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An Algerian endemic species in danger to disappear due to pandemic, *Origanum vulgare* subsp. *glandulosum* (Desf.) Letsw

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Abstract. *Adouani I, Boulaacheb N. 2022. An Algerian endemic species in danger to disappear due to pandemic,* Origanum vulgare *subsp.* glandulosum *(Desf.) Letsw. Biodiversitas 23: 3147-3155.* Algeria is known for its rich flora, and the traditional use of medicinal plants is very ancient. The use of medicinal plants is extremely intensified during the COVID-19 pandemic. To enumerate the most used species by the Algerian population, two ethnobotanical surveys have been conducted from October to December 2021. Thirty herbalists were interviewed, and 165 respondents participated in an online survey. The results showed that a total of 25 species belonging to 16 botanical families had been reported to be used in different modes of preparation to prevent or treat the infection. One of the locally used species is *Origanum vulgare* subsp. *glandulosum* (Desf.) letsw. Generally, Algerians internally use this species as a tea or as a powder preparation with honey or only the powder with water to treat many health problems such as diarrhea, colds, coughs, respiratory infections, rheumatism, and menstrual symptoms. Otherwise, the powder of the plant is externally used alone or with olive oil to cure several illnesses such as rheumatism, and skin irritations. Due to the extensive use of this species during the pandemic, the demand in the market has increased, as also the price. Herbalists reported that they have received between 30-300 people affected or not by COVID-19 per day. The price went from 1500-5000 DA per kg (10.33-34.42 USD). Therefore, the increase rate is expected to be 50-80% for the demand, and 50-90% for the price. This increase in demand during COVID-19 has led to an exaggerated and random collection of species at different stages of the development of the plant. Although *O. vulgare* subsp. *glandulosum* is a common species, but it can be rare or even disappear due to the extensive collection without protective measures due to COVID-19. Therefore, it is important to engage policies for the conservation and cultivation of *O. vulgare* subsp. *glandulosum.*

Keywords: Extensive demand, *Origanum vulgare* subsp. *glandulosum* (Desf.) letsw., Setif, survey, traditional medicine

INTRODUCTION

Traditional medicine is viewed as a combination of knowledge and practice used in diagnosing, preventing, and eliminating the disease (Villena-Tejada et al. 2021). It is old but still widely used in all societies, and it is common in all cultures, including North Africa (Ozioma and Chinwe 2019; Zatout et al. 2021). The use of medicinal plants is a common practice in traditional medicine in Algeria. Its wide use is justified by the richness of the Algerian flora, particularly endemic species and by the diversity of the know-how (Miara et al. 2019). This richness is due to the geographical situation, the climate, and the soil composition of the country.

Since December 2019, the COVID-19 pandemic has been one of the most lethal illnesses in the world (Rastogi et al. 2022). Everyday precautions and preventive measures, such as wearing masks, frequent hand washing, use of disinfectants, and social distancing are required to minimize the risk of contamination (Ouassou et al. 2020; Mola et al. 2021). In addition to these measures, herbal medicine, by its rich composition of vitamins, minerals, and other biomolecules, is also used to increase the immunity, protect against the disease or treat its symptoms (Hamdani and Houari 2020; Khadka et al. 2021; Lim et al. 2021; Villena-Tejada et al. 2021). Numerous studies have been conducted by many scientists around the world to investigate the different plants used during the COVID-19 pandemic (Hamdani and Houari 2020; Vandebroek et al. 2020; Chaudhari and Kokate 2021; Lim et al. 2021). Many plants have been reported, such as ginger (*Zingiber officinale*) in Nepal (Khadka et al. 2021), Indian lilac (*Azadirachta indica*) in Malaysia (Lim et al. 2021), eucalyptus (*Eucalyptus globulus*), ginger (*Z. officinale*), spiked pepper (*Piper aduncum*), garlic (*Allium sativum*), and chamomile (*Matricaria recutita*) in Peru (Villena-Tejada et al. 2021). In China and India, traditional medicine has been integrated with western medicine to treat COVID-19 patients (Vellingiri et al. 2020; Rastogi et al. 2022). This combination showed encouraging results in boosting the immune system of patients leading to better symptom management and reducing complications and mortality rates (Khadka et al. 2021; Rastogi et al. 2022). Hence, the ethnobiological study is important to document the medicinal plants used against COVID-19 with caution to stop the inaccurate sharing of misinformation through social media and to conserve biological and cultural diversity (Khadka et al. 2021).

The aim of the present study is to enumerate the herbal medicines used by the Algerian population to prevent or

treat COVID-19 infection. Furthermore, the purpose of this research work is also to analyze the impact of this medicinal use on the conservation of the local natural resources.

MATERIALS AND METHODS

Study area

Algeria is the largest country in North Africa, covering 58 *wilayas* (provinces) (Figure 1). The Algerian territory is geographically very heterogeneous (coasts, mountains, forests, arid high plains, steppe, and Sahara). It is characterized by two types of climate, namely Saharian climate in the south and Mediterranean climate in the north of the country. Its ecosystemic and climatic diversity shelter huge floristic biodiversity.

One of its most important provinces is Setif located in northwest Algeria (Figure 1). It has 60 municipalities covering an area of 6549.64 Km2 and with a total of 1,610,094 habitats (https://dcwsetif.dz/fr/index.php/wil34). It is characterized by a semi-arid bioclimatic stage in the south where the average annual rainfall rarely exceeds 400 mm, and sub-humid bioclimatic stage in the north where the average annual rainfall is 700 mm. The area is characterized by a short rainy and cold period, averaging from November to March, and another dry and warm period over the rest of the months of the year. The coldest month is January with a minimum of 1°C and the warmest month is Jully, with a maximum of 32°C (https://fr.weatherspark.com/). The maps presented in Figure 1 were generated using https://paintmaps.com/ and ArcGIS® software.

Ethnobotanical investigation and data collection

Two kinds of investigations have been realized from October to December 2021 to collect information about the medicinal plants used by the Algerian population during the COVID-19 pandemic, and to know which plants have been more used and demanded in the market. The collected information included the vernacular name, the mode of preparation, and the used parts.

