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Scientific production on medicinal plants and their efficacy against Covid-19: a review and scientometric analysis based on VOSviewer

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Abstract

Historically, numerous plants have been used to alleviate various diseases, particularly viral diseases (bronchitis, influenza virus and dengue virus). This review evaluated their therapeutic potential against Covid-19 and mapped the 10 most studied plants during the pandemic. The standardized protocol for systematic reviews (PRISMA-P) was developed in this study. All studies involving medicinal plants and their potential against Covid-19 infection were also considered. Two specific search fields "traditional medicine and Covid-19" and "medicinal plants and Covid-19" with appearance in the title, abstract and keywords were used to search for information. Only papers (review and original) published between 2020 and October 2021 were included. Short communications, letters to the editor, books and book chapters were excluded. A total of 24046 articles were recorded among the four databases and an increase of 69% in publications for the 2021 search date, a higher percentage compared to the previous year (31%). China was the country with the highest production with 28% (2725 papers). The analysis of variance showed that the number of studies of *Nigella sativa* L. (1.62±0.21; p = 0.02), *Glycyrrhiza glabra* L. (1.50±0.32; p = 0.03), *Zingiber officinale* Roscoe (1.51±0.32; p = 0.03) were statistically significant with respect to the other species. This is probably because these species show compounds with high antiviral spectrum. Despite the pharmacological potential found in medicinal plants, more large-scale clinical trials are still needed to demonstrate the efficacy of phytocompounds against viral diseases.

Keywords: Covid-19, medicine plants, traditional medicinal, scientometric, VOSviewer

1 Introduction

The new SARS-Cov-2 (severe acute respiratory syndrome) appeared in December 2019 in Wuhan (China), where cases of pneumonia linked to this new strain were appearing. Subsequently, cases increased rapidly throughout much of China (Huang et al. 2020; Luo et al. 2020). The first 41 patients infected with the new strain were confirmed by laboratory testing in early January 2020 in Wuhan. Of the patients, 30 were men and 11 were women with different comorbidities including hypertension, diabetes and cardiovascular problems (Huang et al. 2020). The number of cases spread to regions worldwide, leading the World Health Organization (WHO) to declare the disease a pandemic in mid-March 2020 (Lythgoe and Middleton 2020). By the end of May 2020, there was an increase in cases by more than 5 million and 350000 confirmed deaths (Dheyab et al. 2021). With this concern, the race against time began in search of efficient treatments to stop or at least mitigate the ravages that quickly emerged as a result of the new outbreak (Kupferschmidt 2020; Lythgoe and Middleton 2020). Among the main therapies treatments commonly used are ivermectin, hydroxychloroquine and azithromycin (Alkotaji 2020; Caly et al. 2020; Lythgoe and Middleton 2020; Rajter et al. 2021). However, hydroxychloroquine strategies did not have the desired impact (Mulier 2020). Another global therapeutic strategy has been the use of plants to manage the impacts of nCoV2019 (Khan and Al-Balushi 2021; Ren et al. 2020). According to the International Union for Conservation of Nature (IUCN) there are at least 50,000 to 80,000 plant species with medicinal purposes worldwide (Chen et al. 2016) and it has been estimated that 80% of the world's population relies on the use of medicinal plants as the sole resource for health management in their territories (Paredes, Hopkins, and Villanueva 2020; Saslis-Lagoudakis et al. 2014). Additionally, its evolution in part is due to socio-cultural dynamics and phytochemical properties (Córdoba-Tovar et al. 2021; Farooq et al. 2012; Nakagawa, Hillebrand, and Nunez 2020). However, the traditional knowledge represented by the general public (eg. Indigenous and Afro-descendants) with reference to the health care faced a significant decrease throughout the world mainly due to the negative factor suggesting the destruction of environment, misinterpretation and the invasion of territories by outsiders (Fernández-Llamazares et al., 2021; Misuy et al., 2021; Reyes-Garcia et a., 2013). This is mainly due to the lack of inconclusive policies that often recognizes and protects cultural heritage (Ferdinand et al., 2020; Hill et al., 2020). Nevertheless, there is an important gap that needs to be filled up based on the evidence, where local communities are not recognized as owners of important scientific knowledge (Efferth et al., 2016).

In this sense, the medicinal potential shown by some plant species has boosted the growth of research aimed at exploring new drugs against potentially fatal respiratory diseases. *Nigella sativa* L., *Zingiber officinale* Roscoe, *Glycyrrhiza glabra* L. and *Allium sativum* L. are on the list of plants with enormous promising potential to combat major diseases including Covid-19 (Donma and Donma 2020; Jalali et al. 2021; Maideen 2020; Sommer, Försterling, and Naber 2020). Studies have reported on the use of plants in the management of important diseases such as HIV (Anywar et al. 2020), Dengue (Rosmalena et al. 2019), influenza (H1N1) (Arora et al. 2011), Covid-19 (Li et al. 2020), among others. Some species such as *Rosmarinus officinalis* (L.) Scheid, *Salvia leucantha* Cav and *A. sativum* have been used for arthritis problems, diabetes and viral infections respectively (Andrade et al. 2018; Batiha et al. 2020). In addition, the presence of medically important bioactive compounds such as sesquiterpenes in *Z. officinale* and lepicatechin in *Calotropis procera* (Aiton) W.T. Aiton have been reported (Ahmed et al. 2021; Sharifi-Rad et al. 2017). Despite the plausible potential found in traditional medicine, many countries do not consider this alternative to face public health situations in their territories. A specific case of lack of empathy has been observed in Europe and North America where governments in these regions have been silent on the idea of empowering traditional medicine in the midst of the health crisis caused by Covid-19 (Xiong et al. 2021). In Europe, for example, the traditional evidence base has been greatly weakened and underestimated. Some plants (e.g. *Lythrum salicaria* L.) that used to be considered an effective and potent natural remedy have lost their popularity (Piwowarski, Granica, and Kiss 2015). Furthermore, the lack of credible potential found in traditional medicines, North American and European Governments in the midst of the health emergency chose to remain silent to formulate treatment based on medicinal plants. In the meantime, health authorities in China, India and South Korea quickly issued guidelines to identify traditional medicine to mitigate the impacts of COVID-19. The main aspect from these two regions (Europe and North America) is likely due to the discrepancy in culture, history, and philosophical views of medical care and medication, and discordant policies and standards in the regulation and legalization of traditional practices (Xiong et al. 2021). Lack of political will from others has prevented traditional medicine from acquiring the status it should have within policy agenda´s globally (Gunjan and Moin 2020; Xiong et al. 2021).

