Exhaustive ethnobotanical survey of medicinal plants used to prevent the COVID-19 epidemic in Souk Ahras province, Algeria

Nesrine Gherairia, Soumaya Boukerche, Azzedine Chefrour, Lamia Boutabia

Correspondence

Nesrine Gherairia[1], Soumaya Boukerche[2], Azzedine Chefrour[3], Lamia Boutabia[4,] *

[1] Department of Food Sciences, Faculty of Natural and Life Sciences, Mohamed Cherif Messaadia University, Annaba Road P.O. Box 1553, 41 000 Souk Ahras, Algeria. https://orcid.org/0000-0002-4260-6022
[2] Institute of Agronomic and Veterinary Sciences - Taoura, Mohamed Cherif Messaadia University, P.O. Box 1553, 41 000 Souk Ahras, Algeria. https://orcid.org/0009-0003-9230-3622
[3] Department of Biology, Faculty of Natural and Life Sciences, Mohamed Cherif Messaadia University, P.O. Box 1553, 41000 Souk Ahras, Algeria. https://orcid.org/0000-0003-1495-0771
[4] Laboratory Agriculture and Ecosystem Functioning, Department of Agronomy Sciences, Faculty of Natural and Life Sciences, Chadli Bendjedid University, P.O. Box 73, 36 000 El Tarf, Algeria. https://orcid.org/0000-0002-7757-8228

*Corresponding Author: boutabia-lamia@univ-eltarf.dz

Ethnobotany Research and Applications 30:61 (2025) - http://dx.doi.org/10.32859/era.30.61.1-15
Manuscript received: 10/02/2025 – Revised manuscript received: 30/04/2025 - Published: 05/05/2025

Research

Abstract

Background: The COVID-19 pandemic has posed significant global health challenges, prompting renewed interest in traditional medicine as a complementary approach. This study documents the use of medicinal plants in Souk Ahras Province, Algeria, through an ethnobotanical survey conducted in 2021/2022 among 47 herbalists. The survey aimed to assess the relevance and effectiveness of these plants in managing COVID-19 symptoms.

Methods: Data were collected through semi-structured interviews, and the herbalists' knowledge was quantified using ethnobotanical indices. Principal Component Analysis (PCA) was conducted to assess the impact of socio-demographic factors on ethnobotanical Knowledge.

Results: The study identified 26 medicinal plants from 17 botanical families used by herbalists in Souk Ahras Province. The most commonly cited families were Lamiaceae and Zingiberaceae, with *Syzygium aromaticum* and *Zingiber officinale* emerging as the most frequently cited species, achieving an FC of 44 and an FCR of 0.92. Key symptoms targeted included cough (ICF = 0.96), immunity boosting (ICF = 0.95), body aches, and anosmia (ICF = 0.93 each). Rhizomes (CPP = 0.40) were the most commonly used plant parts, while infusion (CMU = 0.58) was the preferred preparation method. PCA results showed that age and professional experience are key factors in acquiring and retaining ethnobotanical knowledge, while higher education levels may contribute to its decline.

Conclusions: This study emphasizes the significance of traditional medicine in tackling modern health challenges and highlights the potential of these remedies as complementary alternatives to conventional therapies for COVID-19. Additional research is required to confirm their efficacy and safety.

Keywords: Ethnobotany; COVID-19; herbalists; medicinal plants; ethnobotanical indices; PCA; Algeria.

Background

Throughout history, humanity has faced numerous pandemics, including the Black Death, which devastated Europe in the Middle Ages, the Spanish flu of 1918, the human immunodeficiency virus HIV/AIDS, which emerged in the 1980s, and the H1N1 influenza pandemic in 2009 (Lapierre *et al*. 2020). However, the COVID-19 pandemic, caused by SARS-CoV-2, is unprecedented in its global impact over the last century, significantly disrupting human activity and healthcare systems (Coen 2023). Initially emerging in Wuhan, China, in December 2019, the virus presented symptoms of severe pneumonia, which rapidly led to widespread outbreaks. Notably, COVID-19 exhibits high infectivity even during its asymptomatic phase, contributing to its rapid global spread. By March 11, 2020, the World Health Organization (WHO) officially declared COVID-19 a pandemic, with the virus reaching more than 200 countries and territories (Zhang *et al*. 2020). Symptoms range from mild cases, including headaches, fatigue, body aches, and cough, to severe conditions such as acute pneumonia, respiratory distress syndrome, multi organ dysfunction, and even death (Chen *et al*. 2020, Huang *et al*. 2020). Despite substantial global research efforts, no specific antiviral treatment has been established, necessitating the exploration of alternative therapies.

Medicinal plants have played a central role in traditional healthcare systems for thousands of years. Ancient civilizations, including those of Egypt, Rome, China, and India, extensively documented their therapeutic applications (Khare 2024). Rich in bioactive compounds such as alkaloids, flavonoids, and terpenoids, these plants possess antiviral, antimicrobial, and immunomodulatory properties, making them valuable in the management of infectious diseases (Alanazi *et al*. 2023). Recent studies have highlighted their efficacy against various viral infections, including influenza, dengue, and coronaviruses (Oso *et al*. 2022 ; Pranskuniene *et al*. 2022 ; Tapsale *et al*. 2024). In response to the COVID-19 pandemic, interest in herbal medicine has surged worldwide. Traditional Chinese Medicine (TCM), for instance, was integrated into national healthcare protocols to complement conventional treatments (Zhang *et al*. 2020). Similarly, in North Africa, particularly in Algeria, medicinal plants have been widely used to strengthen immunity and mitigate the effects of the disease (Brahmi *et al*. 2022; Hamdani & Houari 2021; Helali *et al*. 2020).

This study aims to quantify the use of medicinal plants in the management of COVID-19 by cataloging traditional practices. An exhaustive ethnobotanical survey was conducted in 2021/2022 among herbalists in the Souk Ahras province. The survey sought to document the most commonly used plants by the local population, assess their significance through various ethnobotanical indices, and understand the local knowledge in managing pandemic-related health challenges.

Materials and Methods

Study area

The study was carried out Souk Ahras province, located in the far east of Algeria, on the border with Tunisia. Formerly known as Thagaste, it has played an important role in Algeria's political and cultural history due to its strategic location. This city has inherited several civilizations, including the Numidians, Phoenicians, Berbers, Carthaginians, Romans, Vandals, and Byzantines. Thagaste is considered one of the most important cities of Eastern Numidia, the oldest Berber kingdom founded by the King of Eastern Algeria (Zelalsan) in the 3rd century BC.

The province of Souk Ahras covers an area of 4,360 km² and is home to 446,012 inhabitants. It is situated at 36° 23’ North latitude and 8° 00’ East longitude. Administratively, it is divided into 10 districts (daïras) and 26 municipalities (Fig. 1). The region has a semi-arid climate, with a Mediterranean influence in the north and a continental climate in the extreme south (Hadji *et al*. 2013). Souk Ahras is characterized by hot and dry summers and cold and wet winters. The annual rainfall reaches 650 mm in the north and 350 mm in the south. The temperature ranges between 1°C and 15°C in winter and between 25°C and 32°C in summer. Traversed by significant Maghreb rivers such as the Seybouse, the Medjerda, and the Mellegue, the province has two major dams (Ain Dalia and Oued Charef, with a total capacity exceeding 240 million m³) and several hill reservoirs meeting the province's needs for potable water and irrigation. Souk Ahras benefits from rich and diverse plant resources, supported by its climatic and natural characteristics. Its forest area is estimated at 97,280 hectares, representing 23% of the total area of the wilaya (DTASA 2019).