The first one was a face-to-face type investigation including herbalists of the Wilaya of Setif. In addition to the socio-economical information of the herbalists, the interview focused on the following questions: (i) Did you receive persons using medicinal plants to treat or prevent COVID-19 during the third wave of the coronavirus pandemic? (ii) If it is yes, how many persons did you receive per day? (iii) Which species are more demanded? (iv) Did the demand in the market increase? (v) Did the price (cost) of the plants increase?

To be sure that the questions were understood by the herbalists, the interview was conducted using the dialect language. All the herbalists have been clearly informed about the nature and objectives of the study. The study has been enrolled for scientific purposes. No economic or political profits were considered. The study was conducted respecting the International Society of Ethnobiology (ISE) code of ethics.

The second investigation was an online survey including adult persons living in different parts of Algeria. A questionnaire has been prepared using Google® Forms developer. A written consent message was clearly placed at the top of the form to explain the nature and the objectives of the survey. We have intended to circulate the questionnaire as much as possible to get more respondents by sharing it through social media and email.

Plant samples identification

Some samples of the plants reported have been purchased to be identified in the laboratory of urban projects, cities, and territories (PUVIT) using the flora of Quézel and Santa (1963). The nomenclature of species is given using https://www.ipni.org/ (International Plant names index) and https://www.ville-ge.ch/ (African Plants Database).

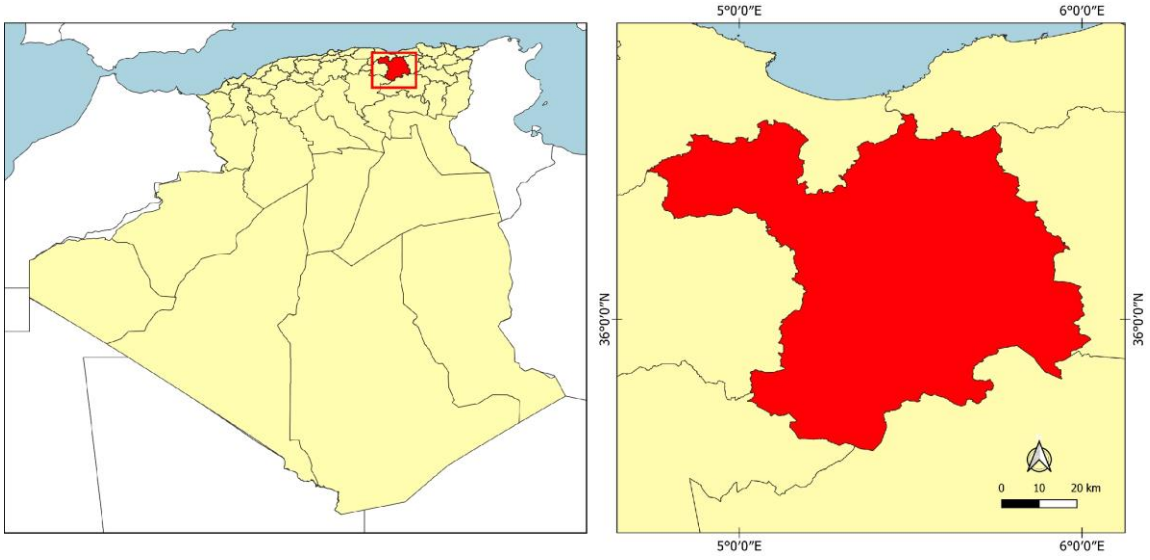

Figure 1. Map of the study area in Setif Province, northeast of Algeria

Data analysis

All data have been statistically treated using IBM® SPSS statistics 22. The graphs have been represented using Microsoft® Excel. For all the recorded species, the relative frequency of citation (RFC) was calculated following Tardio and Pardo-de-Santayana (2008) (Tardío and Pardo-de-Santayana 2008).

$$RFC = \frac{FC}{N},$$

Where; FC is the frequency of citation equal to the number of respondents who mentioned the use of species and N = the total number of respondents who took part in a survey.

RESULTS AND DISCUSSION

Online investigation

The online investigation showed that a total of 165 persons participated in the survey conducted from October to December 2021. The respondents provided information about the different variables used for the study. The age of the respondents varied from 16 to 78 years with a mean of 40.05 ±13.55 years. The majority of respondents were female (74%). Almost all of the respondents were literate (99.4%), and most of them (83.3%) had attended University. Mostly the participants (94.9%) were employees, (1.9%) were students, (1.9%) were retired, and only (0.6%) were jobless. The respondents were from different regions of Algeria, i.e., Setif (60%), Algiers (17%), and others (23%). Forty-eight persons have been infected by sars-cov-2 (58.6%) and did not seek medical assistance. During this investigation, 20 species belonging to 20 genera and 13 botanical families have been enumerated.

Herbalist interview

During the survey, data were collected from 30 herbalists of the Wilaya of Setif. The interview duration varied between 20 to 30 minutes according to the availability of the herbalist. Most of them were literate (90%), and all of them were male. The age ranged between 25 and 45 years. According to all the herbalists, many persons were looking for medicinal plants to prevent or treat COVID-19 infection during the third wave that arose in July 2021 in Algeria. The herbalists have reported that they have received 30 to 300 persons per day. About 99% have received between 100 to 300 persons per day, and only one herbalist (1%) received 30 persons per day during the pandemic. Sixteen (16) species of plants belonging to 16 genera and 11 botanical families were reported to be purchased and used for the treatment or the prevention of COVID-19 infection. All these species have been purchased, identified in the laboratory of urban projects, cities, and territories, and confirmed.

Recorded medicinal plants, used parts, and mode of preparation

All the enumerated species from both investigations are listed in Table 1 with respective botanical family, scientific, local, and English names, used parts (roots, bulbs, leaves, rhizomes, seeds, areal parts, fruit, bark, flowers), mode of preparation (infusion, fumigation, etc.), percentage of citation (%), the relative frequency of citation (RFC), and source of information (whether the online survey, herbalist interview, or both of them).

