOI: 10.9734/EJMP/2020/v31i830261
7. Ngbolua KN, Mpiana PT, Mudogo V. Pharmacopée traditionnelle et lutte contre la drepanocytose: Méthodes de sélection et d'évaluation de l'activité des plantes médicinales. Editions Universitaires Européennes, Riga: Latvia; 2019.
ISBN: 978-613-9-51486-1.
8. Lengbiye EM, Bongo GN, Kongumbeti G, Iteku JB, Inkoto CL, Tshiama C, et al. *Isolona hexaloba* Engl. & Diels: Phytochemistry, pharmacology and future directions: A mini-review. Plant. 2018;6(3): 53-59.
9. Inkoto CL, Bongo GN, Kapepula MP, Masengo AC, Gbolo ZB, Tshiama C, et al. Microscopic features and chromatographic fingerprints of selected Congolese medicinal plants: *Aframomum alboviolaceum* (Ridley) K. Schum, *Annona senegalensis* Pers. and *Mondia whitei* (Hook.f.) Skeels. Emergent Life Sciences Research. 2018;4(1):1-10.
10. Tshilanda DD, Onyamboko DNV, Babady PB, Ngbolua KN, Tshibangu DST, Dibwe EF, et al. Anti-sickling activity of ursolic acid isolated from the leaves of *Ocimum gratissimum* L. (*Lamiaceae*). Natural Products and Bioprospecting. 2015;5:215-221.
DOI: 10.1007/s13659-015-0070-6
11. Mpiana PT, Mudogo V, Tshibangu DST, Kitwa EK, Kanangila AB, Lumbu JBS, et al. Ngbolua, antisickling activity of anthocyanins from *Bombax pentadrum, Ficus capensis* and *Ziziphus mucronata*: Photodegradation effect. Journal of Ethnopharmacology. 2008;120: 413-418.
12. Marshall E. Health and wealth from medicinal aromatic plants. Rural Infrastructure and Agro-Industries Division, Food and Agriculture Organization of the United Nations, Diversification Booklet Number. 2011;73:17.
13. Brazier M; 2020.
Available:https://www.medicalnewstoday.com/articles/10884
Accessed 27/04/2020.
14. Alamgeer, Waqas Y, Hira A, Amber S, Humayun R, Ishfaq AB, et al. Traditional medicinal plants used for respiratory disorders in Pakistan: A review of the ethno-medicinal and pharmacological evidence. Chinise Medicine. 2018;3:48.
Available:https://doi.org/10.1186/s13020-018-0204-y
15. Anonymous; 2020.
Available:https://www.agrimaroc.ma/covid-plantes-aromatiques-medicinales/
Accessed 26/4/2020.
16. Dhifi W, Bellili S, Jazi S, Bahloul N, Mnif W. Essential oils' chemical characterization and investigation of some biological activities: A critical review. Medicines (Basel). 2016;3(4):25.
DOI: 10.3390/medicines3040025

