Ethnobotanical survey on plants used by traditional healers to fight against COVID-19 in Fez city, Northern Morocco

Nesrine Benkhaira, Saad Ibsouida Koraichi and Kawtar Fikri-Benbrahim

Research

Abstract

Background: Coronavirus disease 2019 (COVID-19) has now been spread around the world in the form of a highly contagious pandemic. The lack of effective vaccines against this lethal viral infection is pushing researchers to identify potential sources from natural products that can help fight the pandemic. In Morocco, medicinal and aromatic plants (MAPs) have long been used to combat infectious diseases. According to our knowledge, this is the first ethnobotanical survey in Fez city, aimed to quantify the ethnobotanical knowledge of medicinal plants used by herbalists for fighting against the COVID-19.

Methods: An ethnobotanical survey was conducted in Fez city with traditional herbalists, in a period of two months (from the beginning of November to the end of December 2020). Semi-structured interviews were conducted with 50 well-known traditional herbalists. A quantitative analysis approach was used resulting in the determination of plant use value (PUV) and family use value (FUV) to evaluate the ethnobotanical knowledge.

Results: In total, 49 medicinal plants species were recorded belonging to 28 botanical families. According to the PUV index, the most important species were Syzygium aromaticum (L.) Merr. & Perry, Thymus vulgaris L., Eucalyptus globulus Labill., and Artemisia vulgaris L. The Lamiaceae was the most dominant family. The aerial part was the most used plant part. Most remedies were prepared in the infusion form and mostly administered orally. According to herbalists, 47.36 % of customers were very satisfied using herbal remedies to combat COVID-19.

Conclusion: The ethnobotanical and ethnopharmacological information collected in our study provides basic data on medicinal plants which is promising in the treatment and prevention of COVID-19. Thus, it is recommended that the safety and efficacy of these plants will be confirmed through pharmacological, toxicological and phytochemical studies.

Keywords: Covid-19, medicinal plants, traditional medicine, ethnobotany, Fez, Morocco.

Correspondence

Nesrine Benkhaira, Saad Ibsouida Koraichi,
Kawtar Fikri-Benbrahim

Laboratory of Microbial Biotechnology and Bioactive Molecules, Sciences and Technologies Faculty, Sidi Mohamed Ben Abdellah University, B.P. 2202 Imouzzer Road, Fez, Morocco

*Corresponding Author: kawtar.fikribenbrahim@usmba.ac.ma

Ethnobotany Research & Applications 21:27 (2021)

Résumé

Contexte: Actuellement, la maladie à coronavirus 2019 (COVID-19) s’est propagée dans le monde entier sous forme d’une pandémie hautement contagieuse. Le manque de vaccins efficaces contre cette infection virale et mortelle pousse les chercheurs à identifier des sources potentielles de produits naturels qui peuvent aider à lutter contre la
La pandémie. Au Maroc, les plantes médicinales et aromatiques sont utilisées depuis longtemps pour lutter contre les maladies infectieuses. Selon nos connaissances, il s'agit de la première enquête ethnobotanique dans la ville de Fès, visant à quantifier les connaissances ethnobotaniques des plantes médicinales utilisées par les herboristes pour lutter contre le COVID-19.

**Méthodes:** Une enquête ethnobotanique a été menée dans la ville de Fès auprès des herboristes traditionnels, sur une période de deux mois (du début Novembre à la fin de Décembre 2020). Des entretiens semi-structurés ont été menés avec 50 herboristes traditionnels bien connus. Une approche d'analyse quantitative a été utilisée pour déterminer la valeur d’usage des plantes (PUV) et la valeur d’usage familial (FUV) pour évaluer les connaissances ethnobotaniques.

**Résultats:** Au total, 49 espèces de plantes médicinales, appartenant à 28 familles botaniques, ont été enregistrées. Selon l'indice PUV, les espèces les plus importantes étaient *Syzygium aromaticum* (L.) Merr. & Perry, *Thymus vulgaris* L., *Eucalyptus globulus* Labill. et *Artemisia vulgaris* L. La famille des Lamiaceae était la plus dominante. La partie aérienne représentait la partie la plus utilisée des plantes. La plupart des remèdes était préparée sous forme d'infusion et principalement administrée par voie orale. Selon les herboristes, 47,36% des clients étaient très satisfaisant dans l'utilisation des remèdes à base de plantes pour lutter contre le COVID-19.

**Conclusion:** Les informations ethnobotaniques et ethnopharmacologiques collectées dans notre étude fournissent des données de base sur les plantes médicinales qui semblent prometteuses dans le traitement et la prévention du COVID-19. Ainsi, il est recommandé que l'innocuité et l'efficacité de ces plantes soient confirmées par des études pharmacologiques, toxicologiques et phytochimiques.

**Mots clés:** COVID-19, plantes médicinales, médecine traditionnelle, ethnobotanie, Fès, Maroc.

**Background**

In December 2019, several cases of pneumonia were reported in Wuhan city, Hubei province, China. The causative agent was confirmed as the severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2), previously named 2019 novel coronavirus (2019-nCoV) (WHO 2020). As of April 2020, the virus was rapidly transmitted between humans through direct contact. The virus has spread approximately causing a worldwide pandemic in more than 200 countries (Platto et al. 2020). Recently, in January 2021, the World health organization reported more than 90 million confirmed cases and more than two million deaths (WHO 2021a). The disease was termed COVID-19. It is characterized by fever, dry cough, dyspnea, and diarrhea. In severe cases, the symptoms are pneumonia, metabolic acidosis, septic shock, and bleeding (Yi et al. 2020).

In Morocco, the first confirmed case report was on the 2nd March 2020 concerning a Moroccan man returning from Italy. More recently, Morocco has recorded a number exceeding 400,000 confirmed cases, and more than 7,000 deaths (WHO 2021b). Concerning Fez city, the first case of COVID-19 appeared on March 11th 2020. It was about a woman of Senegalese origin, having 64 years old, who arrived in Fez from France on March 5th. Currently, the Fez-Meknes region has a total number of more than eight hundred confirmed cases of which Fez city often record the highest number of new cases per day (Ministère de la Santé 2021).

To date, several control measures are being instituted around the world to control the spread of the disease including strict quarantine measures, personal hygiene, and development of vaccines such as live attenuated vaccines, vectors of adenovirus, recombinant proteins, and nucleic acid (DNA and mRNA) (Güner et al. 2020, Holmes 2003). However, no vaccine has been approved to be 100% effective against the SARS-CoV-2 so far (Oladele et al. 2020). Today, the pandemic becomes the most frightening and terrifying issue causing huge health impact and huge economic losses around the world (UNIDO 2020).

Therewith, the pharmaceutical industry and scientific research are focusing on exploration of natural products particularly, MAPs producing several bioactive molecules approved effective against viral infections, including those from coronaviruses, enterovirus, hepatitis B, hepatitis C, herpes simplex virus (HSV), human immunodeficiency (HIV), and influenza viruses (IFV) (Monticolo et al. 2020).

Moreover, essential oils (EOs) from aromatic herbs, were also found to be active against a wide variety of viruses, such as IFV, HSV, HIV, yellow fever virus, and avian influenza (Aisl et al. 2020). Therefore, MAPs and EOs could be a better option to product novel antiviral drugs that can be effective against the SARS-CoV-2 (Boukhatem & Setzer 2020).

Furthermore, traditional healers have played a vital role in the fight against many ailments through using plants as natural remedies without even knowing
their bioactive molecules. While today’s researchers are especially interested in bioactive molecules extracted from plants to apply them in the fight against the current pandemic (Asif et al. 2020).