A total of 25 species belonging to 25 genera and 16 botanical families have been recorded. *Viola odorata*, *Saussurea costus*, *Chenopodium quinoa*, *Glycyrrhiza glabra*, and *Moringa oleifera* have only been reported by the herbalist's interview. Eleven species like *Artemisia herba-alba*, *Mentha spicata*, *Origanum vulgare* subsp. *glandulosum*, *Cinnamomum verum*, *Syzygium aromaticum*, *E. globulus*, *Citrus limon*, *Alpinia officinarum*, *Curcuma longa*, and *Z. officinale* have been commonly enumerated in both investigations. In addition to these species, nine other medicinal plants have been reported through the online survey to be used by the Algerian population during the COVID-19 pandemic, including *Thymus* sp, *Marrubium vulgare*, *Hibiscus sabdariffa*, *Trigonella feonum-graecum*, *Dianthus* sp., *Anacyclus pyrethrum*, *Allium cepa*, *Juglans regia*, *Camellia sinensis*. These nine species have not been reported by herbalists.

The infusion was the most used preparation mode (82.6%). The most used parts are leaves (35.71%) followed by roots (28.57%), Rhizome (21.43%), and aerial parts (21.43%).

Status of medicinal plants used during COVID-19 and its impact on the conservation of natural resources

The results obtained from herbalist interviews have shown an increase in demand and a rise in prices during July-August 2021. The demand has been remarkedly increased. The majority of the herbalists (95%) declared that the demand has tripled against only 5% who estimated that the demand has doubled. The price during this period varied from 1500 DA to 5000 DA (10.33- 34.42 USD) per kg. More than half of herbalists (69%) informed that the price went from 1500 DA to 4000 DA (10.33- 27.54 USD) per kg followed by 31% who reported that the price went from 2000 DA to 5000 DA (13.77- 34.42 USD) per kg. Therefore, the demand growth rate has been estimated to be 50-80% and the rise in prices between 50% and 90%.

The online investigation has also shown an intensive use of medicinal plants during the COVID-19 pandemic. Results from both investigations have shown that *Origanum vulgare* subsp. *glandulosum* has been used by the Algerian population to prevent or treat COVID-19 infection. This species is endemic to Algeria and Tunisia.

Table 1. List of species used by the Algerian population during COVID-19

Family	Species	Local name	English name	Used parts	Usage	%	RFC	Source
Amaryllidaceae	*Allium cepa* L.	البصل (El Bsal)	Onion	Bulbs	Slices underfoot	0.64	0.01	Online survey
Amaranthaceae	*Chenopodium quinoa* Willd.	الكينوا (El Qinoa)	Quinoa	Seeds	/	/	/	Herbalist interview
Asteraceae	*Artemisia herba-alba* Asso	الشيح (El Chîh)	White wormwood	Aerial parts	Infusion	5.13	0.08	Both
	Saussurea costus (Falc.) Lipsch.	القسط الهندي (El Qist el Hindi)	Costus	Roots	Fumigation	/	/	Herbalist interview
	Anacyclus pyrethrum (L.) Link	القنطس (El Gantas)	Spanish chamomile	Roots	Powder with honey	1.92	0.03	Online survey
Caryophyllaceae	*Dianthus* sp.	القرنفل (El Qronfol)	Clove pink	Flowers	Infusion	0.64	0.01	Online survey
Fabaceae	*Glycyrrhiza glabra* L.	عرق السوس (Erq-Essous)	Licorice	Roots	Infusion	/	/	Herbalist interview
	Trigonella foenum-graecum L.	الحلبة (El Helba)	Fenugreek	Seeds	Infusion	1.28	0.02	Online survey
Juglandaceae	*Juglans regia* L.	الجوز (El Jouz)	Common walnut	Roots	Infusion	0.64	0.01	Online survey
Lamiaceae	*Mentha spicata* L.	النعناع (El Naânaâ)	Mint	Leaves	Infusion	5.77	0.09	Both
	Origanum vulgare subsp. *glandulosum* (Desf.) letsw.	الزعتر (El Zaater)	Oregano	Aerial parts	Infusion Powder with honey	8.97	0.14	Both
	Thymus sp.	الزعيترة (Z'itrah)	Thyme	Aerial parts	Infusion	7.05	0.11	Online survey
	Marrubium vulgare L.	المروث (El Marouth)	White horehound	Leaves	Infusion	0.64	0.01	Online survey
Lauraceae	*Cinnamomum verum* J.Presl	القرفة (El Qarfa)	Cinnamon	Barks	Infusion	2.56	0.04	Both
Malvaceae	*Hibiscus sabdariffa* L.	الكركدية (El Karkadia)	Roselle	Flowers	Infusion	1.28	0.02	Online survey
Moringaceae	*Moringa oleifera* Lam.	المرنج (El Mernej)	Horseradish tree	Leaves	Infusion Powder with water	/	/	Herbalist interview
Myrtaceae	*Syzygium aromaticum* (L.) Merr. & L. M. Perry	القرنفل/ ألطيب (El Qronfol /El Tib)	Clove	Flowers	Infusion	10.9	0.17	Both
	Eucalyptus globulus Labill.	الكافور/ الكاليتوس (El Kafour/El Kalitous)	Blue eucalyptus	Leaves	Infusion Fumigation	1.28	0.02	Both
Rutaceae	*Citrus limon* (L.) Osbeck	الليمون (El Limone)	Lemon	Fruit	Juice Infusion Mixture with other plants	7.69	0.12	Both
Theaceae	*Camellia sinensis* (L.) Kuntze	الشاي(El Chay)	Tea	Leaves	Infusion	1.92	0.03	Online survey
Verbenaceae	*Aloysia citrodora* Paláu	اللويزة (El Ouiza)	Lemon verbena	Leaves	Infusion	3.85	0.06	Both
Violaceae	*Viola odorata* L.	بوفساد (Boufsad)	Common violet	Flowers	Infusion	/	/	Herbalist interview
Zingiberaceae	*Alpinia officinarum* Hance	خنجلان (khandjlan)	Lesser galangal	Rhizome	Infusion	0.64	0.01	Both
	Curcuma longa L.	الكركم (El korkom)	Turmeric	Rhizome	Infusion	0.64	0.01	Both
	Zingiber officinale Roscoe	مسك نجبير/زنجبيل (Misknadjbir/Zanjabyl)	Ginger	Rhizome	Infusion	5.77	0.09	Both