17. Winska K, Maczka W, Lyczko J, Grabarczyk M, Czubaszek A, Szumny A. Essential oils as antimicrobial agents-myth or real alternative? Molecules. 2019; 24(11):21-30.
DOI: 0.3390/molecules24112130
18. Elfiky AA. Ribavirin, remdesivir, sofosbuvir, galidesivir and tenofovir against SARS-CoV-2 RNA dependent RNA polymerase (RdRp): A molecular docking study. Life Science. 2020;25:117592.
DOI: 10.1016/j.lfs.2020.117592
19. Akram A, Reichling J, Schnitzler P. Screening for antiviral activities of isolated compounds from essential oils. Evidence-Based Complementary and Alternative Medicine. 2011;8.
DOI: 10.1093/ecam/nep187
20. Ramy MR, Sayed AF, Ghada IM. Chemical compositions, antiviral and antioxidant activities of seven essential oils. Journal of Applied Sciences Research. 2010;6(1):60-62.
21. Monica RL, Antoine MS, Rosa T, Giancarlo AS, Francesco M, Ilaria L, et al. Phytochemical analysis and *In vitro* antiviral activities of the essential oils of seven Lebanon species. Chemistry and Biodiversity. 2008;5:61-470.
22. Jun A, Kazuhiro C, Masahiro T, Takao Y. Antiviral activity of lignans and their glycosides from *Justicia procumbens*. Phytochemistry. 1996;42:713-717.
23. Jürgen R, Schnitzler P, Suschke U, Saller R. Essential oils of aromatic plants with antibacterial, antifungal, antiviral and cytotoxic properties an overview. Forsch Komplementmed. 2009; 16:79–90.
DOI: 10.1159/000207196
24. Rocío M, Raquel EO, Jairo RM, Elena ES. Inhibitory effect of essential oils obtained from plants grown in Colombia on yellow fever virus replication *In vitro.* Annals of Clinical Microbiology and Antimicrobials. 2009;8:8.
DOI: 10.1186/1476-0711-8-8
25. Ramling P, Meera M, Priyanka P. Phytochemical and pharmacological review on *Laurus nobilis.* International Journal of Pharmaceutical and Chemical Sciences. 2012;1(2):595-602.
26. Ameur E, Zyed R, Nabil ABS, Samia M, Youssef BS, Karima BHS, et al. Chemical composition of 8 *Eucalyptus* species essential oils and the evaluation of their antibacterial, antifungal and antiviral activities. BMC Complementary and Alternative Medicine. 2012;12:81.
DOI: 10.1186/1472-6882-12-81
27. Omonike OO, Toluwanimi EA, Peter AS, Temitope CF, Adekunle JA. *In vitro* antiviral activity of twenty-seven medicinal plant extracts from Southwest Nigeria against three serotypes of echoviruses. Virology Journal. 2018;15:110.
Available:doi.org/10.1186/s12985-018-1022-7
28. Ogunwande IA, Ascrizzi R, Guido F. Essential oil composition of *Terminalia ivorensis* A. chev. flowers from northern Nigeria. Trends Phytochemistry Research. 2019;3(1):77-82.
29. Garcia CC, Talarico L, Almeida N, Colombres S, Duschatzky C, Damonte EB. Virucidal activity of essential oils from aromatic plants of San Luis, Argentina. Phytotherapy Research. 2003;17:073–1075.
30. Benovit SC, Silva LL, Salbego J, Loro VL, Mallmann CA, Baldisserotto B, et al. Anesthetic activity and bio-guided fractionation of the essential oil of *Aloysia gratissima* (Gillies & Hook.) Tronc. in silver catfish *Rhamdia quelen*. Biological Sciences. 2015;87(3):1675-1689.
DOI: 10.1590/0001-3765201520140223
31. Saddi M, Sanna A, Cottiglia F, Chisu L, Casu L, Bonsignore L, et al. Antiherpes activity of *Artemisia arborescens* essential oil and inhibition of lateral diffusion in vero cells. Annals of Clinical Microbiology and Antimicrobials. 2007;6:1–10.
32. Setzer WN, Vogler B, Schmidt JM, Leahy JG, Rives R. Antimicrobial activity of *Artemisia douglasiana* leaf essential oil. Fitoterapia. 2004;75:192-200.
33. Bourne KZ, Bourne N, Reising SF, Stanberry LR. Plant products as topical microbicide candidates: Assessment of *In vitro* and *In vivo* activity against herpes simplex type 2. Antiviral Research. 1999; 42:219-26.
34. Minami M, Kita M, Nakaya T, Yamamoto T, Kuriyama H, Imanishi J. The inhibitory effect of essential oils on herpes simplex virus type 1 replication *In vitro*. Microbiology Immunology. 2003;47:681-684.
35. Harkat ML, Asma B, Madani K, Said ZBOS, Rigou P, Grenier D, et al. Chemical composition, antibacterial and antioxidant activities of essential oil of *Eucalyptus*

globulus from Algeria. Industrial Crops and Products. 2015;78:148-153.