This review article is aimed to evaluate the scientific production related to traditional medicine and Covid-19 and to identify the top 10 plant species and their main potential phytoconstituents responsible for counteracting the impacts of SARS-Cov-2.

2 Materials and methods

An exhaustive search for information was carried out in four databases, PubMed, ScienceDirect, Scopus and JSTOR. Two specific search fields: 1) "*traditional medicine and*

Covid-19" and 2) "*medicinal plants and Covid-19*" were used for the search with appearance in the title, abstract and keywords. Short communications, letters to the editor, books and book chapters were excluded. Dissertations and conference proceedings were also excluded. These exclusions were done as they did not report on the medicinal plants used to combat the respiratory diseases. After filtering the information, the database files and metadata were downloaded in the following formats (scopus.ris and scopus.bib). For this study, only review articles and originals published between 2020 and october 2021 were included.

2.1 Information eligibility criteria

We included articles that reported on phytocompounds responsible for the inhibitory action of Covid-19, so we ensured that the medicinal plants reported in the studies were exclusively for human use. We also included studies that documented guidelines and on the use of medicinal plants to counteract the effects of Covid-19 in infected patients. Articles that did not report on the aforementioned aspects were excluded. The screening process is shown in Figure 1.

2.2 Data analysis

Two types of analysis were performed: co-occurrence and co-authorship. Keywords and authors were the two main default units of analysis for the particular type of study. For co-authorship analysis a maximum number of 25 authors per document, a minimum of 11 publications per author for a total of 50 authors visualized in the network map within a set of 10199 data and for co-occurrence a maximum occurrence of 148 for 40 keywords in a set of 16699 data were defined. This threshold is defined with the purpose of generating graphical outputs that are not very saturated with information and easy to visualize. The attribute tables generated by the software were manually reviewed and duplicate entities were removed. All analyses were performed with VOSviewer software version 1.6 using only Scopus metadata because it is a larger database. The graphical outputs of the distribution of scientific production among countries, areas and scientific journals were generated with Prisma version 8.1 software and the relationship maps with VOSviewer. The size of the bubbles in the maps represents the mean of the analyzed elements and the color the number of clusters where the data are grouped (van Eck and Waltman 2010; Waltman, van Eck, and Noyons 2010). An analysis of variance fitted to a general linear model was employed to determine which of the medicinal plants have received the most attention during the pandemic. Species were coded as treatments and countries as blocks to form (factors) and number of investigations of each species by country as the only response variable (data transformed to Log10) (Table S1). Means were compared by paired pairwise comparison using a Tukey test at a significance level α 0.05.

2.3 VOSviewer approach

The VOSviewer software is part of the artificial intelligence programs that work with techniques for monitoring, surveillance and mapping of scientific information that allows analyzing and examining large volumes of information, simplifying it and visualizing it through scientific maps. Its analytical approach is based on Jaccard's similarity measures and Pearson's correlation where distances indicate the relationship and strength between elements, i.e., in graphical visualizations a smaller distance indicates a stronger relationship (van Eck and Waltman 2007, 2010; Waltman et al. 2010).

3 Results

3.1 Results of the literature search

A total of 24,046 articles were found among the four databases consulted. The database with the highest number of records was Scopus with 14,953 articles distributed between the two search fields used (Table 1). "*Traditional medicine and Covid-19*" were the field with the highest number of documents in all databases, Scopus (10,852), ScienceDirect (5,733) and PubMed

(2,224). According to Scopus, 72.6% of the information at the date of the search has been published as research articles with 7,880 and 27.4% as reviews with 2,972 documents. The distribution of documents by year showed that during the year 2021 to the date of consultation the production was higher with a total of 7,511 (69%) publications, higher than the 365 days of the previous year where the production was 31% with 3,341 articles. China and USA were the countries with the highest number of publications with 2,725 (28%) and 2,638 (27%) respectively. Biomolecular Structure and Dynamics and Molecules were the journals with the highest number of publications with 225 (38%) and 155 (25%) respectively. In terms of the number of publications by academic area, medicine had the highest number of publications with 5,710 as of the date of the search (Figure 2). The distribution of paper by affiliation showed that the Ministry of Education of China had the largest share of publications with 187 papers followed by Huazhong University of Science and Technology (183), Harvard Medical School (166), Tongji Medical School (162), and University of Toronto (137). Some articles that at the date of the search were cited at least 100 times within the data sample are shown in Table 2. The authors with the highest number of published articles and with the highest occurrence were Zhang, Y. (38), Li, Y. (37), followed by Wang, Y. with 35 (Table S2, Figure 3A). In addition, there was a slight correlation between number of published articles and total link strength and number of citations with a Pearson's coefficient of $r^2 = 0.672$ and $r^2 = 0.519$ respectively. The top keywords with the highest occurrence within the dataset and linking strength within the network were "*Human*" and "*Covid-19*" with 1,497 and 1,189 respectively (Figure 3B, Table S3).