Notes: RFC: relative frequency of citation; / : no information

Discussion

Recorded medicinal plants, used parts, and mode of preparation

Different research works related to COVID-19 ethnobiology have been conducted around the world. Many similar species have been reported by other researchers (Table 2). In our study, a total of 25 species have been recorded. *Syzygium aromaticum*, *Origanum vulgare* subsp. *glandulosum*, *C. limon*, and *Thymus* sp. have been reported to be the most purchased, and most requested by the Algerian people. Our results are similar to the results of an online survey realized in the north of Algeria in 2020, where 22 species belonging to 12 families have been cited to be used to treat COVID-19 infection, and the infusion was the most used preparation mode (Hamdani and Houari 2020). Except, *Mentha pulegium*, *Rosmarinus officinalis*, *Lavandula stoechas*, *A. sativum*, *Juniperus phoenicea*, *Chamaemelum nobile*, *Olea europea*, *Trachyspermum ammi*, all other species have been similar.

A study in Morocco has recorded a total of 23 species which include some similar species, namely *A. herba-alba*, *C. verum*, *E. globulus*, *A. officinarum*, *A. cepa*, and *Z. officinale* (ELalami et al. 2020). Whereas another study conducted in Morocco in 2022 has documented a total of 36 species, including *Z. officinale*, *A. herba-alba*, *E. globulus*, *C. verum*, *S. aromaticum*, *C. limon*, *A. indica* (Najem et al. 2022). This latter was not reported in our study because *A. indica* is not a common species in the Algerian flora.

In Peru, from 17 reported species, *Z. officinale*, *E. globulus*, *A. sativum*, *P. aduncum*, *M. recutita* were the most used for the prevention or the treatment of COVID-19 (Villena-Tejada et al. 2021) and and for treating asthma in Ethiopia (Haile 2022). In a recent review article documenting the different medicinal plants used in the COVID-19 pandemic in India, 26 species have been enlisted, including *Z. officinale*, *C. verum*, *G. glabra*, *S. costus*, and *V. odorata* (Chaudhari and Kokate 2021). In our study, we have also recorded the use of these medicinal plants.

Researchers from Nepal (Khadka et al. 2021), through an online ethnobotanical investigation including 774 respondents, have recorded a total of 60 plants belonging to 36 families used to prevent or cure COVID-19 infection in Nepal. In addition to *Z. officinale*, *S. aromaticum*, *G. glabra*, *Trigonella foenum-graecum*, the top ten recorded species were *A. sativum*, *Mentha arvensis*, *Ocimum basilicum*, *Cinnamomum zeylanicum*, *A. indica*, *Tinospora cordifolia*, *Phyllanthus emblica*, *Citrus aurantifolia*, *Curcuma angustifolia*. The leaves of the plants were the most frequently used part. Mostly, the preparation mode was mixing the powder of the used parts with hot water or milk. In our study, the leaves were the most used parts of the plants corroborating the findings of other related studies but the infusion was the most used preparation mode. A study from Bangladesh (Bhuiyan et al. 2020) screened 149 plants from 71 families and found they have potential molecules for preparing a drug for the treatment of COVID-19. The higher number of documented species in these two studies might be due to the elevated number of participants.

Table 2. Common species used during the COVID-19 in different countries

Study/ references	Country	Number of species	Species
Najem et al. (2022)	Morocco	36	*Zingiber officinale* Rosc., *Artemisia herba-alba* Asso, *Eucalyptus globulus* Labill, *Cinnamomum verum* J. Presl, *Syzygium aromaticum* (L.) Merr. & L.M. Perry, *Citrus limon* (L.) Osbeck, *Azadirachta indica* A. Juss.
Khadka et al. (2021)	Nepal	60	*Zingiber officinale* Rosc., *Syzygium aromaticum* (L.) Merr. & L.M. Perry, *Citrus aurantiifolia* (Christm.) Swingle, *Glycyrrhiza glabra* L., *Trigonella foenum-graecum* L.
Chaudhari et al. (2021)	India	26	*Zingiber officinale* Rosc., *Cinnamomum verum* J. Presl, *Glycyrrhiza glabra* L., *Saussurea Costus* (Falc.) Lipsch., *Viola odorata* L.
Villena-Tejada et al. (2021)	Peru	17	*Zingiber officinale* Rosc., *Eucalyptus globulus* Labill, *Allium sativum* L., *Piper aduncum* L., *Matricaria recutita* L., *Rosmarinus officinalis* L., *Origanum vulgare* L., *Thymus vulgaris* L.
Alami et al. (2020)	Morocco	23	*Zingiber officinale* Rosc., *Rosmarinus officinalis* L., *Artemisia herba-alba* Asso, *Eucalyptus globulus* Labill, *Cinnamomum verum* J. Presl, *Alpinia officinarum* Hance, *Curcuma xanthorrhiza* D. Dietr., *Allium cepa* L.
Hamdani et al. (2020)	Algeria	22	*Zingiber officinale* Rosc., *Rosmarinus officinalis* L., *Artemisia herba-alba* Asso, *Eucalyptus globulus* Labill, *Cinnamomum verum* J. Presl, *Origanum vulgare* L., *Syzygium aromaticum* (L.) Merr. & L.M. Perry, *Citrus limon* (L.) Osbeck, *Aloysia citrodora* Paláu, *Mentha spicata* L., *Thymus vulgaris* L.
Bhuiyan et al. (2020)	Bangladesh	149	*Moringa peregrina* (Forssk.) Fiori, *Syzygium aromaticum* (L.) Merr. & L.M. Perry.