36. Bailac PN, Gende L, Gascon A, Fritz R, Ponzi MI, Eguaras M, et al. Control of *Ascosphaera apis* and *Paenibacillus larvae* subsp. larvae by the use of essential oils for obtaining beehive products without toxic residues. Molecular Medicinal Chemistry. 2006;11:1-2.
37. Koch C, Reichling J, Schnitzler P. Essential oils inhibit the replication of herpes simplex virus type 1 (HSV-1) and type 2 (HSV-2); in Preedy VR, Watson RR (eds). Botanical Medicine in Clinical Practice. 2008;192–197.
38. Kizil S, Hasimi N, Tolan V, Kilinç E, Karatas H. Chemical composition, antimicrobial and antioxidant activities of Hyssop (*Hyssopus officinalis* L.) essential oil. Notulae Botanicae Horti Agrobotanici Cluj-Napoca. 2010;38(3):99-103.
39. Loizzo MR, Saab AM, Tundis R, Statt GA, Menichini F, Lampronti I, et al. Phytochemical analysis and *In vitro* antiviral activities of the essential oils of seven Lebanon species. Chemistry Biodiversity. 2008;5(3):461–470.
40. Koch C. Antivirale effekte ausgewahlter atherischer ole auf behullte Viren unter besonderer berucksichtigung des Herpes simplex Virus Typ 1 und 2.2005. Dissertation, Universitat Heidelberg; 2020.
41. Reichling J, Koch C, Stahl-Biskup E, Sojka C, Schnitzler P. Virucidal activity of a beta-triketone- rich essential oil of *Leptospermum scoparium* (manuka oil) against HSV-1 and HSV-2 in cell culture. Planta Medicine. 2005;71:1123-1127.
42. Porter NG, Smale PE, Nelson MA, Hay AJ, Van Klink JW, Dean CM. Variability in essential oil chemistry and plant morphology within a *Leptospermum scoparium* population. New Zealand Journal of Botany. 1998;36(1):125-133.
DOI: 10.1080/0028825X.1998.9512551
43. Schuhmacher A, Reichling J, Schnitzler P. Virucidal effect of peppermint oil on the enveloped viruses herpes simplex virus type 1 and type 2 *In vitro*. Phytomedicine. 2003;10:504-510.
44. Busatta C, Vidal RS, Popiolski AS, Mossi AJ, Dariva C, Rodrigues MRA, et al. Application of *Origanum majorana* L. essential oil as an antimicrobial agent in sausage. Food Microbiology. 2008;25:207-211.
45. Venditti A, Serrillia AM, Vittori S, Papa F, Maggi F, Di Cecco M, et al. Secondary Metabolites from *Pinus mugo* Turra subsp. mugo growing in the Majella National Park (Central Apennines, Italy). Chemistry Biodiversity. 2013;10:2091-2100.
46. De-Logu A, Loy G, Pellerano ML, Bonsignore L, Schivo ML. Inactivation of HSV-1 and HSV-2 and prevention of cell-to-cell virus spread by *Santolina insularis* essential oil. Antiviral Research. 2000; 48:177-185.
47. Siddiqui YM, Ettayebi M, Haddad AM, Al-Ahdal MN. Effect of essential oils on the enveloped viruses: Antiviral activity of oregano and clove oils on herpes simplex virus type 1 and Newcastle disease virus. Medical Science Research. 1996;24:185-186.
48. Sahin F, Güllüce M, Daferera D, Sökmen A, Sökmen M, Polissiou M, et al. Biological activities of the essential oils and methanol extract of *Origanum vulgare* ssp. vulgare in the Eastern Anatolia region of Turkey. Food Control. 2004;15:549-557.
49. Aboaba SA, Igumoye H, Flamini G. Chemical composition of the leaves and stem bark of *Sterculia tragacantha*, *Anthocleista vogelii* and leaves of *Bryophyllum pinnatum*. Journal of Essential Oil Research. 2017;29(1):85-92.
50. Oladimeji AO. Variation in pre-extraction processes influences the differences in chemical constituent, quantity and biochemical activities of volatile oils from *Crinum jagus* (Th.) D.: Gas chromatography-mass spectrometry analysis. Journal of Taibah University for Sciences. 2018;12(6):748-753.
DOI: 10.1080/16583655.2018.1539446
51. Folashade KO, Omoregie EH. Essential oil of *Lippia multiflora* Moldenke: A review. Journal of Applied Pharmaceutical Science. 2012;2(1):15-23.
52. Lien CC, Lean TN, Pei WCH, Win C, Chun CL. Antiviral activities of extracts and selected pure constituents of. *Ocimum basilicum*. Clinical and Experimental Pharmacology and Physiology. 2005;32: 811-816.
53. Jemâa BJM, Haouel S, Bouaziz M, Khouja ML. Seasonal variations in chemical composition and fumigant activity of five *Eucalyptus* essential oils against three moth pests of stored dates in Tunisia. Journal of Stored Products Research. 2012;48:61-67.

54. Mann TS, Babu GDK, Guleria S, Singh B. Comparison of *Eucalyptus cinerea* essential oils produced by hydrodistillation and supercritical carbon dioxide extraction. Natural Product Communications. 2011; 6(1):107-110.
55. Bailac PN, Duschatzky C, Carrascull A, Ponzi M, Firpo N. Composition of the essential oils of *Tessaria absinthioides* (Hook et Arn.) D. candole. Journal of Essential Oil Research. 1998;10(1):89-91.
56. Duschatzky CB, Possetto ML, Talarico LB, García CC, Michis F, Almeida NM, et al. Evaluation of chemical and antiviral properties of essential oils from South American plants. Antiviral Chemistry & Chemotherapy. 2005;16:247-251.
57. Matondo A, Thomas R, Tsalu PV, Mukeba CT, Mudogo V. α-methylation and α-fluorination electronic effects on the regioselectivity of carbonyl groups of uracil by H and triel bonds in the interaction of U, T and 5FU with HCl and TrH3 (Tr = B, Al). Journal of Molecular Graphics and Modelling. 2019;88:237–246. Available:doi.org/10.1016/j.jmgm.2019.02.006
58. Kasende OE, Matondo A, Muya JT, Scheiner S. Interactions between temozolomide and guanine and its S and Se-substituted analogues. International Journal of Quantum Chemistry. 2017;117: 157−169. DOI: 10.1002/qua.25294
59. Lin LT, Hsu WH, Lin CC. Antiviral natural products and herbal medicines. Journal of Traditional and Complementary Medicine. 2014;4(1):24-35.

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