Figure 1. Location of the study area (QGIS version 3.40.4, 2025)

Ethnobotanical Survey

Sampling design

An exhaustive ethnobotanical survey was conducted to document the medicinal plants traditionally used for COVID-19 prevention in Souk Ahras Province, Algeria. This comprehensive approach ensured that all active herbalists across the province were included. The identification of these practitioners was facilitated through records from the National Center of the Commercial Register (NCCR), which provided essential details such as names, professional status, registration numbers, and addresses. In total, 47 herbalists operating across the ten (10) districts (daïras) of Souk Ahras were surveyed. Notably, all surveyed herbalists were male, as no female practitioners were identified in this region, reflecting the local gender distribution within the profession.

Data collection

Data collection was carried out through face-to-face interviews conducted between 2021 and 2022, using a semi-structured questionnaire designed to capture both qualitative and quantitative information.

The questionnaire consisted of twenty-two questions, including four closed-ended questions for structured responses and eighteen open-ended questions to gain deeper insights into traditional medicinal practices. It was divided into two main sections: the first gathered sociodemographic data, including age, education level, locality, professional experience, and family status, while the second focused on ethnopharmacological details, such as plant species, plant parts used, therapeutic uses, preparation methods, dosages, administration routes, treatment duration, and perceived effectiveness.

To enhance data reliability, interviews were conducted individually at the herbalists' workplaces, and plant samples were collected for verification using Algerian, Tunisian and Moroccan botanical books of medicinal and aromatic plants (Baba Aissa 2000; Bellakhdar 1997; Beloued 2014; Boukef 1987).

Plant species cited by the interviewed herbalits with their local names, were identified according to the flora of Quézel and Santa (1962-1963). The new nomenclature has been updated for the inventoried species, taking into account recent work compiled in the synonymic and bibliographic index of the flora of North Africa (Dobignard & Chatelain 2010-2013).

The study adhered to international ethical guidelines for ethnobotanical research, ensuring respect for traditional knowledge and the intellectual property rights of local practitioners. The documentation of traditional medicinal knowledge was conducted in a manner that aligns with ethical and scientific standards, reinforcing the importance of preserving and valuing this cultural heritage.

Statistical Analyses

Data processing and analysis were conducted using Excel (version 2007) and XLSTAT software (Version 2019.1.3, Addinsoft). Socio-demographic characteristics were expressed as percentages. The herbalists' knowledge and practices regarding medicinal plant use for COVID-19 management were quantified through various ethnobotanical indices, including the Informant Consensus Factor (ICF), Frequency of Citation (FC), Relative Frequency of Citation (RFC), Consensus Value for Plant Part (CPP), and Consensus Value for the Manner of Usage (CMU), as summarized in Table 1.

These indices allow for the quantification of traditional knowledge by transforming the complex and multidimensional notion of plant importance into standardized and comparable numerical values.

To explore the relationships between socio-demographic variables and ethnobotanical knowledge, Principal Component Analysis (PCA) was performed. Additionally, Pearson's correlation coefficient was used to assess associations between variables, with a significance level set at 5%.

Table 1. Calculated Ethnobotanical Indices

Calculated Index / Formula	**Abbreviation Meaning**	**Interpretation**	**References**
Informant Consensus Factor (ICF) ICF = (Nur - Nt) / (Nur - 1)	Nur: Number of use reports Nt: Number of taxa used	Measures the level of agreement on plant use for specific illnesses. ICF ranges from 0 to 1, with higher values showing strong agreement among informants, meaning most healers widely use few species. Lower values suggest disagreement, indicating a broad variety of species used for treating a category of illness.	Heinrich *et al.* (1998)
Frequency of Citation (FC)	FC: Number of informants reporting the use of a species	The higher the FC, the more important that species is considered within the community.	Tardío and Pardo-de-Santayana (2008)
Relative Frequency of Citation (RFC) RFC = FC / N	FC: Number of informants citing a species N: Total number of informants participating in the survey	Measures the local importance of each species. RFC varies between 0 (no informant reports the species as useful) and 1 (all informants mention the species as useful).	Tardío and Pardo-de-Santayana (2008)
Consensus Value for Plant Part (CPP) CPP = Px / Pt	Px: Number of citations for a specific plant part Pt: Total number of citations for all plant parts	Indicates the level of consensus on which part of the plant is used. Higher values suggest a strong preference for a particular plant part.	Monteiro *et al*. (2006)
Consensus Value for the Manner of Usage (CMU) CMU = Mx / Mt	Mx: Number of citations for a specific usage method Mt: Total citations for all usage methods	Reflects the agreement among informants regarding the method of plant usage. A higher CMU indicates strong consensus on the usage method.	Monteiro *et al*. (2006)

Results and Discussion

Socioeconomic Characteristics

The descriptive ethnobotanical survey conducted in the wilaya of Souk Ahras involved interviewing 47 male herbalists, aged 28 to 76 years, with an average age of 47, 17 ± 9,63 years. The majority of the herbalists (54%) are in the age group of 40 to 60 years. Most of the herbalists surveyed are married (94%). Regarding educational level, 98% of the herbalists do not have higher education degrees (19% illiterate, 28% primary level, 51% secondary level). Only 2% of the herbalists are university graduates. Regarding professional experience, 43% of the herbalists have over 10 years of experience.

Additionally, the survey indicates that a notable percentage of herbalists (60%) reside in urban areas, while 40% live in rural areas (Table 2).

The socio-demographic analysis revealed that herbalism in Souk Ahras provence is predominantly practiced by men aged 40 to 60, who benefit from extensive experience and the intergenerational transmission of knowledge. This trend aligns with previous studies (Boutabia *et al*. 2011 and 2020, Djouamaa *et al.* 2022, Gherairia 2020, Klech *et al*. 2022), indicating that older individuals possess more knowledge about medicinal plants, although this transmission is declining. Most herbalists are married, largely motivated by the financial needs of their families, as noted by Ait Ouakrouch (2015) and other researchers. Additionally, almost all herbalists lack a university degree, confirming studies (El Hilah *et al*. 2016) that show phytotherapy is often practiced by individuals with a low level of formal education. The predominance of herbalists in urban areas can be attributed to their strategic choice to establish themselves in major popular markets to promote their goods and reach a broader clientele. Regarding professional experience, a significant portion of herbalists have more than 10 years of experience, highlighting the importance of practical experience in acquiring and mastering herbal knowledge.

Table 2. Socio-demographic features of the informants

Socio-demographic features	Category	Effective	Percentage (%)
Gender	Male	47	100
Age (years old)	20-39	12	26
	40-60	27	57
	>60	8	17
Family situation	Married	44	94
	Single	3	6
Habitat	Urban	19	60
	Rural	28	40
Academic level	Illiterate	9	19
	Primary	13	28
	Secondary	24	51
	University	1	2
Professional experience (year)	1-4	9	19
	5-10	18	38
	> 10	20	43

Ethnopharmacological data

Medicinal plants reported by surveyed herbalists

Based on 47 completed questionnaires, we identified a total of 26 medicinal plants from 17 botanical families. Table 3 summarizes the medicinal plants reported by the surveyed herbalists for the prevention of COVID-19. For each documented plant, we provide its family, scientific names, parts used, therapeutic applications, preparation methods, and administration practices, as well as the frequency of citation (FC) and relative frequency of citation (RFC).

