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Medicinal plants used for the prevention purposes during the covid-19 pandemic in Morocco

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ABSTRACT
COVID-19 was first reported in late 2019 in Wuhan, China, and has since spread extensively in worldwide. The World Health Organization recognized this disease as a pandemic on 11 March 2020. During this pandemic, Moroccan population used several medicinal plants for the prevention purposes. The current work focuses on the study of the most medicinal plants used during this pandemic in Morocco. In early March 2020, preliminary information was obtained through interviews with herbalists. In response to the progression of the Covid-19 epidemic, Moroccan's state of health emergency came into effect 20 March 2020. For this reason, survey data was collected with a Google Form. The participants were selected because of their knowledge of the use of medicinal plants. During this study, we identified a total of 23 medicinal plant species belonging to 11 botanical families used during the Covid-19 pandemic. The most important families were that of the Lamiaceae, Cupressaceae and Zingiberaceae. The most used plants were *Allium Sativum, Olea europaea, Allium cepa, Zingiber officinale, Thymus maroccanus, Eucalyptus globules, Foeniculum vulgare, Curcuma xanthorrhiza, Phoenix dactylifera, Rosmarinus officinalis, Thymus satureioides, Mentha pulegium and Pimpinella anisum.* Information on the biological effects and on the most abundant secondary metabolites in the 23 plants was given. According to several studies the majority of these plants are used to treat many respiratory diseases causing symptoms and signs similar to coronavirus symptoms. These plants have innumerable benefits because of the diversity of the secondary metabolites which they contain. The majority of these compounds, especially essential oils, are well known for their positive biological effects on respiratory functions. But some plants may contain toxic substances which can cause various overdose intoxications and disorders.

1. Introduction:

Morocco has one of the oldest and richest traditions on herbal medicine and local people possess invaluable knowledge of medicinal plants. The researchers counted more than 600 plants used in herbal medicine in this North African country **[1]**. In addition, more than 60 plants are commonly used to treat and prevent respiratory diseases **[1-7]**. The Coronavirus disease (COVID-19) is caused by the coronavirus 2 (SARS-CoV-2). The outbreak was identified in Wuhan, China, on 1 December

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2019 **[8]**. The World Health Organization recognized this disease as a pandemic on 11 March 2020. Today, 27 May 2020 (08:00 CEST), the World Health Organization reported 5 459 061 confirmed cases in 216 countries, areas or territories, resulting 346 232 confirmed deaths **[9]**. In this date, Morocco has confirmed 7 577 cases of the virus, including 202 deaths and 4 881 recoveries. This pandemic has caused severe global socioeconomic disruption. The main modes of the transmission of this disease are the small droplets produced during coughing, sneezing, or talking. At present, the virus has no vaccine and therefore humans must prevent this pandemic either by hygienic measures or by strengthening the immune system. Clinical characteristics of COVID-19 patients have similar characteristics of influenza virus **[10]**.

During the COVID-19 pandemic, the Moroccan population used traditional herbal medicines to prevent this disease. Although we have no facts about the biological effects on the coronavirus, these plants have innumerable benefits because of the diversity of the secondary metabolites which they contain. These plants are rich in bioactive substances. The majority of these compounds, especially essential oils, are well known for their positive biological effects on respiratory and circulatory functions. The current work focuses on the study of medicinal plants used for the prevention purposes during the Covid-19 in Morocco.

2. Material and methods:

This study on medicinal plants used for the prevention purposes during the Covid-19 was conducted in March-May 2020 in Morocco. In early March 2020, preliminary information was obtained through interviews with six herbalists living in the region of Béni Mellal-Khénifra. The Mountain ecosystems of this region have a rich and varied biological diversity. In addition, this region is a rich source of medicinal plants. This richness and diversity of medicinal flora is accompanied by the acquisition of important knowledge on the treatment of diseases by plants. We asked the herbalists about the used part of each plant and the preparation and use methods. According to information from herbalists, we identified 15 plants frequently used during this pandemic.

