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Research paper

COVID-19, prevention and treatment with herbal medicine in the herbal markets of Salé Prefecture, North-Western Morocco

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ARTICLE INFO

Keywords:

COVID-19

Herbal medicine

Herbalists

Medicinal plants

Ethnopharmacology

Survey

ABSTRACT

Introduction: Coronaviruses are important animal and human pathogens. Towards the end of 2019, the novel coronavirus identified in Wuhan, China, presented as a cluster of symptoms of pneumonia. Its quick spread resulted in a global pandemic. This research documents detailed ethnopharmacological information on the medicinal plant species used by herbalists against coronavirus disease.

Methods: The study was conducted in Salé Prefecture, from March 1st, 2020 to May 31st, 2020. Semi-structured face to face interviews were held with 30 herbalists and collected; socio-demographic characteristics, the names of local species, and traditional remedies being used. The data were analyzed through the use reports (UR) and medicinal use value (MUV).

Results: In total, 20 plant species from 20 genera and 14 families had been most frequently used by herbalists from Salé Prefecture for the prevention and treatment of COVID 19. The most mentioned plant was *Eucalyptus globulus* Labill., followed by *Azadirachta indica* A. Juss., and *Ziziphus lotus* (L.) Lam. Moreover, the most commonly used plant parts for herbal preparations were leaves (28.43%) and seeds (17.5%), and the majority of remedies were prepared through infusion.

Conclusions: The present study is the first contribution to the ethnopharmacological profile of this Prefecture. It is recommended that the constituents of indigenous species be studied to determine the therapeutic effects and mechanisms of action. However, attention must be paid to the conservation of medicinal species, comprehensively documenting traditional medicinal knowledge as well as conducting phytochemical validation of reported plants.

1. Introduction

Coronavirus (CoVs), a class of single-stranded RNA viruses, can affect both animals and humans, causing respiratory, gastrointestinal, hepatic, and neurologic diseases [1]. The first case of the novel coronavirus was reported on December 30, 2019, in the city of Wuhan, Hubei province, P.R. China [2].

This causative virus was temporarily named as severe acute respiratory syndrome coronavirus 2 and the resulting disease was named coronavirus disease 2019 (COVID-19) by the World Health Organization [3]. On March 11th, the WHO formally announced that COVID-19 was a pandemic. COVID-19 was confirmed to have reached Morocco on March 2th 2020, when the first COVID-19 case confirmed in Casablanca was a Moroccan immigrant who came from Italy on February 27th, 2020.

Since the very beginning of human civilization, plants have been an essential supply for prevention and healing for humans and livestock, especially in developing countries. This is illustrated by the following

quote from Hippocrates, which dates from the 4th century BC: “nature is the medicine of the sick”. Accordingly, the research on plant species and their use is one of the most fundamental human interests and has been widespread all over the world [4,5].

Developing countries have a penchant for traditional medicine, due to the limitation of medical personnel and provisions and access to fundamental medicine. The ratio of medical doctors to patients in Morocco is poor. For example, according to the latest available information, the numbers of doctors in Morocco is 0.5% per 1 000 inhabitants and hospital beds 1.0% beds per 1 000 inhabitants [6].

It is why people have used diverse medicinal plants as alternatives which originated from ancient popular medicine. Medicinal plants continue to be used in cities and rural communities in Morocco as part of healthcare, because of their low cost and the easy access to plant products in all markets across the country [7].