In this context, our study aims to collect information on herbal remedies employed to fight against the COVID-19, in Fez city, by herbalists and traditional healers who possess valuable knowledge about medicinal plants, in order to valorize the MAPs and to perform basic data that will contribute to overcoming the pandemic. This is the first ethnobotanical investigation in Fez city, aimed to quantify the ethnobotanical knowledge of medicinal plants used by herbalists for fighting against the COVID-19.

**Material and methods**

**Description of the study area**

This study was carried out in Fez, the cultural and spiritual capital of Morocco. Fez is a city in northern inland Morocco, located to the northeast of the Atlas Mountains, (34° 2’ 36” N, 5° 0’ 12” W). Fez connects the important cities of different regions; 206 km from Tangier to the northwest, 246 km from Casablanca and 189 km from Rabat to the west, and 387 km from Marrakesh to the southwest which leads to the Trans-Saharan trade route ("Morocco (IFMSA-Morocco) - Fez" n.d.).

Fez is divided between the old Fez (Fez el-bali) and the new Fez (Fez el-jedid) (Fig. 1). Further south is the town of Sefrou, and further southwest is the city of Meknes. The prefecture of Fez covers an area of 312 km. Its urban commune is divided into six districts: Agdal, Sais, Fez-Medina, Jnan El Ouard, El Mariniyine, and Zouagha. Fez covers 280 hectares with a population of 1.22 million, it is the second largest city in Morocco after Casablanca (Aouchar 2005, Cherkaoui et al. 2017).

Fez has a mild and sunny Mediterranean climate. The highest and lowest temperatures ever reported are 46.7 °C and –8.2 °C, respectively. The winter highs typically reach around 15 °C in December-January. During summer, the average temperature is about 32 °C. The climate of Fez city is similar to that of Cordoba (Climatological Information for Fez, Morocco 2011).

The economy of the local population of Fez city is mainly based on tourism, agriculture and handicraft. The rural area surrounding the city and the fertile plains of Sais represent an important source of producing cereals, beans, olives, and grapes. Moreover, there are two natural parks which constitute the vegetal richness of the city: the Tazeika Park, to the northeast, and the Ifrane national park covering more than 500 km² and including the largest cedar forest in Morocco (UNESCO n.d.).

**Data collection**

In order to gather information on MAPs used for curing and preventing the COVID-19, an ethnobotanical and ethnopharmacological survey was conducted from November 1st to December 31st, 2020. During this period different districts of Fez city were visited (Fig. 1).

![Figure 1. Location of the study area; Fez-Morocco.](image-url)
To collect data, a semi-structured questionnaire was prepared, and information were compiled through face-to-face interviews with herbalists and traditional healers. This method was chosen as it is very convenient for data collection (Jaradat et al. 2017). The questionnaire was divided into two parts; the first concerned the socio-demographic profile of herbalists (age, gender, level academic, and experience years) and the second part was about the MAPs used to fight against the COVID-19 (local, scientific and family names, the part used, preparation modes, posology etc.).

A total of 50 traditional herbalists, including 43 male and 7 female aged between 27 and 76 years, were selected randomly from different districts of Fez city and interviewed. Most of the herbalists were in the region of Fez el-bali (the old medina of Fez) where the inhabitants mainly depend on traditional medicine for healthcare because of the high cost of modern medicine and the low social level of the old medina inhabitants. The aim of our study was clarified to herbalists to maintain transparency and to obtain reliable answers for scientific purposes and not for commercial ones. The interviews with herbalists were conducted in the local language (Arabic) in a period ranging from 20 to 40 minutes by each of them. Then, all documented data were translated into English.

Identification of the species
The species were initially identified by their local names, then validated through special botanical books to know: Medicinal plants of Morocco (Sijelmasi 1993), Practical flora of Morocco: manual for the determination of vascular plants (Fennane et al. 1999), Catalogs of vascular plants of northern Morocco with identification keys (Valdès 2002).

Other standard Moroccan floras were used to ensure identification: The traditional Moroccan pharmacopoeia: ancient Arabic medicine and popular knowledge (Bellakhdar 1997) and Moroccan medicinal and aromatic plants (Hمامouchi 1999). Some botanical databases were also used to confirm the taxonomic names of our species, encyclopedia of Life and The Plant List.

Moreover, the medicinal plants recorded in our work were compared to those reported in ethnomedical surveys carried out in the same study area (Jouad et al. 2001, Mikou et al. 2016, Youbi et al. 2016) as well as in other regions of Morocco (Chaachouay et al. 2019, El Hachlafi et al. 2020, Haouari et al. 2018, Harouak et al. 2018, Najem et al. 2020, Strathern 2002).

Data analysis
Data collected in our study were statistically analyzed using SPSS (System Package for Social Sciences, version 21) and Microsoft Office "Excel 2013". Data concerning socio-demographic profile of herbalists were examined by a simple descriptive statistical method using percentages and frequencies. Whereas the ethnomedical and ethnopharmacological data were analyzed using quantitative value indices; The FUV and PUV.

The Family Use Value (FUV)
The FUV was assessed to determine the significance of medicinal plant families. This index is used in ethnomedical to determine a value of a biological plant taxon. The FUV was calculated according to the following equation (Sreekeesoon & Mahomoodally 2014):

\[ \text{FUV} = \frac{\text{UVs}}{\text{ns}} \]

Where: UVs refers to the use values of the taxa and ns to the total number of species within each family.

Plant Use Value (PUV)
The PUV is a quantitative method, demonstrating the relative importance for each species known locally. The PUV was determined according to the following equation (Trotter & Logan 1986):

\[ \text{PUV} = \frac{\text{U}}{\text{N}} \]

Where: U refers to the number of citations per species and N to the number of herbalists interviewed. A high PUV indicates the potential importance of the plant species reported.

Review study
In order to confirm the ethnomedical and ethnopharmacological information obtained in our study, a literature review was performed about antiviral and immunomodulatory properties of the medicinal plants most recommended by herbalists for preventing and treating the COVID-19 (species with the highest PUV).

A literature review was conducted by a systematic search of the scientific literature using Pubmed, Scopus, and Google Scholar. The following Keywords were used to facilitate the collection of data: individual plant names, “COVID-19” OR “coronavirus” OR “SARS-CoV-2” AND “antiviral” AND “immunomodulatory”. The PubChem database and the software ChemDraw Ultra 12.0 were used to draw the chemical structures.
Results and discussion
Socio-demographic profile of herbalists

Gender
In total, 50 herbalists including 86% of men and 14% of women were interviewed. The predominance of men can be explained by the fact that in our society men work to provide favorable conditions for their families while most women care for their family and manage household affairs. Other ethnobotanical studies recently carried out on a national scale; Taza, Rabat-Sale-Kenitra region, Casablanca, Beni Mellal-Khenifra region, and Meknes city are concordant with our results (Bourhia et al. 2019, El alami et al. 2020, El Hachlafi et al. 2020, Haouari et al. 2018). Other international ethnopharmacological surveys carried out at Algeria, Palestine, and Saymour are also in agreement with our data (Boudjelal et al. 2013, Buwa-Komore et al. 2019, Jaradat et al. 2017).

Age
In the study area, most herbalists were older than 60 years old (34%) followed by those who were between 51 and 60 years (32%), while the two age groups (31-40) and (41-50) were equal (14% for each group). Herbalists with an age less than 30 came in last position (6%). The predominance of elderly herbalists is due to the heritage of the parents' profession. These data are similar to those obtained in the ethnobotanical survey carried out in Rabat-Sale-Kenitra Region and in Lwamondo, Limpopo province of South Africa (El Hachlafi et al. 2020, Mahwasane et al. 2013).