According to table 3, the Lamiaceae family is the most represented, with four species, followed by Myrtaceae and Zingiberaceae, each comprising three species. Asteraceae and Apiaceae families contain two species each, while the other families are represented by only one species. Similarly, Alami *et al*. (2020), Belhaj and Zidane (2021), Brahmi *et al*. (2022) and Helali *et al*. (2020), also reported that the Lamiaceae family was the most commonly used for preventing COVID-19 infection. The predominance of Lamiaceae among the medicinal plants identified in our survey can be attributed to several biological, ecological, and cultural factors. The Lamiaceae family, diverse and widely distributed, is particularly well-suited to the Mediterranean and semi-arid climatic conditions (Kallunki & Heywood 1994, Raja 2012) found in the wilaya of Souk Ahras. Additionally, the historical and cultural use, as well as the abundance of Lamiaceae in this region, reinforce their presence in local herbalist prescriptions.

The medicinal plants most commonly used by herbalists in the management of COVID-19 are *Syzygium aromaticum* (clove) and *Zingiber officinale* (ginger), with a frequency of citation (FC) of 44 and a frequency citation ratio (FCR) of 0.92. Their

widespread use is supported by their well-documented medicinal properties, long-standing traditional use, and widespread global application. Both plants hold significant value in traditional medicine and are progressively being confirmed by contemporary scientific studies for their effectiveness in combating viral infections, including SARS-CoV-2. Their therapeutic efficacy is attributed to a synergistic combination of antiviral, anti-inflammatory, antioxidative, and immunomodulatory properties, underscoring their value as complementary agents in managing COVID-19 (Kiyama 2020, Mao *et al*. 2019, Mellali *et al*. 2022).

Syzygium aromaticum has a well-established history in folk medicine, particularly for alleviating respiratory disorders such as colds, bronchitis, and asthma. Clove's essential oil, rich in eugenol, serves as an expectorant, aiding in the clearing of the respiratory tract, which is crucial in managing respiratory symptoms of COVID-19 (Mittal *et al*. 2014). Clinical studies, such as one conducted in Algeria, have demonstrated that 85% of COVID-19 patients who used dried cloves reported significant improvement within 48 hours, with a reduced incidence of complications compared to those who did not use cloves (Mellali *et al*. 2022). This study also established a significant association between clove use and favorable disease progression, with complications being less frequent among patients who used this plant. Furthermore, similar positive outcomes have been reported in India and Morocco. Surveys conducted in these countries revealed that cloves were among the most frequently used remedies for COVID-19, due to their beneficial properties and accessibility. In India, over 93% of respondents believed that spices, including cloves, are useful for relieving COVID-19 and boosting immunity (Chaachouay *et al*. 2021, Samaddar *et al*. 2020). In Morocco, cloves were also commonly used, and their role in traditional medicine continues to be highly valued in managing respiratory illnesses associated with COVID-19 (Chaachouay *et al*. 2021). Molecular studies further enhance the credibility of clove in COVID-19 symptom management. Research has identified several bioactive compounds in cloves, such as kaempferol, bicornin, and biflorin, which exhibit strong antiviral activity. For example, kaempferol has shown a strong binding affinity to the SARS-CoV-2 main protease (Mpro), a critical enzyme for viral replication, indicating its potential to inhibit the virus (Rehman *et al*. 2020). These findings underscore clove's role not just in traditional medicine but as a scientifically validated option in the fight against COVID-19.

Zingiber officinale, similarly, is renowned for its comprehensive medicinal properties. Ginger is rich in various bioactive compounds, including terpenes like zingiberene and farnesene, and phenolic compounds like gingerols, shogaols, paradols, and zingerone. These compounds contribute to ginger's extensive pharmacological effects, including its ability to modulate immune responses, reduce inflammation, and act as an antioxidant (Kiyama 2020, Mao *et al*. 2019). Fresh ginger has demonstrated significant antiviral properties, especially targeting respiratory viruses like human respiratory syncytial virus (HRSV) and rhinovirus (Chang *et al.* 2013). This antiviral potential is especially relevant in the context of COVID-19, as it can inhibit the virus's ability to attach to and invade host cells, thereby reducing viral replication in the respiratory tract. Additionally, molecular docking studies have highlighted ginger's effectiveness against SARS-CoV-2. Active compounds such as 6-gingerol, 8-gingerol, and 10-gingerol have demonstrated strong binding affinities to key viral proteins, such as the SARS-CoV-2 main protease and spike protein. These interactions suggest that ginger can interfere with the virus's ability to replicate and spread, making it a powerful tool in COVID-19 management (Goswami *et al*. 2020, Oso *et al*. 2022). Moreover, clinical studies from Saudi Arabia and Iran have shown that ginger consumption among COVID-19 patients is associated with lower hospitalization rates and improved clinical symptoms, reinforcing its potential as a complementary therapy (Aldwihi *et al*. 2021). Additionally, in various regions like Bangladesh, Tunisia, and parts of Africa, ginger and clove have been incorporated into traditional remedies for managing COVID-19 symptoms, often with positive outcomes (Aidi Wannes & Saidani Tounsi 2020, Azam *et al*. 2020, Orisakwe *et al*. 2020,). These remedies are not only accessible and affordable but also culturally accepted, making them viable options in regions where access to conventional treatments may be limited.

Table 3. Medicinal plants reported by surveyed herbalists

Family	Scientific Name	Part Used	Therapeutic Use	Preparation Method	Administration	FC	FCR
Amaryllidaceae	*Allium cepa* L.	Bulb	Rhinorrhea, antiviral	Juice extraction	Oral	1	0.02
Anacardiaceae	*Pistacia lentiscus* L.	Fruit	Cough, expectorant, chest pain	Extraction by pressing	Oral, massage	8	0.17
Apiaceae	*Visnaga daucoides* Gaertn.	Seed	Dyspnea	Infusion	Oral	2	0.04
	Pimpinella anisum L.	Seed	Cough, expectorant, rhinorrhea,	Infusion	Oral	3	0.06
Asteraceae	*Anacyclus pyrethrum* (L.) Link	Rhizome	Dyspnea, immune boost, rhinorrhea	Infusion	Oral	14	0.29
	Saussurea costus (Falc.) Lipsch	Rhizome	Immune boost, body aches, rhinorrhea, cough	Decoction, infusion	Oral	16	0.33
Berberidaceae	*Berberis vulgaris* L.	Aerial parts	Expectorant, rhinorrhea	Infusion, maceration	Oral	2	0.04
Burseraceae	*Boswellia sacra* Flueck.	Resin	Cough	Maceration in oil, infusion	Oral	2	0.04
Cactaceae	*Opuntia ficus-indica* L. Mill.	Flowers	Dyspnea	Infusion	Oral	1	0.02
Fabaceae	*Glycyrrhiza glabra* L.	Rhizome	Expectorant, cough, antiviral, immune boost	Decoction, infusion, powder with honey	Oral	18	0.38
Lamiaceae	*Marrubium vulgare* L.	Leaf	Cough, fever	Decoction, infusion	Oral	3	0.06
	Origanum vulgare L.	Leaves	Immune boost, cough, headaches, dyspnea, rhinorrhea, antiviral	Decoction, infusion	Oral	42	0.88
	Salvia rosmarinus Spenn.	Leaves	Immune boost, cough, rhinorrhea, antiviral	Decoction, infusion	Oral	14	0.29
	Thymus vulgaris L.	Leaves	Antiviral, immune boost, rhinorrhea, cough.	Decoction, infusion	Oral	6	0.13
Lauraceae	*Laurus nobilis* L.	Leaves	Cough, expectorant	Decoction	Oral	2	0.04
Myrtaceae	*Myrtus communis* L.	Leaves	Rhinorrhea	Decoction	Oral	2	0.04
	Eucalyptus globulus Labill.	Leaves	Antiviral, immune boost, rhinorrhea, anosmia	Decoction	Inhalation, fumigation	13	0.27
	Syzygium aromaticum (L.) Merr. & Perry	Floral buds, oil	Boosts immunity, sore throat, headaches, dyspnea, rhinorrhea, anosmia, antiviral.	Infusion, maceration, decoction	Oral, inhalation	44	0.92
Oleaceae	*Olea europaea* L.	Fruit	Cough	Extraction by pressing	Oral	2	0.04
Pinaceae	*Pinus halepensis* Mill.	Resin	Expectorant, cough, dyspnea	Maceration in olive oil	Oral	7	0.15
Ranunculaceae	*Nigella sativa* L.	Seed	Cough, expectorant, immune boost	Maceration in olive oil	Oral	4	0.08
Rutaceae	*Citrus limon* (L.) Burm.	Fruit	Immune boost, cough, rhinorrhea, antiviral,	Juice extraction	Oral	1	0.02
Verbenaceae	*Verbena officinalis* L.	Leaves	Cough, rhinorrhea, body aches	Decoction, infusion	Oral	30	0.63
Zingiberaceae	*Curcuma longa* L.	Rhizome	Expectorant, cough, immune boost	Maceration	Oral	9	0.19
	Alpinia officinarum Hance	Rhizome	Cough, dyspnea, expectorant, immune boost, rhinorrhea, antiviral	Decoction, maceration, infusion	Oral	28	0.58
	Zingiber officinale Roscoe	Rhizome	Immune boost, antiviral, cough, rhinorrhea, body aches,	Maceration, infusion	Oral	44	0.92