In response to the progression of the Covid-19 epidemic, Moroccan's state of health emergency came into effect 20 March 2020. For this reason, survey data was collected with a Google Form. The participants were selected because of their knowledge of the use of medicinal plants. We already conducted surveys with some people among them during several previous studies **[7,11-12]** and we have their contact details, including phone number and/or Email. About 100 people were invited to participle in this survey, out of which 55 filled the form. Respondents consist of 59.2% men and 40.2% women. Adults between the ages of 30 and 44 *years* old are over-represented in this survey sample (65.3%), while young adults ages 18-29 *years* old and adults ages 45-59 *years* old are represented, respectively, by 12.2% and 22.4%. A total of 40 percent of the survey respondents live in the region of Casablanca-Settat, 37.8% in Beni Mellal-Khénifra, 11.1% in Marrakech-Safi, 4.4% in Rabat-Salé-Kénitra, 2.2% in Darâa-Tafilalet, Souss-Massa and in Laâyoune- Sakia El Hamra. We have invited respondents to fill the questionnaire in Google form by sending them its link. We asked *Yes*/*No questions* about the use the 15 medicinal plants identified from the interviews with herbalists. In each question, we show a colour picture, scientific and common names of each plant. At the end of the questionnaire, we asked the respondents to give the names of the other plants used during this pandemic. Questions were administered in the Arabic and English languages.

3. Discussion:

During this study, we identified a total of 23 medicinal plant species belonging to 11 botanical families used during the Covid-19. The most important family is that of the Lamiaceae represented by seven species (*Thymus maroccanus*, *Thymus satureioides*, *Mentha suaveolens*, *Mentha suaveolens*, *Rosmarinus officinalis*, *Lavandula dentate* and *Lavandula dentate*), followed by the family of Cupressaceae with three species (*Tetraclinis articulate*, *Juniperus phoenicea* and *Juniperus oxycedrus*) and the family of Zingiberaceae (*Zingiber officinale*, *Alpinia officinarum* and *Curcuma xanthorrhiza*). The family of Apiaceae is represented by two species (*Pimpinella anisum* and *Foeniculum vulgare*) and the family of Liliaceae is represented by *Allium cepa* and *Allium Sativum*. The other six families are only represented by a single species (Asteraceae: *Artemisia herba-alba*; Myrtaceae: *Eucalyptus globules*; Ranunculaceae: *Nigella sativa;* Oleaceae: *Olea europaea*; Arecaceae: *Phoenix dactylifera*; Brassicaceae: *Lepidium sativum*). The scientific and common names, systematic, used part, toxicity and the preparation and use modes of the 23 plants were detailed in previous studies **[7,13]**. Based on the information from interviews with herbalists and from previous studies on medicinal plants in Morocco **[3-5,14,15]**, we noted that the preparation and the use modes of plants are nearly the same for every plant in different Moroccan regions. This confirms that knowledge of medicinal plants has been perfected through experimentation and exchange of information between the Moroccan populations. In general, the infusion or decoction of areal parts of the Lamiaceae and Asteraceae species, the infusion of seeds of the Apiaceae species, the decoction of *Zingiber officinale* and *Alpinia officinarum* rhizomes, and the powder obtained by drying young twigs of the Cupressaceae species are given orally. The bulb of the Liliaceae species, fruits of *Phoenix dactylifera*, seeds of *Lepidium sativum* and of *Nigella sativa*, the rhizome powder of *Curcuma xanthorrhiza* and the oil of *Olea europaea* are taken also orally. Hot infusion of *Eucalyptus globulus* is used for inhalation.

The use frequencies of the main medicinal plants (use frequency > 10%) used during the Covid-19 are shown in the Figure 1. The most used plants (use frequency > 40%) were *Allium Sativum* (80.9%), *Olea europaea* (72.7%), *Allium cepa* (66.7%), *Zingiber officinale* (66%), *Thymus maroccanus* (59.2%), *Eucalyptus globules* (56.5%), *Foeniculum vulgare* (54.3%), *Curcuma xanthorrhiza* (50%), *Phoenix dactylifera* (50%), *Rosmarinus officinalis* (47.9%), *Thymus satureioides* (41.9%), *Mentha pulegium* (41.3%) and *Pimpinella anisum* (40%).