Education level
Regarding the education level, 40% of herbalists had a primary level followed by 28% with a secondary level. While 18% were illiterate and 14 % had a university degree. These data can be explained by the fact that the practice of herbalism is inherited from ancient generations and does not require a diploma. This is in agreement with the ethnopharmac-botanical study conducted in Sulaymaniyyah Province of Irak which reported that 33% of herbalists had a primary school degree (Ahmed 2016). Other ethnobotanical surveys carried out in Morocco (Meknes and Taza) documented that most herbalists had a secondary level followed by a primary level (Harouak et al. 2018, Haouari et al. 2018). Whereas, it was reported that the majority of herbalists in Rabat-Sale-Kenitra region and North Algeria were illiterate (Boudjelal et al. 2013, El Hachlafi et al. 2020).

Years of experience in herbalism
Half of the herbalists (50%) had more than 20 years of experience, followed by 34% who had 11 to 20 years of experience, while only 16% practiced herbalism for one to 10 years. This can be explained by the fact that our study has been dominated by elderly herbalists having therefore a long experience. This also means that herbalism is in great demand from the Moroccan population. This is in agreement with the survey carried out in west bank Palestine which documented that most of herbalists had an experience over 20 years (Jaradat et al. 2017). While in Taza city, the majority were reported to have an experience between 11 to 20 years (Haouari et al. 2018).

Quantitative analysis
Species families and their FUV
A total of 49 species belonging to 28 botanical families were recommended by herbalists to fight against COVID-19. The scientific names of species and their families, local names, the plant's part used, type, condition, preparation and administration modes, PUV, and FUV of the 49 species were detailed in Table 1. According to the number of species, the most representative families were Lamiaceae (12.5 %) followed by Asteraceae (11 %), Apiaceae (7.5 %), and Zingiberaceae (5.5 %). The remaining families were represented by a percentage ranging from 2 % to 4 % (Fig. 2 (a)). In terms of the FUV index, the most cited families are Punicaceae (FUV=1), followed by Amaryllidaceae and Lauraceae having the same FUV (0.212), and Urticaceae (FUV=0.125) (Table 1).

The dominance of these families can be explained by their extensive distribution in Morocco due to its ecological factors favoring the vegetation of the species belonging to these families. Likewise, these families are widely requested by the Moroccan population for the potential of their plant species, especially the Lamiaceae family which includes many aromatic plants producing EOs with powerful properties. Another ethnobotanical study performed in Beni Mellal-Khenifra about medicinal plants used for the prevention of COVID-19 pandemic showed that the Lamiaceae was also the most important family in the data collected (El alami et al. 2020). Furthermore, the ethnobotanical survey carried out in Seksaoua region (Western High Moroccan Atlas) about plants used in the treatment of respiratory diseases recorded that Lamiaceae, Apiaceae, and Asteraceae were the most dominant families. Moreover, the study executed in Rabat-Kenitra-Sale region showed that the families Lamiaceae, Asteraceae, and Apiaceae were the most cited to treat chronic diseases (El Hachlafi et al. 2020).
Table 1. Medicinal plants used to treat and prevent COVID-19.

| Scientific names of species and families | Local name | PPU | Type | Condition | Pr. mode | Ad. mode | PUV | FUV |
|------------------------------------------|------------|-----|------|-----------|----------|----------|-----|-----|
| Amaryllidaceae                           |            |     |      |           |          |          |     | 0.212 |
| *Allium cepa* L.                         | Basla      | Bu  | Cl   | F         | Cd, J    | OA       | 0.14|     |
| *Ammoodaucus leucotrichus Coss.*         | Kamoun soufi | AP  | Sp   | D         | If, Pd   | OA       | 0.08|     |
| *Cuminum cyminum* L.                     | Lkamoun    | S   | Cl   | D         | Pd, If   | OA       | 0.04|     |
| *Petroselinum crispum* (Mill.) Fuss      | Maadhouse  | AP  | Sp   | D         | If, Dc, Pd | OA   | 0.12|     |
| *Pimpinella anisum* L.                   | Ennafaa    | S   | Im   | D         | Pd, Dc, If | OA   | 0.1 |     |
| Apiaceae                                 |            |     |      |           |          |          |     | 0.002 |
| *Apium graveolens* L.                    | Lkrafes    | AP  | Sp   | F, D      | Cd, Pd   | OA       | 0.06|     |
| Araliaceae                               |            |     |      |           |          |          |     | 0.008 |
| *Panax ginseng* C.A. Mey.                | Jinsing    | R   | Im   | D         | Pd, Dc   | OA, In   | 0.16|     |
| Areceaceae                               |            |     |      |           |          |          |     | 0.0012 |
| *Phoenix dactylifera* L.                 | Tmar       | Fr  | Cl   | Im D      | Rw       | OA       | 0.06|     |
| Astereace                                |            |     |      |           |          |          |     | 0.001 |
| *Artemisia vulgaris* L.                  | Chih       | L   | Cl   | D         | Dc, EO, Fm | In, OA | 0.36|     |
| *Artemisia absinthium* L.                | Chiba      | AP  | Sp   | D, F      | Dc, If, Fm | In, OA | 0.06|     |
| *Chamaemulum nobile* (L.) All.           | Babounj    | AP  | Sp   | D         | If       | OA       | 0.08|     |
| *Saussurea costus* (Falc.) Lipsch.       | Kist hindi | R   | Im   | D         | EO, Pd, Dc | In, OA | 0.08|     |
| Brassicaceae                             |            |     |      |           |          |          |     | 0.003 |
| *Brassica rapa* L.                       | Laft       | R   | Cl   | F         | Cd       | OA       | 0.06|     |
| *Lepidium sativum* L.                    | Hab errachad | S  | Imp  | D         | If, Rw   | OA       | 0.12|     |
| Capparaceae                              |            |     |      |           |          |          |     | 0.003 |
| *Capparis spinosa* L.                    | Lkabbar    | Fl.B | Sp  | D         | If, Dc   | OA       | 0.04|     |
| Fabaceae                                 |            |     |      |           |          |          |     | 0.002 |
| *Glycyrrhiza glabra* L.                  | Arq souss  | R   | Im   | D         | Pd, If, Dc | OA   | 0.08|     |
| Family             | Species                                      | Common Name   | Uses          | Essential Oils (%) | Notes           |
|--------------------|----------------------------------------------|---------------|---------------|--------------------|------------------|
| Iridaceae          | Crocus sativus L.                            | Zaafaran tor  | St, Sp, D, If | OA 0.06            |                 |
| Juglandaceae       | Juglans regia L.                             | Gargaa        | Fr, Cl, F, D, Rw | OA 0.06            |                 |
| Lamiaceae          | Lavandula angustifolia Mill.                 | Lkhzama       | AP, Sp, D, If, EO, Fm, Dc | OA, In 0.2       |                 |
|                    | Mentha pulegium L.                           | Fiou          | AP, Sp, D, F, Dc, EO | OA, In 0.24      |                 |
|                    | Mentha spicata L.                            | Naanaa        | AP, Sp, D, If, EO, Dc | OA, In 0.1       |                 |
|                    | Origanum majorana L.                         | Mardaddouche  | AP, Cl, D, If, EO, Fm | OA, In 0.08      |                 |
|                    | Rosmarinus officinalis L.                    | Azir          | AP, Sp, D, If, EO, Fm, Dc | OA, In 0.24      |                 |
|                    | Salvia officinalis L.                        | Salmia        | AP, Sp, D, If, EO, Fm, Dc | OA, In 0.1       |                 |
|                    | Thymus vulgaris L.                           | Zaatar        | AP, Sp, D, If, Dc, Pd, EO | OA, In 0.46      |                 |
| Lauraceae          | Cinnamomum verum J. Presl                   | Lqarefa       | B, Im, D, Pd, Dc, If, EO | OA, In 0.22      |                 |
|                    | Laurus nobilis L.                            | Wraq sidna moussa | L, Sp, D, If, Dc | OA, In 0.02      |                 |
| Linaceae           | Linum usitatissimum L.                       | Zriaa Itttan  | S, Cl, D, If | OA 0.06            |                 |
| Meliaceae          | Azadirachta indica A. Juss.                 | Neem          | L, F, Cl, D, If, Dc | OA 0.08           |                 |
| Myrtaceae          | Eucalyptus globulus Labill.                 | Kalyptous     | L, Sp, D, Dc, If, EO | In, OA 0.4      |                 |
|                    | Syzygium aromaticum (L.) Merr. & Perry.     | Qronfel/Oud nouwar | F, B, Im, D, If, EO | In, OA 0.46     |                 |
| Oleaceae           | Olea europaea L.                             | Zitoun        | L, Fr, Sp, F, If, Dc, M, VO | OA 0.12       |                 |
| Piperaceae         | Piper nigrum L.                              | Ibzar         | Fr, Im, D, Pd | OA 0.04            |                 |
| Family             | Species                              | Plant's Part Used | Cultivation | Part | Preparation | Administration |
|--------------------|--------------------------------------|-------------------|-------------|------|-------------|----------------|
| Poaceae            | Avena sativa L.                      | Khartal/ choufan  | S           | Cl   | D           | Rw, If, Pd     |
|                    |                                      |                   |             |      |             | OA, Ct         |
|                    | Polygonaceae                         |                   |             |      |             |                |
|                    | Fagopyrum esculentum Moench          | Hanta sawdae      | S           | Cl   | D           | Cd             |
|                    |                                      |                   |             |      |             | OA             |
|                    | Punica granatum L.                   | Remman            | Fr          | Sp   | F           | J              |
|                    |                                      |                   |             |      |             | OA             |
|                    | Ranunculaceae                        |                   |             |      |             |                |
|                    | Nigella sativa L.                    | Habba sawdae/sanouj | S       | Cl   | D           | Dc, If, Pd, VO |
|                    |                                      |                   |             |      |             | OA             |
|                    | Rosaceae                             |                   |             |      |             |                |
|                    | Prunus dulcis (Mill.) D.A. Webb      | Louz              | Fr          | Sp   | F, D        | Rw             |
|                    |                                      |                   |             |      |             | OA             |
|                    | Rubiaceae                            |                   |             |      |             |                |
|                    | Rubia tinctorum L.                   | Elfoua            | R           | Cl   | D           | If, Pd         |
|                    |                                      |                   |             |      |             | OA             |
|                    | Urticaceae                           |                   |             |      |             |                |
|                    | Urtica dioica L.                     | Harigua           | AP          | Sp   | D           | Dc, If, Pd     |
|                    |                                      |                   |             |      |             | OA             |
|                    | Zingiberaceae                        |                   |             |      |             |                |
|                    | Alpinia officinarum Hance            | Khoudnjal         | Rh          | Im   | D           | If, Pd         |
|                    |                                      |                   |             |      |             | OA             |
|                    | Curcuma longa L.                     | Lkharquoum        | Rh          | Im   | D           | If, Pd         |
|                    |                                      |                   |             |      |             | OA             |
|                    | Zingiber officinale Roscoe           | Zanjabil          | Rh          | Im   | D           | J, Dc, If, Pd  |
|                    |                                      |                   |             |      |             | OA             |