3.2 Medicinal plants with increased attention during the pandemic

The species *Nigella sativa* L. (299), *Zingiber officinale* Roscoe (275) and *Glycyrrhiza glabra* L. (243) have been the most important during the pandemic with a significant increase in investigations (Table 3). Species such as *Panax ginseng* C.A.Mey (59), *Glycyrrhiza uralensis*

Fisch (56) and *G. glabra* (51) have been the major occurrences in the papers produced in China and *Withania somnifera* (152), *Azadirachta indica* (136) and *Z. officinale* (112) for the case of India. Figure 4 shows the main species with the highest visibility and the countries where they have been studied the most. Analysis of variance (Table S4) showed that *N. sativa* (1.62 ±0.21; p = 0.02), *G. glabra* (1.50 ±0.32; p = 0.03), *Z. officinale* (1.51 ±0.32; p = 0.03) number of studies was statistically significant with respect to the other species, suggesting that these species have received the most attention during the pandemic.

3.3 Main approaches and characteristics of the studies analyzed

Most of the studies have been approached especially from scientific approaches namely phytochemistry, biochemistry, pharmacology and molecular biology. In the case of *N. sativa*, the research objectives have focused on evaluating phytocompounds responsible for the antiviral effect, especially the ability to inhibit virus entry. Other species such as *Z. officinale* and *G. glabra* have described the potential to counteract respiratory effects caused by Covid-19. In all approaches Covid-19 was the strongest keyword in the studies, followed by SARS-CoV-2, human and review (Figure 5).

4 Discussion

4.1 Importance of medicinal plants during the pandemic

This study quantitatively explored the scientific production related to the plausible role of traditional medicine in the management of the Covid-19 pandemic. Our study also identified 10 superior medicinal plants that have received the most attention during the pandemic. China, USA and India have been the countries with the highest related scientific output. In particular, health authorities in China and India during the health emergency explored herbal formulations to cope with Covid-19 (Vellingiri et al. 2020; Yang et al. 2020). Moreover, these countries have been the most supportive of traditional medicine as a possible therapeutic alternative against SARS-Cov-2 (Ang, Lee, YongChoi, et al. 2020; Divya et al. 2020; Xiong et al. 2021; Zhang et al. 2020). On the contrary, some European and North American countries have remained silent on the use of medicinal plants to cope with the pandemic (Xiong et al. 2021). In the absence of a cure against the disease, health programs were created in 23 Chinese provinces during the health crisis to protect and save human lives, so guidelines were quickly issued for the use of plants such as A. *membranaceus*, *G. uralensis*, *Saposhnikovia divaricata* (Turcz.) Schischk., *Atractylodis macrocephala* Koidz, among others (Ang, Lee, Kim, et al. 2020; Luo et al. 2020) and at least 85% of Covid-19 infected people in China received some herbal treatment (Yang et al. 2020). Of the 28 herbal formulations included in the Asian region policy guidelines, the Chinese government and the remaining two by the Korean government issued 26. In general, formulations were defined for different stages of Covid-19 infection (mild, moderate, severe and recovery) (Ang, Lee, Kim, et al. 2020; Ang, Lee, YongChoi, et al. 2020). In addition, the efficacy of *S. divaricata*, *Lonicera japonicae* Thumb, *A. membranaceus* against Covid-19 has been demonstrated through a retrospective study where it was observed that of the human groups studied, none of the patients who took the indicated remedy contracted the virus (Luo et al. 2020). Other plants such as *G. glabra*, *A. sativum*, *A. paniculata*, *Z. officinale* and *E. globulus* show promising and positive effects according to the results observed in most studies (Silveira et al. 2020) and *C. longa* may be a therapeutic option against Covid-19, since curcumin could inhibit the entry of the virus (Dhar and Bhattacharjee 2021).

4.2 Mechanisms of action of the phytocompounds

The healing potential of some medicinal plants seems to be closely related to their chemical compounds. At the same time, they become a promising source for the design of specific drugs. For example, the anticovid-19 potential of *A. racemosus* species may be related to its compounds such as Asparoside-C and Asparoside-F. Both with good binding affinities to the spike receptor and endoribonuclease NSP15 with binding energies of 6261 and 55.19 kcal/mol respectively. In other words these compounds could function as inhibitors of Covid-19 proteins (Chikhale et al. 2020). The efficacy of *R. emodi* against the new coronavirus is related to compounds such as emodin, aloe-emodin, antrarufin, alizarin and danthron, which show binding affinity in the three potential active sites of the RNA-binding domain of the virus nucleocapsid phosphoprotein. These phytocompounds alone or in combination could be a good therapeutic alternative for managing of SARS-Cov-2 (Rolta et al. 2020). Compounds such as 27-hydroxyethanolide B, anaferin, 12-deoxy-contramonolide and withastramonolide found in *W. somnifera*. Others such as Limonin, Solvanol and Azadiradionolide present in *N. sativa*, *Solanum nigrum* L., and *A. indica* respectively could target non-structural proteins (NSP) of SARS-Cov-2 (Parida, Paul, and Chakravorty 2021). *N. sativa* in particular is a plant with particular antiviral characteristics. The antiviral effect is related to the name compound "thymoquinone" which is similar to chloroquine and hydroxychloroquine. In addition, the antiviral spectrum of this compound has been found to be superior to that of hydroxychloroquine, and it is speculated that it may neutralize the new coronavirus (Maideen 2020; Sommer et al. 2020). Thymoquinone in combination with nigelimine may be a potential remedy to combat Covid-19. One of the reasons is that the combination could lead to blockade of SARS-CoV-2 entry by the action of angiotensin-converting enzyme 2 (ACE2) in pneumocytes. This potential could also be enhanced by Zn supplementation, enhancing innate and adaptive immunity during infection (Rahman 2020).