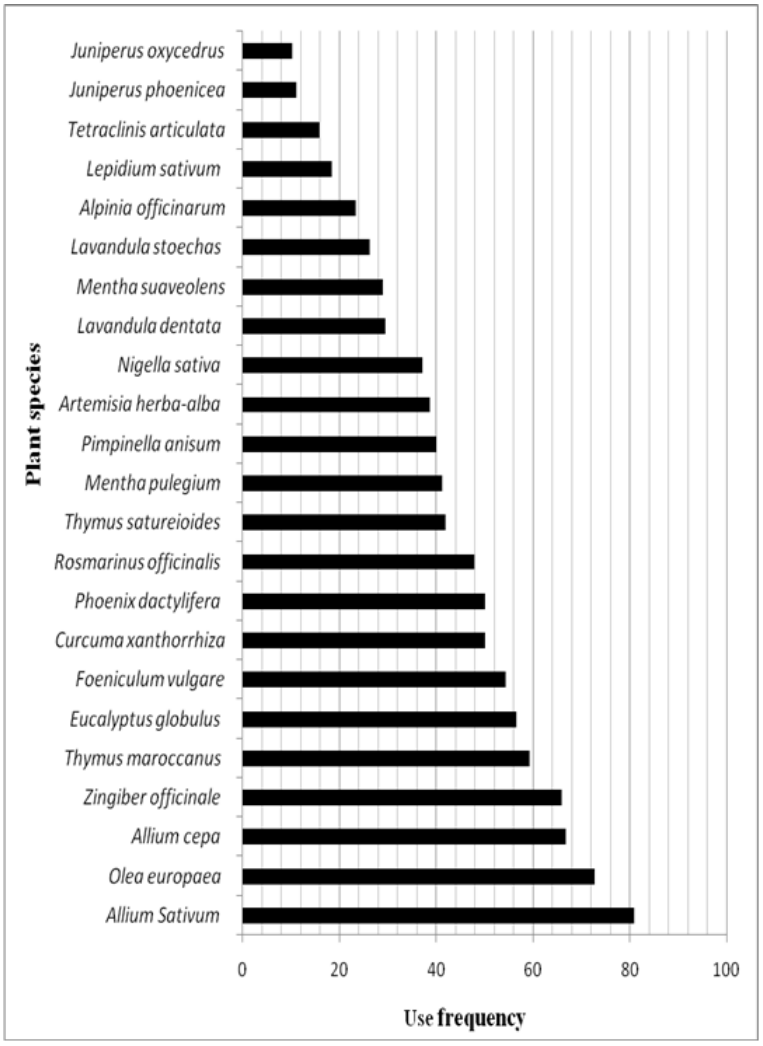

Figure 1. Use frequencies of the main medicinal plants used for the prevention purposes during the Covid-19 pandemic in Morocco.

The use frequencies of the other plants ranged between 10.3% and 38.6% (Figure 1). Although we have no facts about the biological effects of the medicinal plants on the coronavirus, these plants have innumerable benefits because of the diversity of the secondary metabolites which they contain. These plants are frequently used by Moroccans to treat a wide variety of diseases, including respiratory disorders such as lung, throat and respiratory tract cancers, allergies, asthma, sleep apnea, bronchitis, bronchiolitis, rhinitis, pneumonia, flu, colds, sinusitis, laryngitis and pharyngitis. According to several studies the majority of these plants are used to treat many respiratory diseases causing symptoms and signs similar to coronavirus symptoms **[2-7,14,15]**. These plants contain many active compounds responsible for various biological effects. The majority of these compounds, especially essential oils, are well known for their positive biological effects on respiratory and circulatory functions.

Information on the biological effects and on the most abundant secondary metabolites in the major plants used for the prevention purposes during the Covid-19 pandemic were given in the table 1. The majority of these plants play an important role in nutrition and human health. They are rich in sugars, vitamins, minerals, fatty acids, amino acids, enzymes, etc. These plants contain a wide variety of bioactive compounds including essential oils, flavonoids, organosulfur compounds, glycosides, secoiridoid, tannin, mucus, lignans, coumarins, alkaloids, aromatic constituents, phenolic lipids, carotenoids, steroids and many other compounds (Table 1). The medicinal plants of this mixture include also a very large number of essential oils including α-Pinene, Thymol, Eucalyptol, β-Pinene, γ-Terpinene, Sabinene, trans-Anethole, Caryophyllene,

Limonene, Linalool, Myrcene, Disulfide, Trisulfide, Gingerol, Myrcene, Camphor, Camphene, Carvacrol, Myrtenol, Verbenone, etc. (Table1). This variety of bioactive compounds is responsible for many biological effects such as antiinflammatory, antifungal, antiviral, antibacterial, antioxidant, antiseptic, antitumor, anticancer, antiallergic, antiatherogenic and analgesic activities (Table 1).

But these plants may contain toxic substances which can cause various overdose intoxications and disorders. The majority of medicinal plants used for prevention purposes during the Covid-19 pandemic may contain toxic substances such as phenols, colchicine, carvone, anisatin, neoanisatin, anethole, sesquiterpene lactones, cyanogenic glycosides, myristicin, safrole, Coumarin, Cinnamaldehyde, Elemicine and Nigelline which in overdose can cause a wide variety of disorders and intoxications **[14-20]**.

Table 1. The most abundant secondary metabolites including essential oils and the main biological activities of medicinal plants used for the prevention purposes during the Covid-19 pandemic in Morocco.