PPU: plant’s part used; L: Leaves; Fl.B: Flower buds; Sp: Spontaneous; D: dry; F: Fresh; Dc: Decoction; If: infusion; OA: oral administration; Im: Imported; Fl: Flowers; Cl: Cultivated; Fm: fumigation; R: root; Pd: powder; AP: aerial part; Rh: rhizome; J: juice; B: Bark; Bu: bulb; Cd: cooked; Fr: fruit; M: maceration; S: seeds; Rw: raw; VO: vegetal oil; St: stigma; Ct: cataplasmce; Ma: Massage; Pr: preparation; Ad: administration.
Medicinal plants and their PUV

The PUV index of species is calculated to evaluate the importance of medicinal plants. Data showed that the PUV of reported species ranged from 0.46 to 0.02. *Syzygium aromaticum* (L.) Merr. & Perry., and *Thymus vulgaris* L. exhibited the highest value (PUV=0.46), followed by *Eucalyptus globulus* Labill. (PUV=0.4), *Artemisia vulgaris* L. (PUV=0.36). The species *Rosmarinus officinalis* L. and *Mentha pulegium* L. had the same PUV index (PUV=0.24), followed by *Cinnamomum verum* J. Presl (PUV=0.22) (Table 1). Species with a high PUV index are the most mentioned by herbalists. Therefore, they could have important antiviral and immunostimulatory properties.

Literature review

Medicinal plants having the highest PUV indexes appear to possess promising antiviral and immunostimulatory properties. Thereupon, bibliographic research was performed aiming the scientific evidence through in vivo and in vitro studies of the plants’ properties. Table 2 summarizes data collected from the literature, and Figure 3 shows the chemical structures of the main active compounds indicated in the table below.

Parts of the medicinal plants used

In general, the aerial part has been reported as the most used part by the interviewed herbalists for herbal medicine preparations (10.91%), followed by seeds (7.27%), fruits (7.27%), leaves (4.55%), and roots (4.55%). Other parts of plants (stigma, bark, flower, flower buds) come last with a percentage between 0.91 to 2.73% (Fig.2 (b)). The frequent use of aerial part is due to the availability, simplicity of harvest, and herbal medicine preparation. Moreover, the leaves store many secondary metabolites that are responsible for the biological activities of the species. Another study showed that aerial parts, seeds, and leaves were the most used in the treatment of respiratory disorders with slight differences (Sbai-Jouili et al. 2017).

Methods of remedies' preparation

Several preparation modes are used to facilitate the administration of active principles of medicinal plants. Our study showed that infusion was the dominant preparation method of herbal remedies to fight against COVID-19 (28.18%). Followed by decoction (21.82%), powder (15.45%), essential oil (12.73%), and other methods of preparation (juice, fumigation, raw, cooked, vegetal oil, and maceration) ranged from 1 to 5.45% (Fig.2 (c)). The infusion is frequently used because it allows collecting the most active compounds of medicinal plants as well as it can attenuate the toxic effect of some recipes. It also prevents the destruction of certain bioactive molecules in medicinal plants. Our data are in agreement with the ethno-botanical survey of the medicinal plant used to treat metabolic disorders in Moroccan Rif (Chaachouay et al. 2019).
Table 2. Antiviral and immunostimulatory properties of the most cited medicinal plants.