The presence of compounds including thymoquinone, dithymoquinone, thimohydroquinone and nigelimine together with antiviral properties, e.g., antioxidant, anti-inflammatory, anticoagulant, immunomodulatory, and bronchodilator makes *N. sativa* a species with the ability to enhance the immune responses of some common drugs such as hydroxychloroquine, chloroquine, lopinavir/ritonavir and remdesivir (Maideen 2020; Rahman 2020). Dithiomoquinone for example has shown a higher binding affinity in SARS-CoV-2 (-8.6 kcal/mol) than chloroquine (-7.2 kcal/mol). This suggests that the compound could function as a potential inhibitor of virus-host interactions (Ahmad et al. 2020). Therefore, *N. sativa* could easily be considered for the design of new antiviral drugs against Covid-19, as well as other plants such as *A. sativum*, *Allium cepa* L. and *Z. officinale*, because its safety and efficacy is well established (Donma and Donma 2020; Jalali et al. 2021; Mehmood et al. 2021). *E. globulus* other of the best-known and most widely used plants worldwide, its two bioactive compounds apigenin-o-7-glucuronide and ellagic acid also promise a beneficial role against Covid-19 through inhalation therapies. Easily these compounds could be directed to the respiratory tract. This is considering that SARS-CoV-2 enters the host through the nasal cavity and infects the oral cavity (Gowrishankar et al. 2021). Easily these compounds could be directed to the respiratory tract. Therefore, the effect against respiratory diseases, including SARS-CoV-2, is closely related to its compounds mentioned above (Gowrishankar et al. 2021; Silveira et al. 2020).

A. paniculata and *C. cyminum* are species whose role in the management of Covid-19 has also been recognized. These species have been attributed with the potential to alleviate symptoms such as fever and cough in patients infected with Covid-19 and others such as *T. vulgaris*, *G. glabra*, *A. sativum*, *Althea officinalis* L. and *P. ginseng* could modulate the immune system and exert a preventive therapeutic role (Jalali et al. 2021). *A. paniculata* for example, has shown versatile biological activities including immunomodulation and SARS-CoV-2 binding site determination, which may exert a key role against Covid-19 (Banerjee et al. 2020). Other compounds such as methyl rosmarinate and myricitrin found in H. atrorubens and *Myrica* *cerifera* L. respectively, have shown better binding affinity and docking score than control drugs (nelfinavir and prulifloxacin).

This suggests that the potential of these compounds may be comparable to some commonly used medications for the management of complex respiratory infections (Qamar et al. 2020). However, more long-term clinical and preclinical trials are needed to confirm efficacy with more scientific rationale, as so far there are no reliable trials on Covid-19 supported by medicinal plants (Dong, Hu, and Gao 2020; Jalali et al. 2021; Khan and Al-Balushi 2021; Luo et al. 2020).

4.3 Brief historical data on the use of medicinal plants against viral diseases

Historical evidence shows that medicinal plants for centuries have played a plausible role in the management of historical diseases that transcended to pandemics among them Zika virus (ZIKV) (Chen and Evans 2017), Ebola virus (EBOV) (Phoolcharoen et al. 2011; Plantguy 2014) y Asian Flu (H2N2) (Hudson et al. 2005; Vimalanathan et al. 2005). Many of the medicinal plants documented in this study in particular *A. membranaceus*, *A. indica*, *A. sativum*, *C. longa*, *N. sativa* have historical background in viral disease management, mainly dengue virus and influenza virus (H1N1), which in part has allowed their visibility during the Covid-19 pandemic as the latter is a viral-like disease (Bussmann et al. 2018; Cech et al. 2010; Dao et al. 2012; Durazzo et al. 2021; Majeed et al. 2020). However, the medicinal potential among plants seems to be different, which is associated with the effectiveness of the compounds found in a certain plant (Ahmad et al. 2020; Chikhale et al. 2020; Dao et al. 2012; Kaushik et al. 2018). Brief evidences of the use of medicinal plants against historical viral diseases are presented in Table 4. Evidences suggest that during the present pandemic, in many rural areas the vaccines arrived late around the globe and the holders of traditional knowledge were protagonists in these regions that was contrary to what happened in major cities.

5 Conclusion

This study showed that *N. sativa*, *Z. officinale*, *G. glabra*, *A. sativum*, *A. indica* and *W. somnifera* were the species that have received the most attention in the midst of the pandemic according to the number of investigations. However, the number of studies of the first three plants mentioned were statistically significant in contrast to the rest of the plants recorded. According to the literature, some of these species show a promising potential against which are related to bioactive compounds such as thymoquinone found in *N. sativa* and 27-hydroxyethanolide B, anaferin, 12-deoxy-contramonolide and withastramonolide found in *W. somnifera*, which seem to have an important efficacy against Covid-19 infection. We believe that traditional medicine could be an important ally of modern medicine in helping to manage future respiratory diseases by searching for and creating new specific antiviral drugs. However, more large-scale clinical trials are still needed to demonstrate the efficacy of phytocompounds. It is stressed that mainly the traditional medicines should be patented as a drug where traditional knowledge should be implemented. The cultural, transmission mechanisms and international treaties should be protected thus to strengthen the cultural practice in different regions. The fact that protecting these traditional medicinal practices will also help to protect the uses of biodiversity.