Most of the species reported in our study are locally available, and some are used for daily food at home (*A. sativum*, *A. cepa*, *C. verum*, *C. longa*, *Z. officinale*) or traditionally used for their therapeutic effects (*M. vulgare*, *A. pyrethrum*, *A. herba-alba*. The reported plants belong to botanical families which are very rich in different chemical constituents (phytonutrients, vitamins, minerals, and bioactive compounds) which might have different therapeutic effects likewise antipyretic (*V. odorata*; Tafazoli et al. 2020), (*Z. officinale*; Kausar et al. 2021), anti-inflammatory (*Z. officinale*; Gupta et al. 2021), (*R. officinalis*; Gupta et al. 2021), (*Saussura costus*; Choi et al. 2021), (*V. odorata*; Sikander et al. 2021), (*G. glabra*; Hasan et al. 2021), (*C. longa*; Gupta et al. 2021), antitussive (*Z. officinale*; Bera et al. 2016), (*G. glabra*; Kuang et al. 2018), anti-emetic (*Z. officinale*; Kausar et al. 2021), antiviral (*Z. officinale*; Kaushik et al. 2020), (*G. glabra*; Wang et al. 2015), (*C. longa*; Bhuiyan et al. 2020), (*C. verum*; Fatima et al. 2016), antioxidant (*Z. officinale*; Tohma et al. 2017), (*C. verum*; Yakhchali et al. 2021), (*C. longa*; Bhuiyan et al. 2020), (*G. glabra*; Kuang et al. 2018), antidiarrheal (*S, costus*; Negi 2013), anti-asthmatic (*V. odorata*; Qasemzadeh et al. 2015), (*G. glabra*; Hasan et al. 2021), immune-modulator (*S, costus*; Tag et al. 2016), (*Citrus* sp.; Merheb et al. 2019), antithrombotic (*V. odorata*; Sikander et al. 2021), and analgesic (*G. glabra*; Raut et al. 2021), (*Z. officinale*; Kausar et al. 2021), and decongestant (*Z. officinale*; Casula et al. 2022) which may explain their effectiveness to reduce the symptoms which helps to cure COVID-19 infection or even protect against it.

Moreover, *M. vulgare* is locally used for controlling fever, while *A. cepa*, *A. pyrethrum*, and *Z. officinale* are used to treat respiratory infections. Some plants, i.e., *M. spicata*, *Origanum vulgare* subsp. *glandulosum*, *S. aromaticum*, *E. globulus* are locally known to have disinfectant properties. *Artemisia herba-alba* and *G. glabra* usually heal digestive problems.

Some clinical symptoms correlated with COVID-19 infection include fever, headache, dizziness, dry cough, dyspnea, chest pain, fatigue, myalgia, abdominal pain, diarrhea, nausea, and vomiting (Chaudhari and Kokate 2021). These explain the use of the above documented medicinal plants for COVID-19 prevention and treatment. These plants can affect several key events in the pathogenic process (Bhuiyan et al. 2020). Hence, they might act against the virus or attenuate the major symptoms associated with the infection. COVID-19 patients might have a cytokine storm, *Curcuma* species like *angustifolia* and *caesia* can regulate cytokines release in the human body (Bhuiyan et al. 2020; Khadka et al. 2021).

According to Villena-Tejada et al. (2021), the COVID-19 pandemic in Peru has led to people seeking alternative treatments such as preventives and treatment options such as medicinal plants. This web-based cross-sectional survey involving 1747 respondents reported significant use of medicinal plants to prevent infection in 80.2% of respondents or to cure the respiratory symptoms in 71% of respondents.

The recent sanitary crisis due to the COVID-19 pandemic has obliged scientists all around the world from different fields to be involved in discovering a way to develop efficient therapeutics against the virus (Bhuiyan et al. 2020). Because of their rich composition and chemical diversity, medicinal plant species have always been an important source for drug discovery and development (Khadka et al. 2021). There are several classes of bioactive compounds which could be responsible for the biological activities of herbal medicines, including the antiviral effect (Cilla et al. 2018). Thus, a good knowledge of the chemical composition of the plants leads to a better understanding of their possible and specific medicinal effect (Bhuiyan et al. 2020). COVID-19 is a new disease, and the effectiveness of the biomolecules to cure this kind of viral infection has not yet been demonstrated (Vandebroek et al. 2020). Investigations are undergoing to find the appropriate molecules from numerous herbal preparations that could be an effective option against COVID-19, as most of them are safer and more cost-effective compared to synthetic drugs (Bhuiyan et al. 2020). A wide variety of plant metabolites such as polyphenols, alkaloids, saponins, terpenes, and carbohydrates have been a source of natural compounds with a broad spectrum of antiviral activities and some of them have shown anti-SARS-CoV-1 activity (Bhuiyan et al. 2020; Vellingiri et al. 2020). Because SARS-CoV-2 has shown many structural similarities with SARS-CoV-1, the previously reported anti-SARS-CoV-1 plant metabolites might be a desired drug candidate that could be effective against SARS-CoV-2 (Bhuiyan et al. 2020). *Glycyrrhiza glabra* has an inhibition effect on SARS viral replication and modulates membrane fluidity (Vellingiri et al. 2020). *Cinnamomum verum* has also been demonstrated to have an effect on COVID-19 (Yakhchali et al. 2021). Our study showed that *G. glabra* and *C. verum* had been used as an infusion of the roots during COVID-19 infection.

According to *in silico* screening of plant metabolites, numerous plant-based products showed promising anti-SARS-CoV-2 activity, likewise polyphenols can inhibit both SARS CoV-2 Mpro and RdRp effectively while flavonoids can only inhibit Mpro and terpene Ginkgolide A which can strongly inhibit protease enzyme (Bhuiyan et al. 2020). The species enumerated in our investigation are rich in polyphenols and flavonoids, which may explain their beneficial use during the pandemic.

On another hand, some in vitro and in vivo investigations revealed promising results. Chloroquine, a derivative of alkaloid, is found to be active against anti-SARS CoV-2 (Rashed 2021). Chemical constituents like 8-Gingerol and 10-Gingerol from *Z. officinale* were active against COVID-19 (Khadka et al. 2021). Some plant formulations used in traditional Chinese medicine (TCM) have been reported as being anti-SARS CoV-2 and cured thousands of COVID-19-infected patients (Cui et al. 2020; Ren et al. 2020). Thus, TCM and herbal medicine have been promoted as alternative therapeutic solutions in conjunction with western medicine treatment (Ren et al. 2020). Therefore, TCM was officially included in the Chinese Guideline for the diagnosis and treatment of COVID-19 (Rastogi et al. 2022).