| Species                  | Antiviral properties                               | Immunostimulatory properties                     | Active compounds | Mechanism of action                                                                 | References                                                                 |
|-------------------------|---------------------------------------------------|--------------------------------------------------|------------------|--------------------------------------------------------------------------------------|---------------------------------------------------------------------------|
| Artemisia annua L.      | ME obtained from the aerial parts showed a strong in vitro anti-herpetic activity (HSV1-infected HeLa cells) | ME and leaf powder of A. annua showed an increase performance, cellular and humoral immunity of Cobb broiler chicks | Artemisinin      | Suppression of flaviviruses replication, enhancement of type I interferon response by up-regulation of key factor phosphorylation (Interferon Regulatory Factor 3), signal transduction and activation of transcription 1 and 2 | (Hou & Huang 2016, Gholamrezaie et al. 2013, Karamoddini et al. 2011, Wang et al. 2020) |
| Cinnamomum verum J. Presl. | In vitro study showed that EO and powder of cinnamon exhibits antiviral activity against NDV in chickens. | Crude and EAPs extracted from bark of C. verum showed an increase of the cell growth in PBMCs, indicating immunostimulating effect. | Cinnamaldehyde  | Blocking NF-κB activation in immune cells. inhibition of cell viability, proliferation and induction of apoptosis in a dose-dependent manner | (Conti et al. 2014, Flechas et al. 2018, Flouchi & Fikri-benbrahim 2020, Goyal et al. 2018, Roth-Walter et al. 2014, Singh et al. 2020) |
| Eucalyptus globulus Labill. | EO of Eucalyptus globulus showed a significant in vitro antiviral activity against H1N1 | EO has been shown to improve respiratory tract immune function and body immunity with upregulating effect on CD8 cells of Sprague-Dawley rats | 1,8-cineole (eucalyptol) | Induction of interferon regulatory factor 3, and up-regulation of NF-κB accompanied by down-regulation of mucin genes (MUC2, MUC19) and modulating of reactive oxygen species | (Astani & Schnitzler 2014, Flouchi & Fikribenbrahim 2020, Juergens et al. 2020, Marchese et al. 2017, Salehe et al. 2019, Shao et al. 2020) |
| Mentha pulegium L. | ME showed an important antiviral activity against HSV-1 in HeLa cell line | The powder of aerial part of *M. pulegium* showed a Stimulation of the immune system of broiler chickens by increasing the lymphocytes production and improving the lymphocyte ratio | Pulegone | Inhibition of NF-κB and MAPKs signaling pathways and cytokine production | (Brahmi et al. 2017, Choi et al. 2018, Mahdavi et al. 2013, Parsania et al. 2017) |
|------------------|-------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|-------|-------------------------------------------------|----------------------------------|
| Rosmarinus officinalis L. | EA fraction of *R. officinalis* exerted a strong inhibitory in vitro effect against hRSV infection | An in vitro study showed a stimulation of adaptive immunity of mice, injected with sheep red blood cells, through oral administration of rosemary leaf extract which increases the number of certain isotypes of antibodies, IgM and IgG, at primary and secondary responses respectively. | Carnosic acid | Suppression of viral gene expression, blocking the expression of hRSV genes; inhibition of the replication of hRSV | (Ahmed & Babakir-Mina 2020, Lai et al. 2009, Li et al. 2018, Luo et al. 2020, Shin et al. 2013) |
|                  |                                                 |                                                                                                                                                      | Carnosol | Inhibition of Th17 cell differentiation and signal transducer and activator of transcription 3 phosphorylation, and blocking transcription factor NF-κB nuclear translocation |            |
|                  |                                                 |                                                                                                                                                      | Rosmanol | Inhibition of LPS-stimulated iNOS and COX-2 protein and gene expression, reduction of translocation of the nuclear factor-κB (NF-κB) subunits by prevention of the degradation and phosphorylation of inhibitor κB (IκB) |            |
|                  |                                                 |                                                                                                                                                      | Rosmarinic acid | Inhibition of IFN-γ and IL-4 generation by stimulating CD4+ T cells. Decrease of IFN-γ and IL-4 production via activation of T cells and the level of total serum IgE. |            |
|                  |                                                 |                                                                                                                                                      | Eugeniin | NR                                             |
| Plant Name                        | Extract Type | Activity/Effect                                                                 | Compound | Antiviral Activity                                                                                       | References |
|----------------------------------|--------------|--------------------------------------------------------------------------------|----------|--------------------------------------------------------------------------------------------------------|------------|
| *Syzygium aromaticum* (L.) Merr. & Perry | AE | showed strong anti-HSV-1 activity *in vivo* on brain and skin of mice          | Eucalyptol | Damage to viral envelopes of freshly formed virions and inhibition of initial stage of viral replication | (Cortés-Rojas et al. 2014, Carrasco et al. 2009, Pramod et al. 2010) |
|                                  | Clove EO     | increased the total white blood cell and enhanced the DTH response in mice *in vivo* |          |                                                                                                         |            |
|                                  |              |                                                                 | Eugenol |                                                                                                         |            |
|                                  |              |                                                                 |          |                                                                                                         |            |
| *Thymus vulgaris* L.             | EE           | showed an antiviral activity against NDV, HSV1 and 2, and acyclovir-resistant strains of HSV1 *in vitro* on RC-37 cells |          | Modulation of pro-inflammatory and anti-inflammatory mediators (IL-17, IFN-γ, TGF-β, IL-6, IL-10, and IL-4), enhancement of autoimmunity by increasing cytokines production | (El-Boshy et al. 2019, Flouchi & Fikri-benbrahim 2020, Javed et al. 2021, Kuete 2017, Wani et al. 2020, Wu et al. 2016) |
|                                  |              |                                                                 | Carvacrol |                                                                                                         |            |
|                                  |              |                                                                 |          |                                                                                                         |            |
|                                  |              |                                                                 | Caffeic acid |                                                                                                         |            |
|                                  |              |                                                                 | Quercetin | Suppression of viral-cell fusion by interaction with influenza hemagglutinin protein                      |            |

AE: aqueous extract; HSV-1: herpes simplex virus type 1; EO: essential oil; DTH: delayed-type hypersensitivity; EE: ethanol extract; NDV: newcastle disease virus; Pb: Lead; H1N1: influenza A virus subtype; ME: methanolic extract; EA: ethyl acetate; hRSV: human respiratory syncytial virus; IgG: immunoglobulin G; IgM: immunoglobulin M; EAPs: ethyl acetate polysaccharides; PBMCs: peripheral blood mononuclear cells; NR: No Reported; NF-κB: nuclear factor kappa; MAPK: mitogen-activated protein kinase
Figure 3. Chemical structures of the main active compounds of the medicinal plants having the highest PUV indices.
Administration routes
In our study, data analysis has revealed that most of the remedy preparations are orally prescribed (43.64%), followed by inhalation (17.27%), massage (5.45%), and cataplasm (0.91%) (Fig.2 (d)). The dominance of the oral administration can be explained by the fact that oral route allows better absorption of active compounds contained in medicinal plants. Our results are consistent with other national and international ethnobotanical surveys reporting that the oral route is the most cited administration mode (Alalwan et al. 2019, Chaachouay et al. 2019, El Hachlafi et al. 2020, Haouari et al. 2018).

Conditions of herbal remedies’ preparation
In our study area, herbal remedies were mostly prepared from dry (64%) than fresh plant material (16%), and 10% has been prepared from either fresh or dry plants. The use of dry plants can be explained by the fact that drying preserves medicinal plants better and it allows access to different parts of the plant during all seasons of the year (Alalwan et al. 2019). In most cases, the preparation of herbal remedies has been obtained from individual plants with water being the main component. Honey is also used to be mixed with plant powder. Moreover, some preparations are made from plant mixtures such as a juice of Lemon and Ginger (Zingiber officinale Roscoe), a fumigation of thyme (Thymus vulgaris L.), lavender (Lavandula angustifolia Mill.), mugwort (Artemisia vulgaris L.), rosemary (Rosmarinus officinalis L.) and eucalyptus (Eucalyptus globulus Labill.), or infusion preparation from a mixture of thyme, rosemary, mint (Mentha spicata L.), and sage (Salvia officinalis L.).

Posology
Most herbalists use handle, finger length, and teaspoon as units of measurements. One teaspoon of herbal preparation has been the most common dose used (34 %), followed by a handle (24 %) and finger length (14 %) by a glass of water. Regarding the number of times per day, all herbalists (100 %) recommend using the herbal preparations once a day at night. The duration of treatment was reported until healing (until the disappearance of COVID-19 symptoms).