Consensus value for plant part (CPP)

According to the herbalists surveyed, the most frequently cited plant part in the preparation of COVID-19 remedies is the rhizome, with a Consensus Value for Plant Part (CPP) of 0.40, followed by leaves (CPP = 0.29), floral buds (CPP = 0.14), aerial parts (CPP = 0.07), fruits, seeds and resin, each with a CPP of 0.03 (Fig. 2).

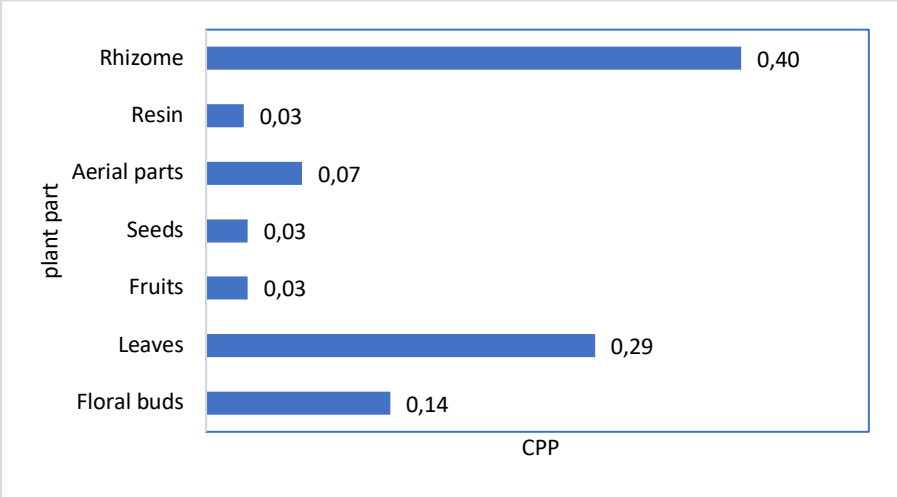

Figure 2. Distribution of plant parts according to (CPP)

The preference of rhizome use can be attributed to the widespread utilization of plants from the Zingiberaceae family, such as turmeric (*Curcuma longa*), galangal (*Alpinia officinarum*), and ginger (*Zingiber officinale*), for both preventive and curative purposes during the pandemic. Rhizomes are known for their richness in bioactive compounds with antiviral, anti-inflammatory, and immunostimulatory properties, making them particularly effective in combating respiratory infections, including COVID-19. The extensive use of leaves can be attributed to the ease and efficiency of their collection, as well as their year-round availability. Moreover, the higher levels of photosynthetic and metabolic activity in the aerial parts of plants, particularly in the leaves, lead to the accumulation of bioactive compounds with therapeutic properties (Alaoui *et al.* 2012, Jdaidi & Hasnaoui 2016).

Consensus value for manner of usage (CMU)

To extract active compounds from plants, various therapeutic preparation techniques are commonly employed, including decoction, infusion, maceration, extraction by pressing, and more specialized methods like cold soaking and percolation. The choice of method depends on the nature of the active ingredients and the specific plant part being used. In our study, infusion emerged as the most favored method among herbalists, with a consensus value of 0.58. This was followed by maceration (CMU = 0.22) and decoction (CMU = 0.17). Extraction by pressing (CMU = 0.03) and other preparation methods (CMU = 0.01) exhibit the lowest consensus, suggesting that they are rarely utilized or considered effective (Fig.3).

The preference for infusion is due to its simplicity and efficiency in extracting bioactive compounds without altering them, which is crucial for maintaining the therapeutic properties of plants, especially those rich in volatile or heat-sensitive compounds, such as leaves and flowers. Maceration, on the other hand, is typically reserved for fresh rhizomes and floral buds, where active compounds are more effectively extracted at cold temperatures. The decoction is favored for tougher plant parts that require extended heating to release their active compounds. This observation aligns with other ethnobotanical research highlighting infusion as the most commonly cited method due to its ease of use. Hamdani and Houari (2021) noted that infusion represented 74% of the methods used by the population in northern Algeria during the COVID-19 pandemic. Similarly, Boutabia *et al*. (2011) and Hamel *et al*. (2018) confirmed that infusion was the predominant preparation method in the Zitouna region and the Edough Peninsula (Algeria), respectively, underscoring its deep roots in traditional practices.

Therapeutic Targets and Informant Consensus Factor (ICF)

Our ethnobotanical research has identified various therapeutic and preventive applications of medicinal plants in response to COVID-19 and its associated symptoms. As depicted in Figure 4, herbalists have prescribed these plants for eleven different therapeutic purposes in the fight against the pandemic. The most commonly targeted ailment is cough, with a

Consensus Informant Factor (ICF) of 0.96, followed by boosting immunity (ICF = 0.95) and alleviating body aches and anosmia (ICF = 0.93 each). Antiviral uses also show a high consensus (ICF = 0.90), along with sore throat (ICF = 0.87), rhinorrhea (ICF = 0.83), and expectorant purposes (ICF = 0.80). Headaches (ICF = 0.77), chest pain (ICF = 0.69), and respiratory disorders (ICF = 0.64) exhibit lower ICF values.