Finally, when we were completing this particular article, World Health Organization has declared another disease "*Monkey Pox*" as a global health alert and the need for governments to redouble their efforts to support traditional medicine has increased as few countries seem to support this initiative.

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PRISMA 2020 flow diagram for new systematic reviews which included searches of databases, registers and other sources

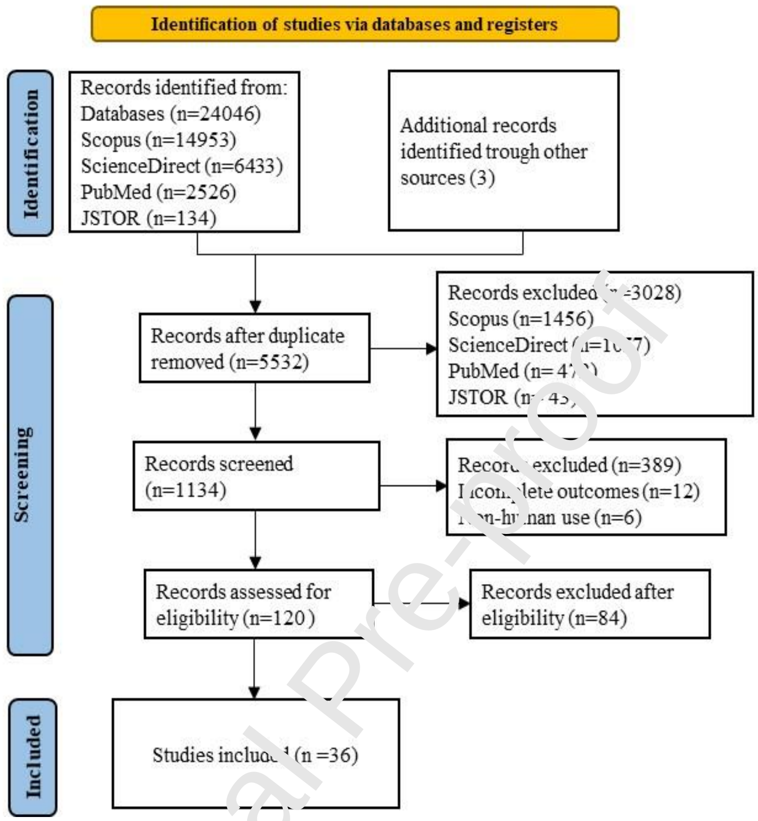

Figure 1 Flow diagram of the study selection process

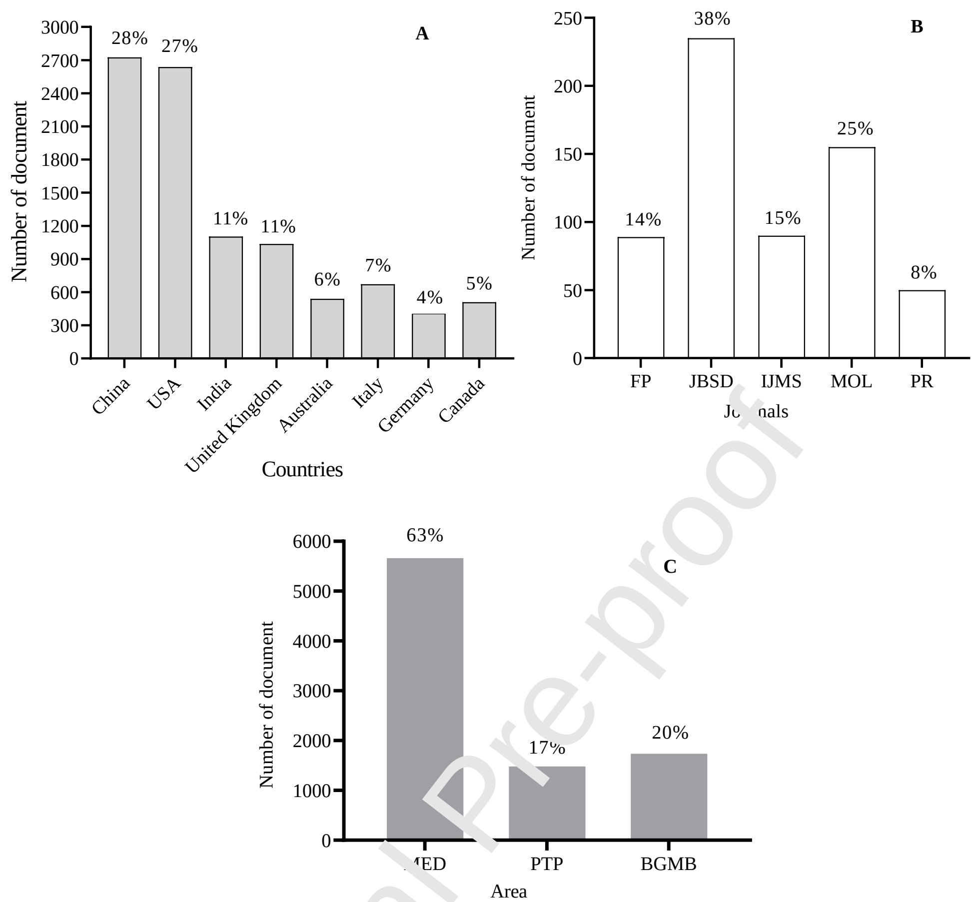

Figure 2a-c Distribution of document production. (A) main countries witch highest production, (B) FP = Frontiers in Pharmacology, JBSD=Journal of Biomolecular Structure and Dynamics, MOL = Molecules, PR = Phytotherapy Research, IJMS = International Journal of Molecular Sciences, (C) MED = Medicine, PTP = Pharmacology, Toxicology and Pharmaceutics, BGMB = Biochemistry, Genetics and Molecular Biology. Based on scopus data only