Scientific names	Bioactive compounds; Essential oils	Biological activities
Allium Sativum	Flavonoids, organosulfur compounds and saponins **[21]** ; essential oils with the major compounds are diallyl-Trisulfide and diallyl-Disulfide **[22]**.	Rich in nutrients that can contribute to the protection and preservation of human health and it has antioxidant, antibacterial, antiinflammatory and anticancer activities **[21].**
Olea europaea	Glycosides, secoiridoid, flavonoids and poly-unsaturated fatty acids **[23]**; several biophenolic compounds **[24]**.	Many interesting biological properties **[24]**; antioxidant, antiviral, antimicrobial, anti-diabetic and cardioprotective effects **[23].**
Allium cepa	Flavonoids, organosulfur compounds and saponins **[21]**; over twenty compounds were identified in its essential oils **[22]**.	Antioxidant, antibacterial, antiinflammatory, antiproliferative and anticancer activities **[21,25]**.
Zingiber officinale	Paradols, Dihydroparadols, Gingerols, Gingerdiols, acetyl derivatives of Gingerols, Shogaols, 3-Dihydroshogaols, mono- and diacetyl derivatives of Gingerdiols, 1-Dehydrogingerdiones, Diarylheptanoids, and Methyl ether derivatives of some of these compounds **[26,27]**.	Antiinflammatory and antimicrobial properties [26]; antidiabetic, antioxidant, anti-inflammatory, hepatoprotective, antimicrobial, hypocholesterolemic, hypolipidemic and anticancer effects **[27]**.
Thymus maroccanus	Carvacrol, p-Cymene, α-Pinene, γ-Terpinene, β-Caryophyllene, Limonene, Linalool and Myrcene **[28]**; Tricyclene , α-Thujene, α-Pinene, Camphene,, Myrcene, α-Phellandrene, α-Terpinene, p-Cymene, Limonene, γ-Terpinene, cis-Sabinen hydrate, Linalool, Borneol Terpinen-4-ol **[29]**	Antimicrobial activity, antioxidant, antimicrobial activities **[28,29]**.
Eucalyptus globulus	Eucalyptol, α-Pinene, α-Terpineol acetate, Alloaromadendrene, β-Pinene, Sabinene, Limonene, Isoledene, α-Gurjunene, Aromadendrene **[30]**.	Antimicrobial, antifungal, antiviral, antiinflammatory, antinociceptive, analgesic, antioxidant and antidiabetic activities **[31]**.
Foeniculum vulgare	Saponins, flavonoids, cardiac glycosides, sterols, triterpenes, coumarins, proteins, volatile oils, trace elements and vitamins **[32]**; The dominant constituent in essential oils is trans-Anethole **[33]**; it contains also Limonene, Fenchone, Methyl chavicol, Myrcene and α-Pinene **[34]**.	Reproductive, urinary, antidiabetic, antioxidant, anticancer, antimicrobial, cardiovascular, immunological, dermatological and many other pharmacological effects **[32]**.
Curcuma zanthorrhiza	Xanthorrhizol, α -Curcumene, Germacrone, Curcumin and Zederone **[35]**.	Antioxidant, antimicrobial, antiviral, antiinflammatory, anticancerous, antiproliferative, hypocholesterolemic, antidiabetic, antihepatotoxic, antidiarrheal, hypotensive activities **[35]**.
Phoenix dactylifera	Polyphenols compounds including phenolic acids, flavonoids, lignans, and carotenoids **[36]**.	Antioxidant, antiinflammatory and antitumor activities and it provide alternative therapy in various diseases **[37]**.
Rosmarinus officinalis	Cineole, Camphor, α-Pinene, Camphene, β-Pineno, Borneol, Bornyl acetate, Caryophyllene **[38,39]**.	Antioxidant activity, inhibition of mucosal injury and gastric ulcer **[38,39]**.
Thymus satureioides	Borneol and Thymol **[40,41]**.	Antibacterial and antioxidant activities **[40,41]**.
Mentha pulegium	Pulegone, Piperitone, p-Menthane-1,2,3-triol, Elemenene, Guaiene, Carvacrol acetate and Phenyl ethyl alcohol **[42]**.	Antioxidant and antimicrobial effects **[42]**.
Pimpinella anisum	The dominant constituent in its essential oils is trans-Anethole **[33]**, it contain also many other constituents such as cis-Dihydrocarvone, Methyl chavicol, *α*-Himachalene, γ-Himachalene, β-Himachalene and trans-Pseudoisoeugenyl 2-Methylbutyrate **[34]**.	Antimicrobial, antifungal and antioxidant effects **[33,34]**.