Status of medicinal plants used during COVID-19 and its impact on the conservation of natural resources

Vandebroek et al. (2020) have discussed how the pandemic will impact local and indigenous communities, and their use or management of natural resources. They concluded that COVID-19 might have increased demand for medicinal plants, particularly in China and USA. In another study, Khadka et al. (2021) reported that the use of medicinal plants has increased during COVID-19 which might have increased the demand. We have also found that the use and the demand for medicinal plants have increased during the pandemic in Algeria. This led to an increase the prices. Therefore, the excessive use of medicinal plants, however, could be problematic and is a matter of concern.

In Algerian flora, the genus *Origanum* is represented by three species, namely *O. floribundum* Munby, *O. majorana* L., and *O. vulgare* subsp. *glandulosum* (Desf.) Letsw. All are herbaceous or may be under-woody at the base. Only, *O. vulgare* subsp. *glandulosum* has been widely used during the COVID-19 infection. It is one of the Lamiaceae family, which is locally called *Zâteur* in Algeria. It is a perennial plant. The stems are all erect with opposite olive-green leaves. The flowers are purple or white, produced in dense and erect spikes in summer. Corolla presents two lips; the lower lip is much longer than the upper lip. In Algeria, this common plant grows in scrubs and scrublands (Quézel and Santa 1963).

Origanum vulgare subsp. *glandulosum* is one of the most popular plants, widely known by all categories of ages, and usually used in folk medicine (Miara et al. 2019). It has a long history of use as a medicinal plant in numerous applications (Miara et al. 2019; Bouzabata and Mahomoodally 2020). Researchers reported the richness of this species on biomolecules, especially essential oils, which are responsible for its biological activities such as antibacterial, antioxidant, and antifungal (Mechergui et al. 2016; Nabti et al. 2020).

We have inherited from our grandparents the art of harvesting this majestic species. They taught us that the best harvesting period must be in July during the fruitful phase. Concerning the mode of harvesting, we should only cut the aerial parts. It is very important to respect these recommendations. These allow the species to grow, develop all the metabolites, and form its seeds. Underground parts, such as roots and rhizomes, are rich in bioactive constituents. However, indiscriminate use of underground parts might lead to conservation threats, particularly to endemic species. Similarly, the use of bark in an excessive amount, and the whole plant use might create problems in conservation (Khadka et al. 2021).

With the anarchic collection, the lack of cultivation, and due to the rise in the demand, *O. vulgare* subsp. *glandulosum* which is endemic to Algeria and Tunisia has been exaggeratedly used during the COVID-19 period which exposes it to the danger of disappearing. The high demand for medicinal plants, especially for *O. vulgare* subsp. *glandulosum* during the coronavirus pandemic led to an increase in the harvest of the species. The species is plucked from the roots during its vegetative stage. This uncontrolled harvest has a bigger impact than climate change. Thus, it becomes indispensable to protect this species. It is very important to control human activities by checking harvests and commercialization of *O. vulgare* subsp. *glandulosum*. Unchecked harvest and commercialization of medicinal plants are threatening the future of these natural resources. In addition, overharvesting puts many medicinal species in danger of extinction (Jan and Abbas 2018; Rathore et al. 2021).

For sustainable use, we must conserve our natural heritage. For biodiversity conservation, it is also important to know what quantities of plant materials are harvested, not only for home consumption but also for trade. Commercial trade often stimulates extensive wild-collection, which often has negative effects on medicinal plant population sizes and recovery after harvesting and causes several issues in the conservation of plants (Boadu and Asase 2017). The development of gardening or farming practices in the country will support the sustainable conservation of medicinal plants.

This study permitted us to enumerate many interesting species used by the Algerian population during the COVID-19 pandemic. The validity and reliability of such medicinal plants should be tested further by phytochemical and pharmacological research. One of the most used species is *O. vulgare* subsp. *glandulosum*. The use of these medicinal plants has increased during COVID-19, which led to an increase the demand and consequently the rise of their prices. The situation is critical in Algeria because of the high demand and over-exploitation of *O. vulgare* subsp. *glandulosum*. For these reasons, the conservation of this species has become increasingly urgent and must be listed as threatened. To reduce the overharvest, we recommend the cultivation of *O. vulgare* subsp. *glandulosum*. This study has demonstrated how certain human practices and activities can be dangerous for some species, especially if they are widely used in folk medicine, such as *O. vulgare* subsp. *glandulosum*.

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REFERENCES

Bera K, Nosalova G, Sivova V, Ray B. 2016. Structural elements and cough suppressing activity of polysaccharides from *Zingiber officinale* Rhizome. Phyther Res 30 (1): 105-111. DOI: 10.1002/ptr.5508.

Bhuiyan FR, Howlader S, Raihan T, Hasan M. 2020. Plants metabolites: Possibility of natural therapeutics against the COVID-19 pandemic. Front Med 7: 444. DOI: 10.3389/FMED.2020.00444/BIBTEX.

Boadu AA, Asase A. 2017. Documentation of herbal medicines used for the treatment and management of human diseases by some communities in southern Ghana. Evid-Based Complement Altern Med 2017: 1-12. DOI: 10.1155/2017/3043061.

Bouzabata A, Mahomoodally MF. 2020. A quantitative documentation of traditionally-used medicinal plants from Northeastern Algeria:

Interactions of beliefs among healers and diabetic patients. J Herb Med 22: 100318. DOI: 10.1016/j.hermed.2019.100318.

Casula E, Manconi M, Lopez-Mendez TB, Pedraz JL, Calvo E, Lozano A, Zaru M, Castangia I, Orrù G, Fais S, et al. 2022. Complementary effect of *Zingiber officinalis* extract and citral in counteracting non allergic nasal congestion by simultaneous loading in ad hoc formulated phospholipid vesicles. Colloids Surfaces B Biointerfaces 209 (2): 112170. DOI: 10.1016/j.colsurfb.2021.112170.

Chaudhari VM, Kokate K. 2021. Role of Medicinal plants in Covid-19 pandemic: An Ayurveda perspective. Intl J Ayurvedic Med 12 (2): 204-218. DOI: 10.47552/ijam.v12i3.1930.