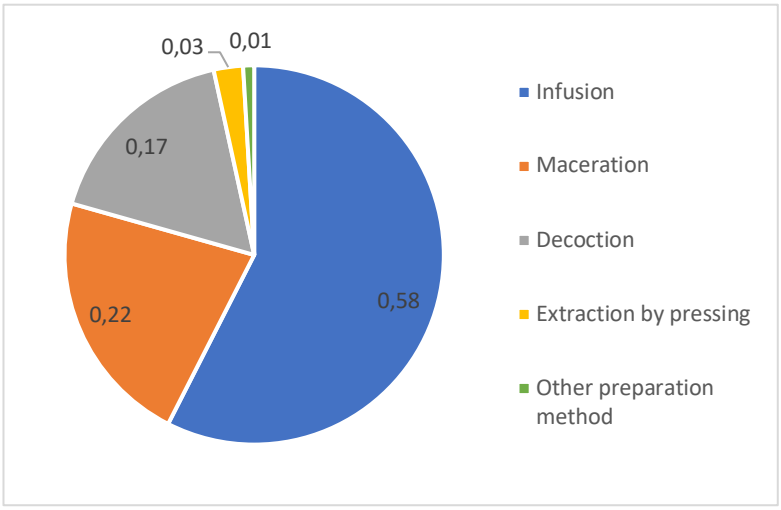

Figure 3. Consensus Values for Different Methods of Preparing Medicinal Plants

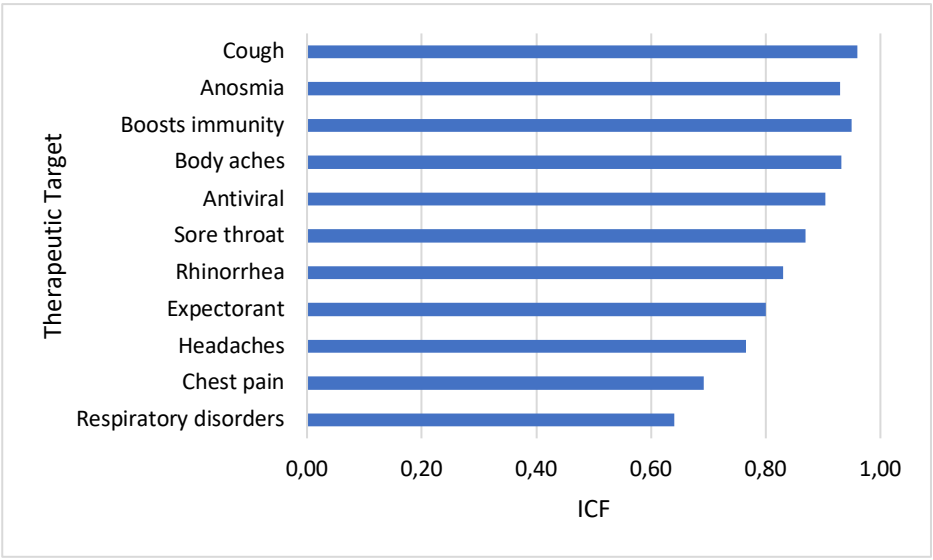

Figure 4. Informant consensus factor (ICF) for therapeutic targets of medicinal plants in the management of COVID-19 Symptoms

The range of ICF values from 0.64 to 0.96 highlights a strong agreement among informants for most symptoms, indicating well-defined criteria for plant selection and effective knowledge exchange within the community. The high ICF values for cough, immunity boosting, and other major symptoms suggest a robust consensus and a well-established selection of medicinal plants for these conditions. In contrast, the lower ICF values for headaches, chest pain, and respiratory disorders indicate a greater variability in plant choices and potentially less consensus or knowledge sharing for these less frequently addressed symptoms. Overall, these findings reflect a comprehensive understanding and shared practices among herbalists for preventing COVID-19 symptoms, demonstrating the value of traditional knowledge in addressing pandemic-related health challenges. These findings demonstrate a deep understanding and consistent practices among herbalists for managing COVID-19 symptoms, highlighting the enduring value of traditional knowledge in addressing health challenges. The focus on cough relief and immune support aligns with both traditional uses and recent research, reinforcing the effectiveness of plants like ginger (*Zingiber officinale*) and cloves (*Syzygium aromaticum*) for respiratory issues and immune enhancement (Firdaus *et al*. 2024, Gairola *et al*. 2010, Garnier & Shahidi 2021, Mohapatra *et al*. 2021, Pranskuniene *et al*.

2022, Sultana *et al*. 2016). This alignment between traditional practices and modern research underscores the valuable role of these medicinal plants in managing viral infections, bridging ancient remedies with contemporary health solutions.

Relationship between ethnobotanical knowledge and socio-demographic factors

To explore the relationship between ethnobotanical knowledge and socio-demographic factors, a principal component analysis (PCA) was performed. This method examines the distribution of the studied variables along the first two principal axes (F1 and F2), which together explain 82.26% of the total variance, providing a reliable representation of their relationships (Fig. 5). The total number of known plants and medicinal uses were considered additional quantitative variables, and Pearson's correlation coefficient was used to assess associations between them.

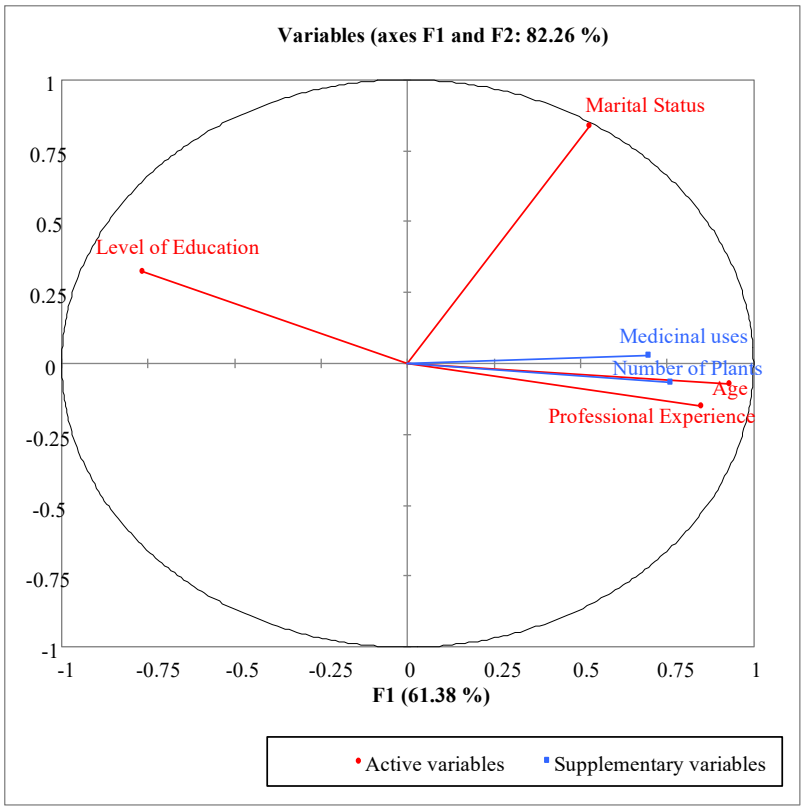

Figure 5. Principal Component Analysis (PCA) showing the relationships between ethnobotanical knowledge and socio-demographic factors.

Axis F1, which accounts for 61.38% of the variance, is positively correlated with age (0.771), professional experience (0.856), total number of known plants (0.638), and medicinal uses (0.699). Conversely, it is negatively correlated with education level (-0.638). These findings suggest that older and more experienced individuals possess greater knowledge of medicinal plants and their therapeutic applications, whereas a higher education level appears associated with a decline in this knowledge.

Axis F2, which explains 20.88 % of the total variance, is primarily influenced by marital status (0.368). This correlation indicates a possible influence of marital status on the acquisition and transmission of ethnobotanical knowledge.

Older and more experienced individuals likely accumulate and transmit this knowledge over time. Healers and herbalists with extensive experience tend to develop expertise in identifying, using, and preparing medicinal plants (Boudjelal *et al.* 2013). These results align with previous studies (El Hilah *et al*. 2016, Jdaidi & Hasnaoui 2016, Voeks & Leony 2004), which highlight that older individuals typically possess richer ethnobotanical knowledge due to oral and empirical transmission.

However, the correlation between age and knowledge does not guarantee continuous intergenerational transmission. Socio-economic and cultural shifts, such as urbanization and modernization, have limited younger generations' exposure to ethnobotanical practices, contributing to the gradual erosion of traditional knowledge. This trend has been observed not

only in rural communities but also among traditional healers, as seen in Ethiopia, where younger practitioners exhibit declining ethnomedical knowledge (Yineger *et al.* 2008).