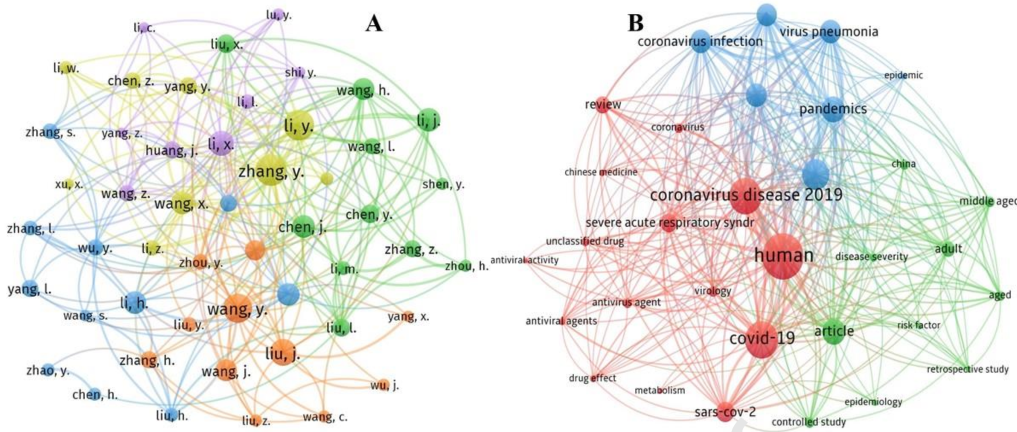

Figure 3a-b Co-occurrence and co-authorship map. (A) main relevant authors, (B) main keywords with the highest occurrence in the studies. Based on Scopus data only

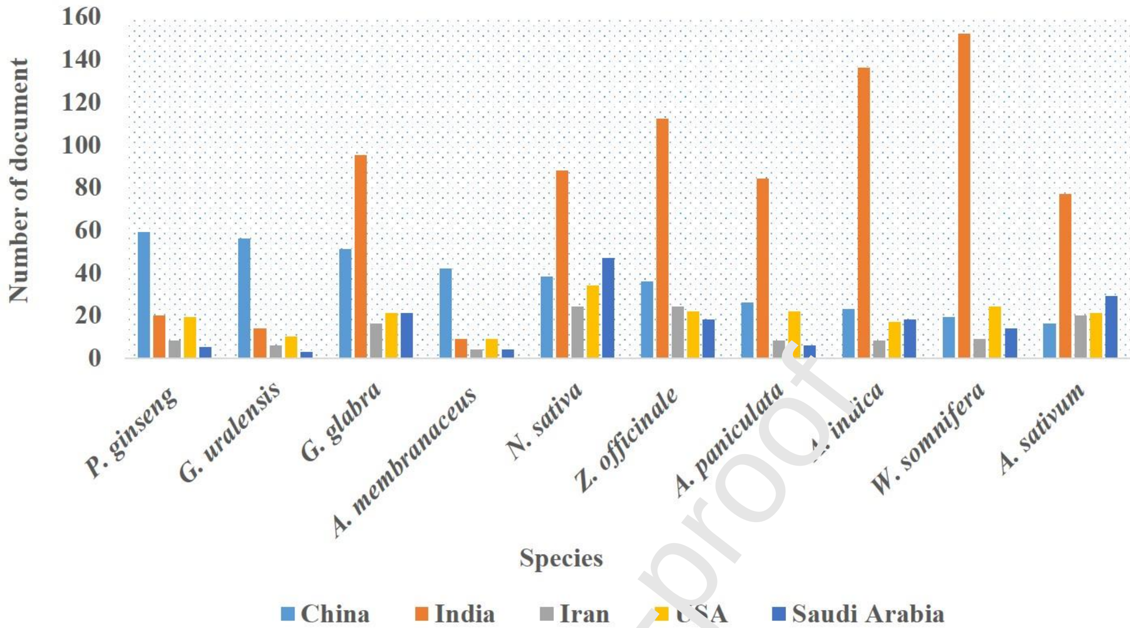

Figure 4 Distribution of the number of investigations among countries of the top 10 species. Based on scopus data only