Satisfaction level of costumers
Most herbalists have reported that their customers were very satisfied (47.36 %). Others were satisfied (34.21 %) with the use of herbal remedies to combat the virus, since they subsequently return to purchase the same herbal recipes to prevent the disease. These high percentages show the potential therapeutic effect of herbal remedies in the treatment of COVID-19. While few clients were Unsatisfied (18.42 %) due to the absence of a therapeutic effect that can be explained by an incorrect posology.

Knowledge origin of herbalists
In our survey, most herbalists (82%) acquired their knowledge about the medicinal use of plants from their parents and elderly relatives, whereas 18% built their knowledge by reading books about traditional Arab medicine. This reflects that the relative transmission of herbalism from one to the next generation remains an effective means to transfer this knowledge.

Conclusion
To the best of our knowledge, this survey is the first study carried out in Fez city to focus on the ethnopharmacological knowledge about medicinal plants used by herbalists and traditional healers to combat COVID-19. In short, 49 species, belonging to 28 botanical families, are used in our study area to fight against the pandemic with the domination of the Lamiaceae family. Syzygium aromaticum L., Thymus vulgaris L., Eucalyptus globulus Labill. were the most cited medicinal species. The infusion was the most applied method of herbal preparation and the oral route has been the most common route of administration. The ethnobotanical and ethnopharmacological data demonstrated that medicinal plants play a crucial role in the treatment and prevention of COVID-19 since their use is satisfying the inhabitants of Fez city. It also reveals the importance of traditional medicine in the primary healthcare system of Moroccan people, in the study area, as well as the appreciable antiviral properties of the diverse medicinal plants recorded in our study. However, many plants lack ethnomedicinal evidence. Therefore, our ethnobotanical survey could represent baseline data for future biological, pharmacological, toxicological, and phytochemical investigations of the plants listed to identify new, affordable, effective, and eco-friendly antiviral agents. Also, further surveys are needed in other regions of Morocco to collect more data about medicinal species used in the treatment and prevention of COVID-19.

Declarations
List of abbreviations: COVID-19: Coronavirus disease 2019, MAPs: medicinal and aromatic plants, PU: plant use value, FUV: family use value, 2019-nCoV: 2019 novel coronavirus, SARS-CoV-2: severe acute respiratory syndrome coronavirus-2, HSV: virus herpes simplex, HIV: human immunodeficiency, IFV: influenza viruses, EOS: essential oils, SPSS: System Package for Social
Ahmed contributed survey. traditional
Acknowledgements

Methodology, manuscript Saad participation design, Authors grant Funding: Competing

Ethics consent about anonymity and confidentiality. administration.

advisory to us. The number of herbalists interviewed, UVs: the use values of the taxa, ns: total number of species within each family. AE: aqueous extract, DTH: delayed-type hypersensitivity, EE: ethanol extract, NDV: newcastle disease virus, Pb: Lead, H1N1: influenza A virus subtype, ME: methanolic extract, EA: ethyl acetate, hRSV: human respiratory syncytial virus, IgG: immunoglobulin G, IgM: immunoglobulin M, EAPs: ethyl acetate polysaccharides, PBMCs: peripheral blood mononuclear cells, PPU: part plant used, L: Leaves, Fl.B: Flower buds, Sp: Spontaneous, D: dry, F: Fresh, Dc: Decoction, If: infusion, OA: oral administration, Fl: Imported, Fl: Flowers, C: Cultivated, Flm: fumigation, R: root, Pd: powder, AP: aerial part, Rh: rhizome, J: juice, B: Bark, Bu: bulb, C: cooked, Fr: fruit, M: maceration, S: seeds, Rw: raw, VO: vegetal oil, St: stigma, Ct: cataplasme, Ma: Massage, Pr: preparation, Ad: administration.

Ethics approval and consent to participate: The data were collected with respect to confidentiality, anonymity and consent. All herbalists were informed about the aim of this study.

Consent for publication: Not applicable.

Availability of data and materials: The data was not deposited in public repositories.

Competing interests: The authors declare no conflict of interest.

Funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Authors' contributions: Nesrine Benkhaira: Study design, ethnobotanical surveys conduction, active participation to methodology structuring, First draft manuscript writing, data analysis and interpretation. Saad Ibnsouda Koraichi: Study supervision, manuscript revision. Kawtar Fikri-Benbrahim: Conception and supervising, contribution to Methodology, manuscript improving and Review-Editing. All authors read, reviewed and approved the manuscript.

Acknowledgements

Authors wish to express their sincere thanks to all the traditional herbalists who have participated in this survey. Authors are also grateful to all those who contributed to the realization of this work.

Literature cited

Ahmed HM. 2016. Ethnopharmacobotanical Study on the Medicinal Plants Used by Herbalists in Sulaymaniyah Province, Kurdistan, Iraq. Journal of Ethnobiology and Ethnomedicine 12:1-17.

Ahmed HM, Babakir-Mina M. 2020. Investigation of Rosemary Herbal Extracts (Rosmarinus officinalis) and Their Potential Effects on Immunity. Phytotherapy Research 34:1829-1837.

Alalwan TA, Alkhuzaei JA, Jameel Z, Mandeel QA. 2019. Quantitative Ethnobotanical Study of Some Medicinal Plants Used by Herbalists in Bahrain. Journal of Herbal Medicine 17:100278.

Aouchar A. 2005. Fès, Meknès. Flammarion, Paris, France.

Asif M, Saleem M, Saadullah M, Yaseen HS, and Al Zarzour R. 2020. COVID-19 and Therapy with Essential Oils Having Antiviral, Anti-Inflammatory, and Immunomodulatory Properties. Inflammpharmacology 1-9.

Astani A, Schnitzler P. 2014. Antiviral activity of monoterpenes beta-pinene and limonene against herpes simplex virus in vitro. Iranian Journal of Microbiology 6:149-55.

Bellahkhdar J. 1997. The Traditional Moroccan Pharmacopoeia: Ancient Arabic Medicine and Popular Knowledge. Ibis press, Paris, France.

Boudjelal A, Henchiri C, Sari M, Sarri D, Hendif N, Benkhaled A, Ruberto C, 2013. Herbalists and Wild Medicinal Plants in M’Sila (North Algeria): An Ethnopharmacology Survey. Journal of Ethnopharmacology 2:395-402.

Boukhedorn M, Setzer WN. 2020. Aromatic Herbs, Medicinal Plant-Derived Essential Oils, and Phytochemical Extracts as Potential Therapies for Coronaviruses: Future Perspectives. Plants 9:800.

Bourhia M, Abdelaziz Shahat A, Mohammed Almarfadi O, Ali Naser F, Mustafa Abdelmageed W, Ait Haj Said A, El Gueddari F, Naamane A, Benbacer L, Khili N 2019. Ethnopharmacological Survey of Herbal Remedies Used for the Treatment of Cancer in the Greater Casablanca-Morocco. Evidence-Based Complementary and Alternative Medicine.

Brahmi F, Khodir M, Mohamed C, Pierre D. 2017. Chemical Composition and Biological Activities of Mentha Species. Aromatic and Medicinal Plants-Back to Nature 47-78.

Buwa-KomorenLV, Mayekiso B, Minhana Z, Adeniran AL. 2019. An Ethnobotanical and Ethnomedicinal Survey of Traditionally Used Medicinal Plants in Seymour, South Africa: An Attempt toward Digitization and Preservation of Ethnic Knowledge. Pharmacognosy Magazine 15:115.