The negative correlation between education level and medicinal plant knowledge can be attributed to several factors related to formal education. Studies suggest that higher levels of schooling reduce opportunities to acquire traditional knowledge, which has historically been passed down orally and through direct experience within communities. Modern educational curricula tend to prioritize scientific and technological disciplines, often sidelining local knowledge and contributing to a growing disconnect between younger generations and their natural environment, as well as traditional ethnobotanical practices (Saynes-Vásquez *et al*., 2013; Shukla & Sinclair, 2009). This trend is further reinforced by urbanization and socio-economic factors. Individuals with higher education levels are more likely to reside in urban areas, where access to modern healthcare is readily available and the use of medicinal plants is less prevalent. Additionally, formal education fosters greater trust in conventional medicine, which can lead to the gradual erosion of interest in traditional plant-based remedies (Arjona-García *et al.* 2021).

Regarding marital status, the positive correlation observed in the PCA suggests that being married may facilitate the acquisition and transmission of ethnobotanical knowledge. Interactions within couples and extended families create opportunities for knowledge exchange, particularly through intergenerational transmission. Traditional remedies are often incorporated into family caregiving practices, which could explain why married individuals appear more knowledgeable about medicinal plants (Abreu *et al*. 2015, Salali *et al*. 2016).

Our findings align with studies emphasizing the role of socio-cultural and environmental factors in shaping how traditional knowledge is acquired and maintained across generations (Abreu *et al.* 2015, Arjona-García *et al.* 2021, Boudjelal *et al*. 2013, Jdaidi & Hasnaoui 2016, Salali *et al*. 2016; Saynes-Vásquez *et al*. 2013, Shukla & Sinclair 2009, Voeks & Leony 2004, Yineger *et al*. 2008).

Conclusion

This study underscores the significance of traditional medicinal plants in addressing COVID-19-related health challenges in Souk Ahras Province, Algeria. The documented plant species, particularly *Syzygium aromaticum* and *Zingiber officinale*, are widely used for their anti-inflammatory, antiviral, and immunomodulatory properties. The analysis of ethnobotanical indices highlights a strong consensus among herbalists regarding the selection of plant parts—such as rhizomes—and preparation methods, notably infusions, to alleviate symptoms like cough, body aches, and anosmia. Additionally, the PCA analysis reveals the influence of socio-demographic factors on ethnobotanical knowledge. While age and professional experience play a crucial role in acquiring and preserving knowledge of medicinal plants and their therapeutic uses, higher education levels may contribute to its decline.

Despite these valuable insights, the study's limitations, including the relatively small sample size and the absence of female representation, should be acknowledged, as they may affect the generalizability of the findings. Moreover, while these plants have been traditionally used for respiratory ailments, their specific role in preventing or alleviating COVID-19 symptoms requires further scientific validation through pharmacological and clinical studies.

These findings reaffirm the relevance of ethnobotanical knowledge in contemporary healthcare and highlight the necessity of integrating traditional remedies into modern medical practices through rigorous scientific evaluation. Future research should focus on expanding sample diversity, conducting biochemical analyses, and exploring the long-term sustainability of traditional medicinal practices in the face of evolving healthcare challenges.

Declarations

List of abbreviations: CMU: Consensus Value for the Manner of Usage; COVID-19: Coronavirus Disease 2019; CPP: Consensus Value for Plant Part; FC: Frequency of Citation; HRSV: Human Respiratory Syncytial Virus; ICF: Informant Consensus Factor; NCCR: National Center of the Commercial Register; RFC: Relative Frequency of Citation

Ethics approval and consent to participate: The study was conducted in accordance with international ethical guidelines for ethnobotanical research. Participation was voluntary and based on the acceptance of a Free and Informed Consent Form. Ethical approval was obtained from the scientific and ethics committee of the University of Souk Ahras.

Consent for publication: All authors read and approved the final manuscript.

Availability of data and materials: Data used in this article are available for any requests.

Competing interests: Authors declare no conflict of interest.
Funding: Authors have not received any funding during this research.
Authors' Contributions: N Gherairia: Conceptualization, methodology, data curation, writing - reviewing and editing. S Boukerche: Investigation, resources, writing. A Chefrour: Supervision and validation. L Boutabia: Supervision and validation.

Acknowledgements

The authors express their heartfelt gratitude to all the herbalists who generously shared their knowledge. They also wish to thank Dr. Kamel Eddine Mederbal for his assistance in revising the map (Figure 1).

Literature cited

Abreu DBO, Santoro FR, Albuquerque UP, Ladio AH, Medeiros PM. 2015. Medicinal plant knowledge in a context of cultural pluralism: A case study in Northeastern Brazil. Journal of Ethnopharmacology 175:124-130. doi: 10.1016/j.jep.2015.09.019

Aidi Wannes W, Saidani Tounsi M. 2020. Can medicinal plants contribute to the cure of Tunisian COVID-19 patients? Journal of Medicinal Plants Studies 8(5):218-226. doi: 10.22271/plants.2020.v8.i5c.1218

Ait Ouakrouch I. 2015. Enquête ethnobotanique à propos des plantes médicinales utilisées dans le traitement traditionnel du diabète de type II à Marrakech. Thèse de Doctorat en médecine. Université Cadi Ayyad-Marrakech.92p.

Alami AE, Fattah A, Chait A. 2020. Medicinal plants used for the prevention purposes during the COVID-19 pandemic in Morocco. Journal of Analytical Sciences and Applied Biotechnology 2(1):4-11. doi: 10.48402/IMIST.PRSM/jasab-v2i1.21056

Alanazi HH, Elasbali AM, Alanazi MK, Azab EFE. 2023. Medicinal herbs: promising immunomodulators for the treatment of infectious diseases. Molecules 28(24): 8045. doi: 10.3390/molecules28248045

Alaoui Jamali C, El Bouzidi L, Bekkouche K, Lahcen H, Markouk M, Wohlmuth H, Leach D, Abbad A. 2012. Chemical composition and antioxidant and anticandidal activities of essential oils from different wild Moroccan *Thymus* species. Chemistry & Biodiversity 9(6): 1188-1197. doi: 10.1002/cbdv.201200041

Aldwihi LA, Khan SI, Alamri FF, AlRuthia Y, Alqahtani F, Fantoukh OI, Assiri A., Almohammed OA. 2021. Patients' behavior regarding dietary or herbal supplements before and during COVID-19 in Saudi Arabia. International Journal of Environmental Research and Public Health 18(10): 5086. doi: 10.3390/ijerph18105086

Arjona-García C, Blancas J, Beltrán-Rodríguez L, López Binnqüist C, Colín Bahena H, Moreno-Calles AI, Sierra-Huelsz JA, López-Medellín X. 2021. How does urbanization affect perceptions and traditional knowledge of medicinal plants? Journal of Ethnobiology and Ethnomedicine 17(1): 48. doi: 10.1186/s13002-021-00473-w

Azam MN, Al Mahamud R, Hasan A, Jahan R. 2020. Some home remedies used for treatment of COVID-19 in Bangladesh. Journal of Medicinal Plants Studies 8(4): 27-32. https://www.plantsjournal.com/archives/2020/vol8issue4/PartA/8-3-32-113.pdf

Baba Aissa F. 2000. Encyclopédie des plantes utiles: Flore d'Algérie et du Maghreb, substances végétales d'Afrique d'Orient et d'Occident. Ed. EDAS, librairie moderne, Rouiba. 178 p.

Bellakhdar J. 1997. La pharmacopée marocaine traditionnelle, Médecine arabe ancienne et savoirs populaires. Editions Le Fennec, Ibis Press, Paris, France.