Choi D-H, Kim J-Y, An J-H, Sung S-H, Kong H-S. 2021. Effects of *Saussurea costus* on apoptosis imbalance and inflammation in benign prostatic hyperplasia. J Ethnopharmacol 279: 114349. DOI: 10.1016/j.jep.2021.114349.

Cilla A, Bosch L, Barberá R, Alegría A. 2018. Effect of processing on the bioaccessibility of bioactive compounds - A review focusing on carotenoids, minerals, ascorbic acid, tocopherols and polyphenols. J Food Compos Anal 68: 3-15. DOI: 10.1016/j.jfca.2017.01.009.

Cui H, Li Y, Guo L, Liu X, Shan WL, Jia J, Liao J, Miao J, Zhang Z, Wang Li, et al. 2020. Traditional Chinese medicine for treatment of coronavirus disease 2019: a review. Tradit Med Res 5 (2): 65-73. DOI: 10.53388/TMR20200222165.

ELalami A, Fattah A, Chait A. 2020. Medicinal plants used for the prevention purposes during the Covid-19 pandemic in Morocco. J Anal Sci Appl Biotechnol 2 (1) :4-11. DOI: 10.48402/IMIST.PRSM/jasab-v2i1.21056.

Fatima M, Zaidi N-SS, Amraiz D, Afzal F. 2016. In vitro antiviral activity of *Cinnamomum cassia* and its nanoparticles against H7N3 influenza A virus. J Microbiol Biotechnol 26 (1): 151-159. DOI: 10.4014/jmb.1508.08024.

Gupta M, Singh N, Gulati M, Gupta R, Sudhakar K, Kapoor B. 2021. Herbal bioactives in treatment of inflammation: An overview. South Afr J Bot 143: 205-225. DOI: 10.1016/j.sajb.2021.07.027.

Haile AA. 2022. Ethnobotanical study of medicinal plants used by local people of Mojana Wadera Woreda, North Shewa Zone, Amhara Region, Ethiopia. Asian J Ethnobiol 5 (1): 35-43. DOI: 10.13057/asianjethnobiol/y050104.

Hamdani FZ, Houari N. 2020. Phytotherapy of covid-19. a study based on a survey in North Algeria. Phytotherapie 18 (5): 248-254. DOI: 10.3166/PHYTO-2020-0241.

Hasan MK, Ara I, Mondal MSA, Kabir Y. 2021. Phytochemistry, pharmacological activity, and potential health benefits of *Glycyrrhiza glabra*. Heliyon 7 (6): e07240. DOI: 10.1016/j.heliyon.2021.e07240.

Jan S, Abbas N. 2018. Himalayan Phytochemicals: Sustainable Options for Sourcing and Developing Bioactive Compounds. Elsevier. DOI: 10.1016/B978-0-08-102227-6.00004-8.

Kausar T, Anwar S, Hanan E, Yaseen M, Aboelnaga SMH, Azad ZRAA. 2021. Therapeutic role of ginger (*Zingiber officinale*) - A review. J Pharm Res Intl 33 (29B): 9-16. DOI: 10.9734/jpri/2021/v33i29B31584.

Kaushik Sulochana, Jangra G, Kundu V, Yadav JP, Kaushik Samander. 2020. Anti-viral activity of *Zingiber officinale* (Ginger) ingredients against the Chikungunya virus. VirusDisease 31 (3): 270-276. DOI: 10.1007/s13337-020-00584-0.

Khadka D, Dhamala MK, Li F, Aryal PC, Magar PR, Bhatta S, Thakur MS, Basnet A, Cui D, Shi S. 2021. The use of medicinal plants to prevent COVID-19 in Nepal. J Ethnobiol Ethnomed 17 (1): 26. DOI: 10.1186/s13002-021-00449-w.

Kuang Y, Li B, Fan J, Qiao X, Ye M. 2018. Antitussive and expectorant activities of licorice and its major compounds. Bioorg Med Chem 26 (1): 278-284. DOI: 10.1016/j.bmc.2017.11.046.

Lim XY, Teh BP, Tan TYC. 2021. Medicinal plants in COVID-19: Potential and limitations. Front Pharmacol 12: 611408. DOI: 10.3389/fphar.2021.611408.

Mechergui K, Jaouadi W, Coelho JA, Serra MC, Khouja ML. 2016. Biological activities and oil properties of *Origanum glandulosum Desf*: A review. Phytothérapie 14 (2): 102-108. DOI: 10.1007/s10298-015-0963-x.

Merheb R, Abdel-Massih RM, Karam MC. 2019. Immunomodulatory effect of natural and modified Citrus pectin on cytokine levels in the spleen of BALB/c mice. Int J Biol Macromol 121: 1-5. DOI: 10.1016/j.ijbiomac.2018.09.189.

Miara MD, Bendif H, Rebbas K, Rabah B, Hammou MA, Maggi F. 2019. Medicinal plants and their traditional uses in the highland region of Bordj Bou Arreridj (Northeast Algeria). J Herb Med 16: 100262. DOI: 10.1016/j.hermed.2019.100262.

Mola S, Aweke Z, Jemal B, Hussen R, Hailu S, Neme D, Mulugeta H, Zemedkun A. 2021. Magnitude and associated factors for attitude and practice toward COVID-19 and its prevention among the residents of Gedeo Zone, Southern Ethiopia: A community-based cross-sectional study. Risk Manag Healthc Policy 14: 253-262. DOI: 10.2147/RMHP.S277904.

Nabti LZ, Sahli F, Laouar H, Olowo-okere A, Wandjou JGN, Maggi F. 2020. Chemical composition and antibacterial activity of essential oils from the Algerian Endemic *Origanum glandulosum* Desf. against multidrug-resistant uropathogenic *E. coli* isolates. Antibiotics 9 (1): 29. DOI: 10.3390/antibiotics9010029.

Najem M, Ibijbijen J, Nassiri L. 2022. Phytotherapy in response to COVID-19 and risks of intoxication: A field study in the city of Meknes (Morocco). J Pharm Pharmacogn Res 10 (3): 357-386.