Carrasco FR, Schmidt G, Romero AL, Sartoretto JL, Caparrozo-Assef SM, Bersani-Amado CA, Cuman RKN. 2009. Immunomodulatory Activity of Zingiber officinale Roscoe, Salvia officinalis L. and Syzygium...
aromaticum L. Essential Oils: Evidence for Humor-and Cell-mediated Responses. Journal of Pharmacy and Pharmacology 61:961-67.

Chaachouay N, Benkhnigue O, Fadli M, El Ibaoui H, Zidane L. 2019. Ethnobotanical and Ethnopharmacological Studies of Medicinal and Aromatic Plants Used in the Treatment of Metabolic Diseases in the Moroccan Rif. Heliyon 5: e02191.

Cherkaoui TE, Medina F, Mridedk A. 2017. Re-Examination of the Historical 11 May, 1624 Fez Earthquake Parameters. Fisica de la Tierra 29:135-57.

Choi YY, Kim MH, Lee H, Jo SY, Yang WM. 2018. (R)-(+) pulegone suppresses allergic and inflammation responses on 2, 4-dinitrochlorobenzene-induced atopic dermatitis in mice model. Journal of Dermatological Science 91: 292-300.

Climatological Information for Fez, Morocco. 2011. Hong Kong Observatory. http://www.weather.gov.hk/wxinfo/climat/world/eng/africa/mor_al/Fes_e.htm.

Conti BJ, Bušćo MC, Golim MDA, Bankova V, Storcin JM. 2013. Cinnamic acid is partially involved in propolisimmunomodulatory action on human monocytes. Evidence-Based Complementary and Alternative Medicine, 2013.

Cortés-Rojas DF, De Souza CRF, Oliveira WP. 2014. Clove (Syzygium Aromaticum): A Precious Spice. Asian Pacific Journal of Tropical Biomedicine 4:90-96.

El alami A, 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 2:1-2.

El-Boshy ME, Refaat B, Qasem AH, Khan A, Ghaith M, Almasmoum H, Mahbub A, Almaimani RA. 2019. The Remedial Effect of Thymus Vulgaris Extract against Lead Toxicity-Induced Oxidative Stress, Hepatorenal Damage, Immunosuppression, and Hematological Disorders in Rats. Environmental Science and Pollution Research 26:22736-46.

El Hachlafi N, Chebat A, Soulaymani Bencheikh R, Fikri-Benbrahim K. 2020. Ethnopharmacological Study of Medicinal Plants Used for Chronic Diseases Treatment in Rabat-Sale-Kenitra Region (Morocco). Ethnobotany Research and Applications 20:1-23.

Fennane M, Ibn Tattou M, Mathez J. 1999. Flore Pratique Du Maroc: Manuel de Détermination Des Plantes Vasculaires. Pteridophyta, Gymnospermae, Angiospermae (Lauraceae-Neuradaceae). Institut scientifique, Rabat, Maroc.

Flechas MC, Ocazionez RE, Stashenko EE. 2018. Evaluation of in vitro antiviral activity of essential oil compounds against dengue virus. Pharmacognosy Journal 10.

Flouchi R, Fikri-Benbrahim K. 2020. Prevention of COVID-19 by Aromatic and Medicinal Plants: A Systematic Review. Journal of Pharmaceutical Sciences and Research 12:1106-11.

Gholamrezaie SL, Mohammadi M, Jalali SJ, Abolghasemi SA, Roostaei AM. 2013. Extract and Leaf Powder Effect of Artemisia Annua on Performance, Cellular and Humoral Immunity in Broilers. International Journal of Virtual Reality 15:20.

Goyal M, Kaur H, Bhandari M, Rizvanov AA, Khaiboullina SF, Baranwal M. 2018. Antioxidant and Immune Effects of Water Soluble Polysaccharides Isolated from Cinnamomum Verum Bark. Bio Nano Science 8:935-40.

Güner HR, Hasanoglu I, Aktaş F. 2020. COVID-19: Prevention and Control Measures in Community. Turkish Journal of Medical Sciences 50:571-77.

Hamsas El Youbi AE, Ouahidi I, EL Mansouri L, Daoudi A, Bousta D. 2016. Ethnopharmacological Survey of Plants Used for Immunological Diseases in Four Regions of Morocco. European Journal of Medicinal Plants 1-24.

Haouari E, Makou SE, Jnah M, Haddaouy A. 2018. A Survey of Medicinal Plants Used by Herbalists in Taza (Northern Morocco) to Manage Various Ailments. Journal of Materials and Environmental Science 9:1875-88.

Harouak H, Falaki K, Bouiamrine EH, Oudija F, Ibibijen J, Nassiri L. 2018. Ethnobotanical Survey of Plants Used in Treatment of Oral Diseases in the City of MeknesMorocco. International Journal of Herbal Medicine 6:46-49.

Hmamouchi M. 1999. Les Plantes Médicinales et Aromatiques Marocaines. Imprimerie de Fédala, Mohammedia, Maroc.

Holmes KV. 2003. SARS Coronavirus: A New Challenge for Prevention and Therapy. The Journal of Clinical Investigation 111:1605-9.

Hou L, Huang H. 2016. Immune Suppressive Properties of Artemisinin Family Drugs. Pharmacology & Therapeutics 166:123-27.

Jaradat NA, Zaid AN, Al-Ramahi R, Alqub MA, Hussein F, Hamdan Z, Mustafa M, Qneibi M, Ali I. 2017. Ethnopharmacological Survey of Medicinal Plants Practiced by Traditional Healers and
Herbalists for Treatment of Some Urological Diseases in the West Bank/Palestine. BMC Complementary and Alternative Medicine 17:255.

Javed H, Meeran MFN, Jha NK, Ojha S. 2021. Carvacrol, a Plant Metabolite Targeting Viral Protease (Mpro) and ACE2 in Host Cells Can be a Possible Candidate for COVID-19. Frontiers in Plant Science 11:601335.

Jouad H, Haloui M, Rhiouani H, El Hilaly J, Eddouks M. 2001. Ethnobotanical Survey of Medicinal Plants Used for the Treatment of Diabetes, Cardiac and Renal Diseases in the North Centre Region of Morocco (Fez-Boulemane). Journal of Ethnopharmacology 77:175-82.

Juergens LJ, Worth H, Juergens UR. 2020. New perspectives for mucolytic, anti-inflammatory and adjutant therapy with 1, 8-cineole in COPD and asthma: review on the new therapeutic approach. Advances in Therapy 37:1737-1753.

Karamoddini MK, Emami SA, Ghannad MS, Sani EA, Sahebkar A. 2011. Antiviral Activities of Aerial Subsets of Artemisia Species against Herpes Simplex Virus Type 1 (HSV1) in Vitro. Asian Biomedicine 5:63-68.

Kuete V. 2017. Thymus Vulgaris. In Medicinal Spices and Vegetables from Africa 599-609.

Lai CS, Lee JH, Ho CT, Liu CB, Wang JM, Wang YJ, Pan MH. 2009. Rosmanol potently inhibits lipopolysaccharide-induced iNOS and COX-2 expression through downregulating MAPK, NF-κB, STAT3 and C/EBP signaling pathways. Journal of Agricultural and Food Chemistry 57:10990-10998.

Li X, Zhao L, Han JJ, Zhang F, Liu S, Zhu L, Wang ZZ, Zhang GX, Zhang Y. 2018. Carnosol modulates Th17 cell differentiation and microglial switch in experimental autoimmune encephalomyelitis. Frontiers in Immunology 9:1807.

Luo C, Zou L, Sun H, Peng J, Gao C, Bao L, Ji R, Jin Y, Sun S. 2020. A review of the anti-inflammatory effects of rosmarinic acid on inflammatory diseases. Frontiers in Pharmacology 11:153.