Morocco is one of the nations of the Mediterranean area with diverse climatic conditions that are favorable for the development of rich and

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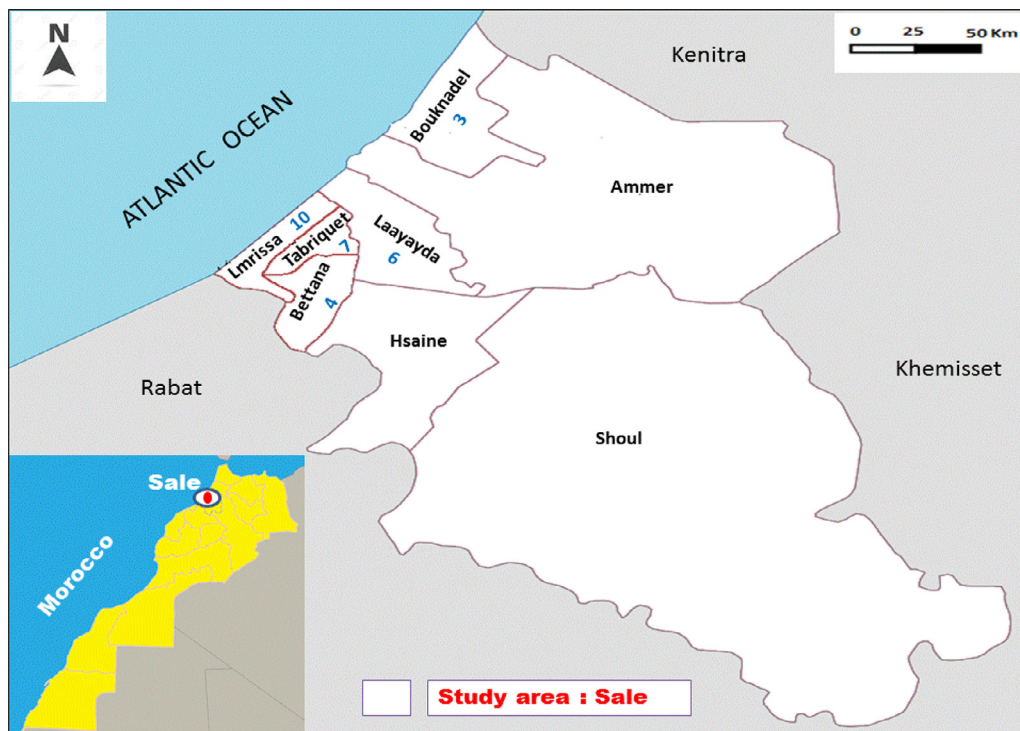


Fig. 1. Geographical Location of the study area, Salé – Morocco [9].

varied vegetation, and is rich in plant species. Moreover, Moroccans have excellent medical knowledge and traditional experience of basic medicinal plants [8].

Morocco, as is the case in other countries internationally, notably in emerging countries, has seen the relocation of the rural population towards cities which is considered a significant phenomenon of the twentieth century that has led to rapid economic, social and cultural changes. This study aimed to investigate traditional herbalists use of plants for therapeutic purposes in response to the coronavirus pandemic in the Salé Prefecture, Morocco, during 2020.

2. Methods

2.1. Study area

Salé is located in North-Western Morocco, right on the Atlantic coast, near the Moroccan capital Rabat. Its approximate geographic location is 34° 3' 11 Northern latitude and 6° 47' 54 Western longitude (Fig. 1).

Founded in about 1030 by Arabic-speaking Berbers, the Banu Ifran later became a haven for pirates in the 17th century as an independent republic, before being incorporated into Alaouite Morocco. The total surface area of Salé is 672 km² with a population of about 890 403 inhabitants, according to the 2014 Moroccan census [9].

Located along the Atlantic Ocean, Sale has a mild, moderate climate, shifting from cool in winter to warm days in summer. The winter typically gets as cold as 17.2°C during December–February. As for summer, daytime the temperature usually range from 25°C and may occasionally exceed 30°C, especially during heatwaves.

Summer nights are usually pleasant and cool, ranging between 11°C and 19°C and rarely exceeding 20°C. Salé belongs to the sub-humid bioclimatic zone with an average annual precipitation of 560 mm [10].