Negi S. 2013. Antidiarrheal activity of methanol extract and major essential oil contents of *Saussurea lappa Clarke*. Afr J Pharm Pharmacol 7 (8): 474-477. DOI: 10.5897/AJPP2012.1532.

Ouassou H, Kharchoufa L, Bouhrim M, Daoudi NE, Imtara H, Bencheikh N, ELbouzidi A, Bnouham M. 2020. The pathogenesis of coronavirus disease 2019 (COVID-19): Evaluation and prevention. J Immunol Res 2020: 1-7. DOI: 10.1155/2020/1357983.

Ozioma E-OJ, Chinwe OAN. 2019. Herbal medicines in African traditional medicine. IntechOpen.

Qasemzadeh MJ, Sharifi H, Hamedanian M, Gharehbeglou M, Heydari M, Sardari M, Akhlaghdoust M, Minae MB. 2015. The effect of *Viola odorata* flower syrup on the cough of children with asthma. J Evid Based Complementary Altern Med 20 (4): 287-291. DOI: 10.1177/2156587215584862.

Quézel P, Santa S. 1963. Nouvelle flore de l'Algérie et des régions désertiques méridionales. Centre National de la Recherche Scientifique.

Rashed K. 2021. Alkaloids group as medicinal compounds for treatment of COVID-19: A short review. Intl J Pharm Sci Drug Anal 1 (1): 61-63.

Rastogi S, Pandey DN, Singh RH. 2022. COVID-19 pandemic: A pragmatic plan for ayurveda intervention. J Ayurveda Integr Med 13 (1): 100312. DOI: 10.1016/j.jaim.2020.04.002.

Rathore S, Debnath P, Kumar R. 2021. Kuth *Saussurea costus* (Falc.) Lipsch.: A critically endangered medicinal plant from Himalaya. J Appl Res Med Aromat Plants. 20: 100277. DOI: 10.1016/j.jarmap.2020.100277.

Raut IH, Lodhi NG, Kalode PD. 2021. A review on analgesic herbal. Intl J Adv Res. 9 (01): 1126-1132. DOI: 10.21474/IJAR01/12400.

Ren J, Zhang A-H, Wang X-J. 2020. Traditional Chinese medicine for COVID-19 treatment. Pharmacol Res 155: 104743. DOI: 10.1016/j.phrs.2020.104743.

Sikandar T, Anum Bhatti A, Mushtaq Z, Shahid M, Nighat F, Anwar S. 2021. Evaluation of the bioactive role of indegenous *Viola odorata* leaf extracts. Pak J Bot 53 (2): 541-549. DOI: 10.30848/PJB2021-2(23).

Tafazoli V, Shahriari M, Heydari M, Nikbakht HA, Zarshenaas MM, Nimrouzi M. 2019. The effect of *Viola odorata* L. oil for fever in children: A randomized triple-blinded placebo-controlled clinical trial. Curr Drug Discov Technol 17 (5): 696-703. DOI: 10.2174/1570163816666190620142256.

Tag HM, Khaled HE, Ismail HAA, El-Shenawy NS. 2016. Evaluation of anti-inflammatory potential of the ethanolic extract of the *Saussurea lappa* root (costus) on adjuvant-induced monoarthritis in rats. J Basic Clin Physiol Pharmacol 27 (1): 71-78. DOI: 10.1515/jbcpp-2015-0044.

Tardío J, Pardo-de-Santayana M. 2008. Cultural importance indices: A comparative analysis based on the useful wild plants of southern Cantabria (northern Spain)1. Econ Bot 62 (1): 24-39. DOI: 10.1007/s12231-007-9004-5.

Tohma H, Gülçin İ, Bursal E, Gören AC, Alwasel SH, Köksal E. 2017. Antioxidant activity and phenolic compounds of ginger (*Zingiber officinale Rosc*.) determined by HPLC-MS/MS. J Food Meas Charact 11 (2): 556-566. DOI: 10.1007/s11694-016-9423-z.

Vandebroek I, Pieroni A, Stepp JR, Hanazaki N, Ladio A, Alves RRN, Picking D, Delgoda R, Maroyi A, van Andel T, et al. 2020. Reshaping the future of ethnobiology research after the COVID-19 pandemic. Nat Plants 6 (7): 723-730. DOI: 10.1038/s41477-020-0691-6.

Vellingiri B, Jayaramayya K, Iyer M, Narayanasamy A, Govindasamy V, Giridharan B, Ganesan S, Venugopal A, Venkatesan D, Ganesan H,

Rajagopalan K, Rahman PKSM, Cho SG, Kumar NS, Subramaniam MD. 2020. COVID-19: A promising cure for the global panic. Sci Tot Environ 725: 138277. DOI: 10.1016/j.scitotenv.2020.138277.

Villena-Tejada M, Vera-Ferchau I, Cardona-Rivero A, Zamalloa-Cornejo R, Quispe-Florez M, Frisancho-Triveño Z, Abarca-Meléndez RC, Alvarez-Sucari SG, Mejia CR, Yanez JA. 2021. Use of medicinal plants for COVID-19 prevention and respiratory symptom treatment during the pandemic in Cusco, Peru: A cross-sectional survey. PLoS One 16 (9): e0257165. DOI: 10.1371/journal.pone.0257165.

Wang L, Yang R, Yuan B, Liu Y, Liu C. 2015. The antiviral and antimicrobial activities of licorice, a widely-used Chinese herb. Acta Pharm Sin B 5 (4): 310-315. DOI: 10.1016/j.apsb.2015.05.005.

Yakhchali M, Taghipour Z, Ardakani MM, Vaghasloo MA, Vazirian M, Sadrai S. 2021. Cinnamon and its possible impact on COVID-19: The viewpoint of traditional and conventional medicine. Biomed Pharmacother 143: 112221. DOI: 10.1016/j.biopha.2021.112221.

Zatout F, Benarba B, Bouazza A, Babali B, Nacer Bey N, Morsli A. 2021. Ethnobotanical investigation on medicinal plants used by local populations in Tlemcen National Park (extreme North West Algeria). Mediterr Bot 42 (30): e 69396. DOI: 10.5209/mbot.69396.