Belhaj S, Zidane L. 2021. Medicinal plants used to boost immunity and decrease the intensity of infection caused by SARS-COV-2 in Morocco. Ethnobotany Research and Applications 21: 1-17. doi: 10.32859/era.21.41.1-17

Beloued A. 2014. Plantes médicinales d'Algérie. Ed. Office des Publications Universitaires, Alger, 296p.

Boudjelal A, Henchiri C, Sari M, Sarri D, Hendel N, Benkhaled A, Ruberto G. 2013. Herbalists and wild medicinal plants in M'Sila (North Algeria): An ethnopharmacology survey. Journal of Ethnopharmacology 148(2): 395-402. doi: 10.1016/j.jep.2013.03.082

Boukef MK. 1986. Les Plantes dans la médicine traditionnelle Tunisienne. Ed. Agence de Coopération Culturelle et Technique. Paris. 350p.

Boutabia L, Telailia S, Menaa M. 2020. Traditional therapeutic uses of *Marrubium vulgare* L. by local populations in the Haddada region (Souk Ahras, Algeria). Ethnobotany Research and Applications 19(44): 1-11. http://dx.doi.org/10.32859/era.19.44.1-11

Boutabia L, Telailia S, Cheloufi R., Chefrour A. 2011. La flore médicinale du massif forestier d'Oum Ali (Zitouna-wilaya d'El Tarf-Algérie): Inventaire et étude ethnobotanique. Actes des 15èmes Journées Scientifiques de l'INRGREF: «Valorisation des Produits Forestiers Non Ligneux », 28-29 Septembre 2010, Gammarthe Tunis. 15 :201-213.

Brahmi F, Iblhoulen Y, Issaadi H, Elsebai MF, Madani K, Boulekbache-Makhlouf L. 2022. Ethnobotanical survey of medicinal plants of Bejaia localities from Algeria to prevent and treat coronavirus (COVID-19) infection. Advances in Traditional Medicine 23 : 819-831. doi: 10.1007/s13596-022-00649-z

Chaachouay N, Douira A, Zidane L. 2021. COVID-19, prevention and treatment with herbal medicine in the herbal markets of Salé Prefecture, North-Western Morocco. European Journal of Integrative Medicine 42: 101285. doi: 10.1016/j.eujim.2021.101285

Chang JS, Wang KC, Yeh CF, Shieh DE, Chiang LC. 2013. Fresh ginger (*Zingiber officinale*) has anti-viral activity against human respiratory syncytial virus in human respiratory tract cell lines. Journal of Ethnopharmacology 145(1): 146-151. doi: 10.1016/j.jep.2012.10.043

Chen N, Zhou M, Dong X, Qu J, Gong F, Han Y, Qiu Y, Wang J, Liu Y, Wei Y, Xia J, Yu T, Zhang X, Zhang L. 2020. Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: A descriptive study. The Lancet 395(10223): 507-513. doi: 10.1016/S0140-6736(20)30211-7

Coen NB. 2023. The COVID-19 Pandemic : A Comprehensive Review of Global Impacts and Mitigation Strategies. ENDLESS International Journal Of Future Studies 6(2) : 356-365. doi: 10.54783/endlessjournal.v6i2.184

Djouamaa A, Boutabia L, Ayari A, Menaa M, Guellati K, Touarfia M, Maazi MC. 2022. Ethnobotanical survey of the Apiaceae family species used in the region of Souk-Ahras (Northeastern Algeria). Plant Archives 22(2): 143-151. doi: 10.51470/PLANTARCHIVES.2022.v22.no2.026

Dobignard A, Chatelain C. 2010-2013. Index synonymique de la flore d'Afrique du Nord (5 vol.). Ed. Conservatoire et jardins botaniques, Genève. 458p, 428p, 449p, 431p, 465p.

DTASA 2019. Monographie de la wilaya de Souk Ahras. Direction de Tourisme et de l'Artisanat de Souk-Ahras. 35p.

Firdaus A, Yunus MH, Izhar SK, Afaq U. 2024. Medicinal plants in the treatment of respiratory diseases and their future aspects. Recent Patents on Biotechnology 19(1): 2-18 doi: 10.2174/0118722083278561231212072408

Gairola S, Gupta V, Bansal P, Singh R, Maithani M. 2010. Herbal antitussives and expectorants – A review. International Journal of Pharmaceutical Sciences Review and Research 5(2): 5-9. www.globalresearchonline.net.

Garnier A, Shahidi F. 2021. Spices and herbs as immune enhancers and anti-inflammatory agents: A review. Journal of Food Bioactives 14: 20-52. doi: 10.31665/JFB.2021.14266

Gherairia N. 2020. Étude ethnobotanique, caractérisation chimique et activités biologiques des huiles essentielles du genre Thymus de la région de Souk Ahras. Thèse de doctorat, Mohamed-Cherif Messaadia University-Souk Ahra, Algérie. https://scholar.google.com/scholar?cluster=16463041157019708575&hl=en&oi=scholarr

Goswami D, Kumar M, Ghosh SK, Das A. 2020. Natural product compounds in Alpinia officinarum and ginger are potent SARS-CoV-2 papain-like protease inhibitors. ChemRxiv. doi: 10.26434/chemrxiv.12071997.v1

Hadji R, Boumazbeur AE, Limani Y, Baghem M, Chouabi AEM, Demdoum A. 2013. Geologic, topographic, and climatic controls in landslide hazard assessment using GIS modeling: A case study of Souk Ahras region, NE Algeria. Quaternary International 302: 224-237. doi: 10.1016/j.quaint.2012.11.027

Hamdani FZ, Houari N. 2021. Phytothérapie et COVID-19. Une étude fondée sur une enquête dans le nord de l'Algérie. Phytothérapie 18(5): 248-254. doi: 10.3166/phyto-2020-0241

Hamel T, Sadou N, Seridi R, Boukhdir S, Boulemtafes A. 2018. Pratique traditionnelle d'utilisation des plantes médicinales dans la population de la péninsule de l'edough (Nord-Est Algérien). Ethnopharmacologia 59: 75-81. http://www.ethnopharmacologia.org/boutique/ethnopharmacologia-59-mars-2018

Heinrich M, Ankli A, Frei B, Weimann C, Sticher O. 1998. Medicinal plants in Mexico: healers' consensus and cultural importance. Social Science & Medicine 47(11): 1859–1871. doi: 10.1016/S0277-9536(98)00181-6

Helali A, Mokhtari C, Ghoul M, Belhadef MS. 2020. Preventing infection by COVID-19: what place for medicinal plants according to the Algerian population. Algerian Journal of Pharmacy 3(1): 2602-795X. https://www.asjp.cerist.dz/en/PresentationRevue/436

El Hilah FE, Akka FB, Bengueddour R, Rochdi A, Zidane L. 2016. Étude ethnobotanique des plantes médicinales utilisées dans le traitement des affections dermatologiques dans le plateau central marocain. Journal of Applied Biosciences 98: 9252–9260. doi: 10.4314/jab.v98i1.2

Huang C, Wang Y, Li X, Ren L, Zhao J, Hu Y, Zhang L, Fan G, Xu J, Gu X, Cheng Z, Yu T, Xia J, Wei Y, Wu W, Xie X, Yin W, Li H, Liu M, Xiao Y, Gao H, Guo L, Xie J, Wang G, Jiang R, Gao Z, Jin Q, Wang J, Cao B. 2020. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. The Lancet 395(10223): 497-506. doi: 10.1016/S0140-6736(20)30183-5