Artemisia herba-alba	Sesquiterpene lactones, flavonoids, phenolic compounds and waxes; essential oils with the major compounds are α-and ß-Thujones, Camphor, Sabinyl acetate, Germacrene D, α-Eudesmol, Caryophyllene acetate, 1,8-Cineole, p-Cymene, Davanone, Camphene, Borneol, Davana ether and Chrysanthenone **[43]**.	Antihelminthic, antimalaria, antioxidant; Anti-venom, nematicidal, antibacterial, antispasmodic, antileishmanial, hypoglycaemic and cytotoxicity activities **[43]**.
Nigella sativa	Caryophyllene, Thymoquinone, 1,4-Cyclohexadiene, Longifolene and Carvacrol **[44]**.	Physicochemical properties, antioxidant activity and thermal behaviour **[44]**.
Lavandula dentata	Polyphenols and flavonoid **[45]**; essential oils with the major compounds are Eucalyptol, Fenchone, Linalool, Mirtenol, Citronelol, Camphor, Sabinene, ß-Caryophyllene, α –bisabolene, α -selinene, ß-Caryophyllene oxide and p-Cymene **[46]**.	Antimicrobial, antioxidant and radical scavenging activities **[45]**; antibacterial, antimicrobial, antispasmodic antifungal and antioxidant activities **[47]**.
Mentha suaveolens	Piperitenone oxyde, trans-Caryophyllene, Germacrene D, terpinen-4-ol, Nepetalactone, p-Cymen-8-ol and E-hydrate Sabinene **[48]**.	Cytotoxic, antimicrobial, antioxidant, antiinflammatory, hypotensive, hepatoprotective and antifungal activities **[49]**.
Lavandula stoechas	Linalool, Linalyl acetate , Lavandulyl acetate, α -Terpineol, Terpinene-4-ol , Lavandulol , ß-Ocimene **[50]**.	Antifungal effect **[50]**; antibacterial, antimicrobial and cytotoxic activities **[51]**.
Alpinia officinarum	Eucalyptol, α-Terpineol, γ-Muurolene, α-Farnesene, Caryophyllene, α-Bergamotene and γ-Gurjunene **[52]**.	Antioxidant and antimicrobial activities **[52]**.
Lepidium sativum	Glucotropaeoline, Sinapine, Kaempferol di-hexose rhamnose, Sinapoyl di-glucose, Quercetin di-hexose rhamnose, Sinapoyl malate, and many other substances **[53]**.	Antioxidant, antibacterial, antimicrobial, antifungal, anticancer and antiinflammatory effects **[54]**.
Tetraclinis articulata	Bornyl acetate, Camphor, a-Pinene, Tricyclene, Limonene, Camphene hydrate, Myrtenol, Verbenone, Carvone, ... **[55]**.	Antioxidant and antiinflammatory activities **[56]**.
Juniperus phoenicea	α-Pinene, 3-Carene, Myrcene, Fenchone, Camphene, E-β-Caryophelene, Germacrene D, β-Cadinene, β-Pinene, Limonene, Terpinolene **[57,58]**.	Antioxidant activity [56]; hepatoprotective activity **[59]**.
Juniperus oxycedrus	α-Pinene, Limonene, α-Phellandrene, 14-hyd rox y-9-epi -E-Caryophyllene and Germacrene D **[58]**.	High antioxydant potential **[56]**; keratolytics, antipruritics and antimicrobial activities *in vitro* **[60]**; antinociceptives and antiinflammatory effects **[61]**.

4. Conclusion:

Medicinal plants have been used by the Moroccan population from ancient times and they have an important role in traditional healing practices. Today herbal medicine is practiced in all parts of Morocco and it is still the primary healthcare system for a large fraction of the population, especially in rural communities. During this study, we identified a total of 23 medicinal plant species belonging to 11 botanical families used during the pandemic of Covid-19. The results of this survey and the information collected on the most abundant secondary metabolites in the major plants used for prevention purposes during this pandemic confirm that these plants contain bioactive substances that are known in modern medicine for their biological activities. Although we have no facts about the biological effects on coronavirus, these plants have innumerable benefits because of the diversity of the secondary metabolites which they contain. These plants are rich in bioactive substances. The majority of these compounds, especially essential oils, are well known for their positive biological effects on respiratory and circulatory functions. Medicinal plant knowledge is generally transmitted orally through a population. This knowledge has been perfected through experimentation and exchange of information on medicinal plants with other populations. This will help to keep the local people's knowledge of the traditional medicine practices which is disappearing. This work can also be exploited in scientific researches in the field of pharmacology, phytochemistry and biochemistry.

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