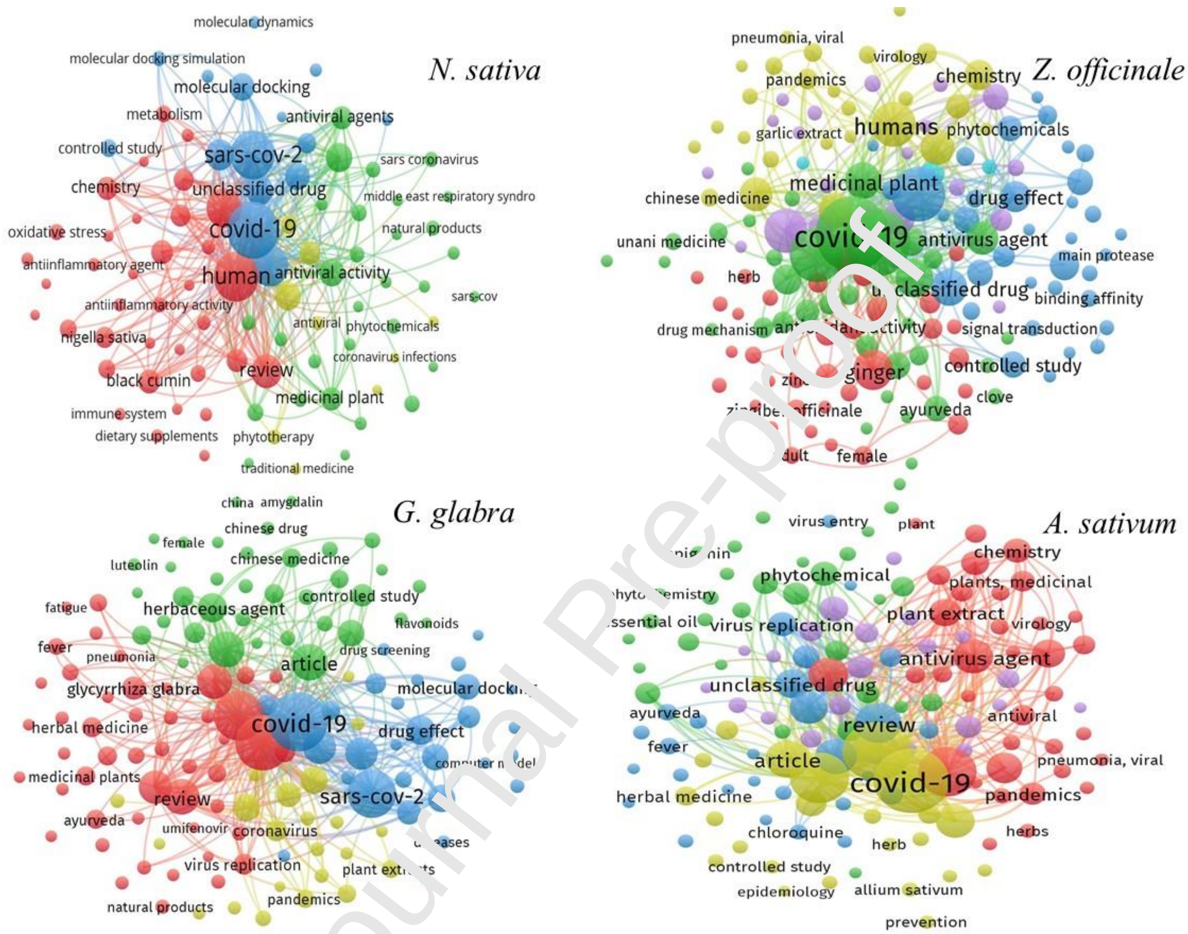

Figure 5 Map of relationship and occurrence of terms associated with studies for the four most visible species during the pandemic. Colors indicate cluster number associated with the dataset, bubble size represents intensity of occurrence, and intersecting bubbles suggest terms co-occurring more frequently. Based on scopus data only.

Table 1 Result of the bibliometric search among the four databases consulted

		Type article*		Results	
Data base	**Search field**	**Review**	**Research**	**Search field**	**Accumulated**
ScienceDirect	Medicinal plants and covid 19	313	387	700	6433
	Traditional medicine and covid 19	1984	3749	5733	
PubMed	Medicinal plants and covid 19	NA	NA	302	2526
	Traditional medicine and covid 19	NA	NA	2224	
Scopus	Traditional medicine and covid 19	2972	7880	10852	14953
	Medicinal plants and covid 19	1631	2470	4101	
JSTOR	Traditional medicine and covid 19	3	122	125	134
	Medicinal plants and covid 19	2	7	9	

*NA= Not available

Table 2 Top most cited articles (> 100 citations)

Article title	Journal	Publication year	Cited
COVID-19: A promising cure for the global panic	Science of the Total Environment	2020	245
Can Chinese medicine se 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	2020	235
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	2020	321
In silico screening of Chinese herbal medicines with the potential to directly inhibit 2019 novel coronavirus	Journal of Integrative Medicine	2020	147

Based on Scopus data only

Table 3 **List of medicinal plants with the highest number of reported studies**

Common name	Scientific name	Botanical family	Document year		Total
			2020	2021	
Black cumin	*Nigella sativa* L.	Ranunculacea	77	222	299
Ginger	*Zingiber officinale* Roscoe	Zingiberaceae	82	193	275
-	*Glycyrrhiza glabra* L.	Leguminosa	76	167	243
Garlic	*Allium sativum* L.	Amaryllidaceae	68	166	234
Indian lilac	*Azadirachta indica* A. Juss.	Meliaceae	66	160	226
Winter cherry	*Withania somnifera* (L.) Dunal	Solanaceae	63	155	218
Indian echinacea	*Andrographis paniculata* (Burm.f.) Nees	Acanthaceae	50	130	180
Ginseng	*Panax ginseng* C.A.Mey.	Araliaceae	34	114	148
Licorice	*Glycyrrhiza uralensis* Fisch.,	Leguminosa	45	67	112
Thyme	*Thymus vulgaris* L.	Lamiaceae	15	90	105
-	*Astragalus membranaceus* (Fisch.) Bunge	Leguminosa	20	62	82
Blue gum	*Eucalyptus globulus* Labill.	Myrtaceae	14	61	75
Savatar	*Asparagus racemosus* Willd.	Asparagaceae	15	48	63
Turmeric	*Curcuma longa* L.	Zingiberaceae	23	34	57
Black nightshade	*Solanun nigrum* L.	Solanaceae	19	37	56
Cumin	*Cuminum cyminum* L.	Apiaceae	8	32	40
Magnolia-bark	*Magnoliae officinalis* Rehder & .H.Wilson	Magnoliaceae	8	7	15
-	*Rheum emodi* Wall.	Polygonaceae	6	9	15
Ment	*Hyptis atrorubens* Poit.	Lamiaceae	0	3	3

Based on Scopus data only

Table 4 **Historical evidence on the use of medicinal plants against viral diseases**