Jdaidi N, Hasnaoui B. 2016. Etude floristique et ethnobotanique des plantes médicinales au nord-ouest de la Tunisie: cas de la communauté d'Ouled Sedra. Journal of Advanced Research in Science and Technology 3(1): 281-291. https://www.researchgate.net/publication/319270512

Jin Z, Liu JY, Feng R, Ji L, Jin ZL, Li HB. 2020. Drug treatment of coronavirus disease 2019 (COVID-19) in China. European Journal of Pharmacology 883(15): 173326. doi: 10.1016/j.ejphar.2020.173326

Kallunki JA, Heywood VH. 1994. Flowering plants of the world. Brittonia 46(4): 316 doi: 10.2307/2806914

Khare A. 2024. A study on medicinal plants with reference to traditional medicine: A review. International Journal of Science and Research 13(5): 471-474. doi: 10.21275/sr24506205308

Kiyama R. 2020. Nutritional implications of ginger: chemistry, biological activities and signaling pathways. The Journal of Nutritional Biochemistry 86: 108486. doi: 10.1016/j.jnutbio.2020.108486

Klech A, Boutabia L, Chefrour A. 2022. Ethnobotanical study of Asteraceae from El Kal a National Park (North-East of Algeria). Plant Archives 22(2): 124-130. doi: 10.51470/PLANTARCHIVES.2022.v22.no2.022

Lapierre A, Fontaine G, Pierre-Luc T, Maheu-Cadotte MA, Desjardins M. 2020. La maladie à coronavirus (COVID-19): portrait des connaissances actuelles. Soins d'urgence 1: 13-18. doi: 10.7202/1102105ar

Mao QQ, Xu XY, Cao SY, Gan RY, Corke H, Beta T, Li HB. 2019. Bioactive Compounds and Bioactivities of Ginger (*Zingiber officinale* Roscoe). Foods 8(6): 185. doi: 10.3390/foods8060185

Monteiro JM, Albuquerque UP, Lins-Neto EMF, Araújo EL, Amorim ELC. 2006. Use patterns and knowledge of medicinal species among two rural communities in Brazil's semi-arid northeastern region. Journal of Ethnopharmacology 105(1–2): 173-186. doi: 10.1016/j.jep.2005.10.016

Mellali S, Haoud K, Dermeche K, Tamert A, Aroussi A. 2022. The use of *Syzygium aromaticum* L. to avoid and control the SARS-CoV-2 related complications. Egyptian Academic Journal of Biological Sciences 14(1): 77-89. doi: 10.21608/eajbsc.2022.215048

Mittal M, Gupta N, Parashar P, Mehra V, Khatri M. 2014. Phytochemical evaluation and pharmacological activity of *Syzygium aromaticum*: A comprehensive review. International Journal of Pharmacy and Pharmaceutical Sciences 6: 67-72. https://journals.innovareacademics.in/index.php/ijpps/article/view/2055/10326

Mohapatra G, Sahoo BM, Chowdhury B, Sruti J, Rana RN, Das R, Jena J. 2022. Herbal Drugs as Immune Booster Against Viral Infections. Current Nutrition & Food Science 18(2): 132-143. doi: 10.2174/1573401317666210816102404

Orisakwe OE, Orish CN, Nwanaforo EO. 2020. Coronavirus disease (COVID-19) and Africa: Acclaimed home remedies. Scientific African 10: e00620. doi: 10.1016/j.sciaf.2020.e00620

Oso BJ, Adeoye AO, Olaoye IF. 2022. Pharmacoinformatics and hypothetical studies on allicin, curcumin, and gingerol as potential candidates against COVID-19-associated proteases. Journal of Biomolecular Structure and Dynamics 40(1): 389-400. https://www.tandfonline.com/doi/abs/10.1080/07391102.2020.1813630

Pranskuniene Z, Balciunaite R, Simaitiene Z, Bernatoniene J. 2022. Herbal Medicine Uses for Respiratory System Disorders and Possible Trends in New Herbal Medicinal Recipes during COVID-19 in Pasvalys District, Lithuania. International Journal of Environmental Research and Public Health 19(15): 8905. doi: 10.3390/ijerph19158905

Quézel P, Santa S. 1962-1963. Nouvelle flore de l'Algérie et des régions désertiques méridionales. Editions du CNRS, Paris, 2 volumes, 1170 pp.

Raja R. 2012. Medicinally Potential Plants of Labiatae (Lamiaceae) Family: An Overview. Research Journal of Medicinal Plant 6: 203-213. doi: 10.3923/rjmp.2012.203.213

Rehman MT, AlAjmi MF, Hussain A. 2020. Natural Compounds as Inhibitors of SARS-CoV-2 Main Protease (3CLpro): A Molecular Docking and Simulation Approach to Combat COVID-19. Current Pharmaceutical Design 27(33): 3577-3589. doi: 10.2174/1381612826999201116195851

Salali GD, Chaudhary N, Thompson J, Grace OM, van der Burgt XM, Dyble M, Page AE, Smith D, Lewis J, Mace R, Vinicius L, Migliano AB. 2016. Knowledge-Sharing Networks in Hunter-Gatherers and the Evolution of Cumulative Culture. Current Biology 26(18): 2516-2521. doi: 10.1016/j.cub.2016.07.015

Samaddar A, Gadepalli R, Nag VL, Misra S. 2020. The Enigma of Low COVID-19 Fatality Rate in India. Frontiers in Genetics 11. doi: 10.3389/fgene.2020.00854

Saynes-Vásquez A, Caballero J, Meave JA, Chiang F. 2013. Cultural change and loss of ethnoecological knowledge among the Isthmus Zapotecs of Mexico. Journal of Ethnobiology and Ethnomedicine 9(1): 40. doi: 10.1186/1746-4269-9-40

Shukla S, Sinclair AJ. 2009. Becoming A Traditional Medicinal Plant Healer: Divergent Views of Practicing and Young Healers on Traditional Medicinal Plant Knowledge Skills in India. Ethnobotany Research and Applications 7: 039-051. https://ethnobotanyjournal.org/index.php/era/article/view/226

Sultana S, Khan A, Safhi MM, Alhazmi HA. 2016. Cough suppressant herbal drugs: A review. International Journal of Pharmaceutical Science Invention 5(5): 15-28. https://www.researchgate.net/publication/308369657

Tapsale D, Baheti R, Mahore J, Trivedi R, Patole V. 2024. Phytochemicals and medicinal plants: A promising frontier for antiviral research in the age of pandemics: REVIEW. Deleted Journal 9(3): 379-400. doi: 10.59049/2790-0231.1235

Tardío J, Pardo-de-Santayana M. 2008. Cultural Importance Indices: A Comparative Analysis Based on the Useful Wild Plants of Southern Cantabria (Northern Spain). Economic Botany 62(1): 24-39. doi: 10.1007/s12231-007-9004-5

Voeks RA, Leony A. 2004. Forgetting the forest: Assessing medicinal plant erosion in Eastern Brazil. Economic Botany 58(Suppl 1): S294-S306. http://www.jstor.org/stable/4256926

Yineger H, Yewhalaw D, Teketay D. 2008. Ethnomedicinal plant knowledge and practice of the Oromo ethnic group in southwestern Ethiopia. Journal of Ethnobiology and Ethnomedicine 4(1): 11. doi: 10.1186/1746-4269-4-11

Zhang JJ, Dong X, Cao YY, Yuan YD, Yang YB, Yan YQ, Akdis CA, Gao YD. 2020. Clinical characteristics of 140 patients infected with SARS-CoV-2 in Wuhan, China. Allergy 75(7): 1730-1741. doi: 10.1111/all.14238