Mahdavi S, Mehrmannavaz Y, Nobakht A, Zakeri A. 2013. The Effects of Different Amounts of Mentha Pulegium L. on Immune System Performance of Broiler Chickens. International Research Journal of Applied and Basic Sciences 4: 381-84.

Mahwasane ST, Middleton L, Boaduo N. 2013. An Ethnobotanical Survey of Indigenous Knowledge on Medicinal Plants Used by the Traditional Healers of the Lwamondo Area, Limpopo Province, South Africa. South African Journal of Botany 88: 69-75.

Marchese A, Arciola CR, Barbieri R, Silva AS, Nabavi SF, Tsetegho Sokeng AJ, Izadi M, Jafari NJ, Suntar I, Daglia M, Nabavi SM. 2017. Update on monoterpenes as antimicrobial agents: A particular focus on p-cymene. Materials 10:947.

Mikou K, Rachiq S, Oulidi AJ. 2016. Étude Ethnobotanique Des Plantes Médicinales et Aromatiques Utilisées Dans La Ville de Fès Au Maroc. Phytothérapie 14:35-43.

Milanović ŽB, Antonijević MR, Amić AD, Avdović EH, Dimić DS, Milenković DA, Marković ZS. 2021. Inhibitory activity of quercetin, its metabolite, and standard antiviral drugs towards enzymes essential for SARS-CoV-2: the role of acid-base equilibria. RSC Advances 11:2838-2847.

Ministère de la Santé. 2021. Le Portail Officiel Du Coronavirus - Au Maroc. http://www.covidmaroc.ma/pages/Accueilfr.aspx.

Monticolo F, Palomba E, De Santis R, Assentato L, Triscino V, Langella MC, Lanzotti V, Chiusano ML. 2020. Anti-HCoV: A Web Resource to Collect Natural Compounds against Human Coronavirus. Trends in Food Science & Technology.

Morocco (IFMSA-Morocco) - Fez. n.d. Accessed January 15, 2021. https://exchange.ifmsa.org/exchange/explore/lc/355397.

Najem M, Harouak H, Ibibijen J, Nassiri L. 2020. Oral Disorders and Ethnobotanical Treatments: A Field Study in the Central Middle Atlas (Morocco). Helinyon 6: e04707.

Oladele JO, Ajayi EI, Oyeleke OM, Oladele OT, Olowokere BD, Adeniyi BM, Oywole OL, Oladiji AT. 2020. A Systematic Review on COVID-19 Pandemic with Special Emphasis on Curative Potentials of Nigeria Based Medicinal Plants. Helinyon e04897.

Parsania M, Rezaee MB, Monavari SH, Jaimand K, Mousavi-Jazayeri SM, Razazian M, Nadjarha MH. 2017. Antiviral Screening of Four Plant Extracts against Acyclovir Resistant Herpes Simplex Virus Type-1. Pakistan Journal of Pharmaceutical Sciences 30:1407-11.

Platto S, Xue T, Carafoli E. 2020. COVID-19: An Announced Pandemic. Cell Death & Disease 11: 1-13.

Pramod K, Ansari SH, Ali J. 2010. Eugenol: a natural compound with versatile pharmacological actions. Natural product communications 5(12):1934578X1000501236.
Roth-Walter F, Moskovskich A, Gomez-Casado C, Diaz-Perales A, Oida K, Singer J, Kinaciyam T, Fuchs HC, Jensen-Jarolim E. 2014. Immune suppressive effect of cinnamaldehyde due to inhibition of proliferation and induction of apoptosis in immune cells: implications in cancer. PloS one 9 e108402.

Salehi B, Sharifi-Rad J, Quispe C, Llaique H, Villalobos M, Smeriglio A, Trombetta D, Ezzat SM, Salem MA, Zayed A. 2019. Insights into Eucalyptus Genus Chemical Constituents, Biological Activities and Health-Promoting Effects. Trends in Food Science & Technology 91 609-24.

Sbai-Jouilil H, Fadli A, El Hafian M, El Ayad R, Benharbit O, Zidane L. 2017. Floristic and Ethnobotanical Study of Medicinal Plants Used in the Treatment of Respiratory Diseases in Seksoua Region (Western High Moroccan Atlas). Annual Research & Review in Biology 11:10.

Shao J, Yin Z, Wang Y, Yang Y, Tang Q, Zhang M, Jiao J, Liu C, Yang M, Zhen L. 2020.Effects of Different Doses of Eucalyptus Oil from Eucalyptus globulus Labill on Respiratory Tract Immunity and Immune Function in Healthy Rats. Frontiers in Pharmacology 11:1287.

Shin HB, Choi MS, Ryu B, Lee NR, Kim HI, Choi HE, Chang J, Lee KT, Jang DS, Inn KS. 2013. Antiviral Activity of Carnosic Acid against Respiratory Syncytial Virus. Virology Journal 10:1-11.

Sijelmassi A. 1993. Medicinal Plants of Morocco. Le Fennec, Casablanca, Morocco.

Singh N, Rao AS, Nandan A, Kumar S, Yadav SS, Ganaie SA, Narasimhan B. 2020. Phytochemical and Pharmacological Review of Cinnamomum Verum J. Presl-a Versatile Spice Used in Food and Nutrition. Food Chemistry 338:127773.

Sreekeesoon DP, Mahomoodally MF. 2014. Ethnopharmacological Analysis of Medicinal Plants and Animals Used in the Treatment and Management of Pain in Mauritius. Journal of Ethnopharmacology 157:181-200.

Strathern M. 2002. An Anthropological Comment. Virtual Society?: Technology, Cyberbole, Reality 302.

Trotter RT, Logan MH. 1986. Informant Consensus: A New Approach for Identifying Potentially Effective Medicinal Plants.Plants in Indigenous Medicine & Diet. Edited by Nina L. Etkin. New York, United States, Pp.22.

United Nations Educational, Scientific and Cultural Organization (UNESCO). n.d. Medina of Fez - UNESCO World Heritage Centre. Accessed January 9, 2021. https://whc.unesco.org/en/list/170.

United Nations Industrial Development Organization (UNIDO). 2020. Coronavirus: The Economic Impact - 10 July 2020. https://www.unido.org/stories/coronavirus-economic-impact-10-july-2020.

Valdés B. 2002. Checklist of Vascular Plants of N Morocco with Identification Keys. Consejo Superior de Investigaciones Científicas. Spain.

Wang X, Zheng B, Ashraf U, Zhang H, Cao C, Li Q, Chen Z, Imran M, Chen H, Cao S, Ye J. 2020. Artemisinin inhibits the replication of flaviviruses by promoting the type I interferon production. Antiviral research 179:104810.

Wani AR, Yadav K, Khursheed A, Rather MA. 2020. An Updated and Comprehensive Review of the Antiviral Potential of Essential Oils and Their Chemical Constituents with Special Focus on Their Mechanism of Action against Various Influenza and Coronaviruses. Microbial Pathogenesis 104620.

World Health Organization (WHO). 2020. Novel Coronavirus (2019-nCoV): Situation Report. World Health Organization.

World Health Organization (WHO). 2021a. WHO Coronavirus Disease (COVID-19) Dashboard I WHO Coronavirus Disease (COVID-19) Dashboard. https://covid19.who.int/.

World Health Organization (WHO). 2021b. Morocco. https://www.who.int/countries/mar/.

Wu W, Li R, Li X, He J, Jiang S, Liu S, Yang J. 2016. Quercetin as an antiviral agent inhibits influenza A virus (IAV) entry. Viruses 8:6.

Ye Y, Lagniton PNP, Ye S, Li E, Xu RH. 2020. COVID-19: What Has Been Learned and to Be Learned about the Novel Coronavirus Disease. International Journal of Biological Sciences 16:1753.