Plant	Disease	Efect	Reference
Allium sativum L.	Influenza Virus (H1N1)	Antiviral, immunomodulatory	Batiha et al., 2020; Donma and Donma, 2020
Nigella sativa L.	Asthma	Effective control, antiasthmatic	Boskabady et al., 2010; Koshak et al., 2017; Salem et al., 2017
Astragalus membranaceus (Fisch.) Bunge	Influenza Virus (H1N1), Human Immunodeficiency Virus (HIV)	Immunostimulant	Durazzo et al., 2021; Liang et al., 2019; Mukhtar et al., 2008
Curcuma longa L.	Influenza Virus (H1N1)	Inhibitory	Kaushik et al., 2018; Majeed et al., 2020
Azadirachta indica A. Juss.	Dengue virus (DENV)	Inhibitory	Parida et al., 2002
Glycyrrhiza glabra L.	Influenza Virus (H1N1)	Antiviral, immunomodulatory	Arora et al., 2011; Brush et al., 2006
Zingiber officinale Roscoe	Influenza Virus (H1N1)	Antiviral	Wang et al., 2006
Eucalyptus globulus Labill.	Influenza Virus (H1N1), SARS-CoV-2	Antiviral, inhibitory	Mieres-castro et al., 2021; Vimalanathan and Hudson, 2014
Asparagus racemosus Willd.	Human Immunodeficiency Virus (HIV)	Immunostimulant	Mukhtar et al., 2008
Withania somnifera (L.) Dunal	Human Immunodeficiency Virus (HIV)	Immunostimulant	
Thymus vulgaris L.	Herpes simplex virus (HSV)	Inhibitory	Nolkemper et al., 2006; Prasanth Reddy et al., 2014
Magnoliae officinalis Rehder & H.Wilson	Murine norovirus (MNV), Hepatitis C virus (HCV)	Antiviral, inhibitory	Kim et al., 2021; Lan et al., 2012

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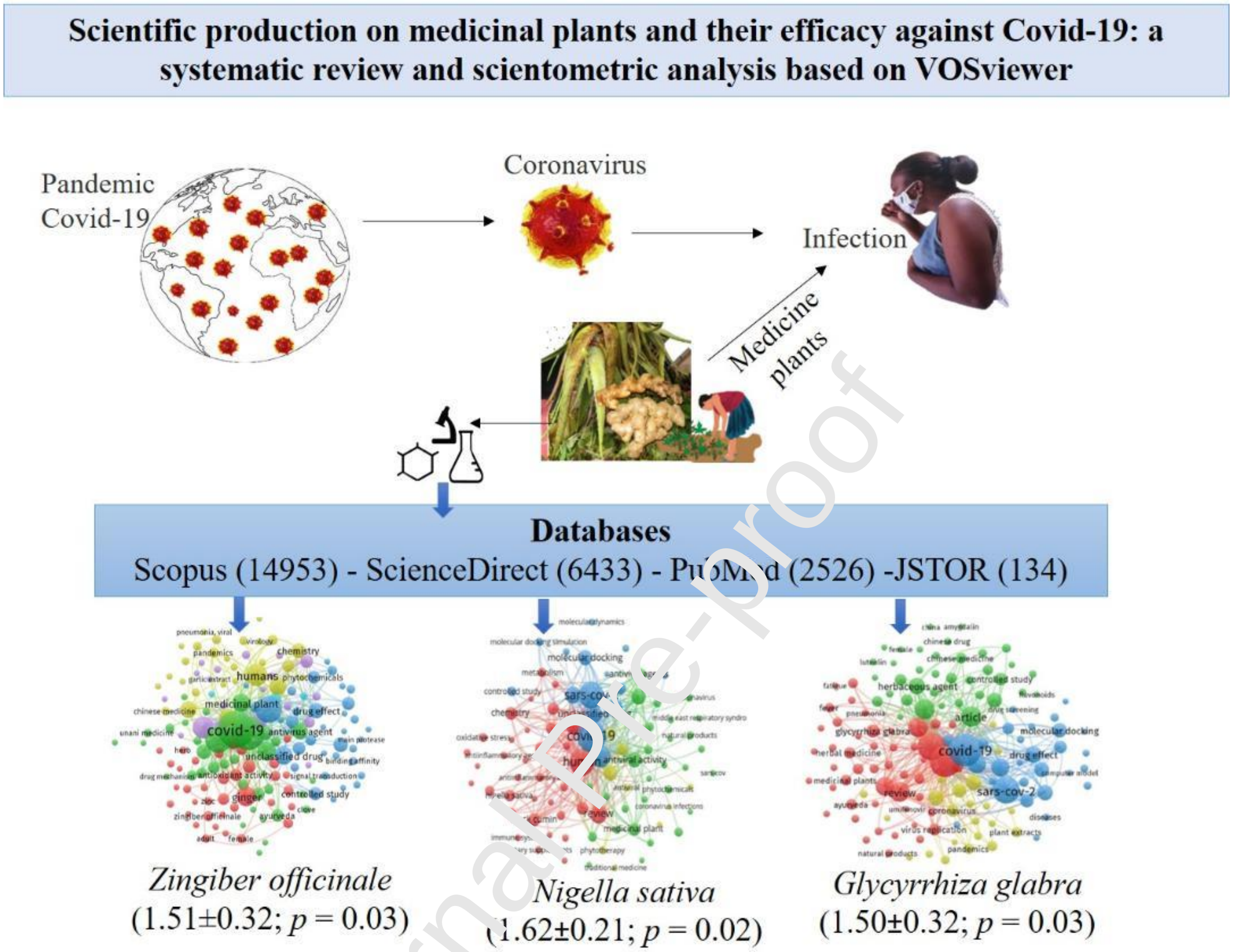
Declaration of interests:

☒ **The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.**

☐The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Graphical abstract



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