2.2. Epidemiological situation of Salé Prefecture

At the time the study was conducted (March 1st, 2020 to May 31st, 2020), the Ministry of Health in Morocco had reported that 7 807 con-

firmed COVID-19 cases had been reported nationally. Out of the cases, 225 were from Salé (Fig. 2), including Tabriquet (75 cases), Hssaine (89 cases), Bettana (36 cases), Lamrissa (17 cases), and Bouknadel (8 cases). Laboratory confirmation of COVID-19 was performed at the military hospital laboratory Mohammed V, in Rabat. RT-PCR assays were performed following the protocol established by the World Health Organization (WHO). The largest number of patients (198) had been admitted to Moulay Abdellah Hospital Salé. The rest of the patients continued their treatment at the Military Hospital Mohammed V, in Rabat [6].

As for the treatment protocol, the Moroccan health authorities allowed their hospitals to use antimalarial drugs to treat novel coronavirus. The Minister of Health, Mr. Khaled Ait Taleb, invited, through a note addressed to the directors of the hospital centers, who receive COVID-19 patients to use the drugs "Hydroxychloroquine", "Azithromycin", "Paracetamol", "Zinc sulfate", and "Vitamin C" to treat the cases with symptoms of the virus.

2.3. Herbalists in Morocco

The herbalists in Morocco are male and female, and older than 20 years of age. The training to become an herbalist is usually either through an inherited traditional knowledge from parents, or acquired through formal training. Among the herbalists, some followed old popular lifestyle, while others, notably the young, were more associated with a modern western lifestyle. These herbalists fall under a legal framework called the "Union of Moroccan Herbalists (UMH)". Unfortunately, there are no official statistics on their total number. From a legislative point of view, the profession of herbalists in Morocco is regulated by three legal chapters all dated before 1960:

- **The Dahir of February 27, 1923 (corresponding to Rajab 11, 1341 AH)**, subjecting the practice of herbalist to the provisions of the Dahir of April 12, 1916, whose second article is: "it is especially forbidden for herbalists to sell any poisonous or toxic plants" [11].
- **The Dahir of August 20, 1926 (corresponding to Safar 11, 1345 AH)**, where "any person who has the herbalist certificate and authorized under the conditions provided for in the article, may hold and

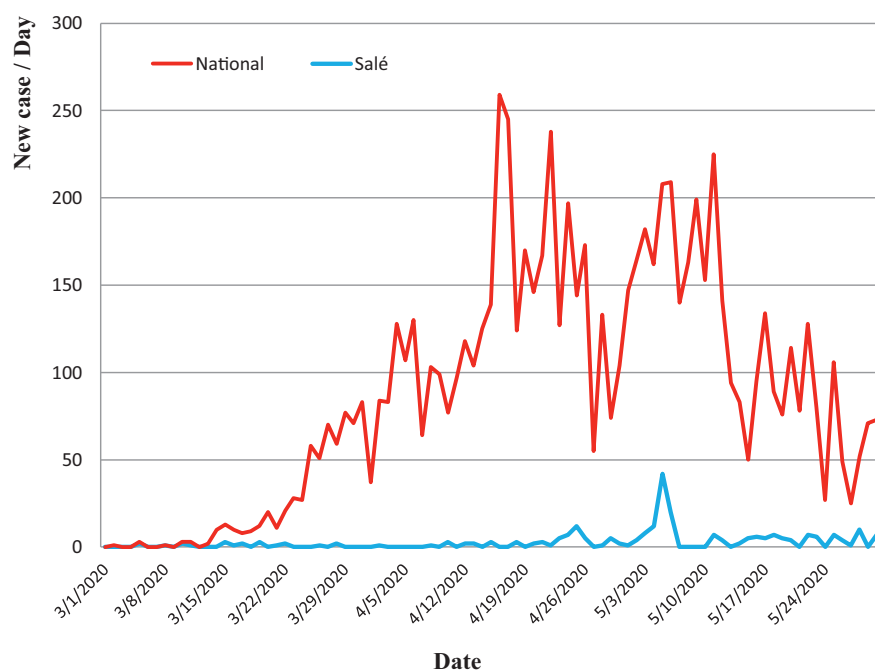


Fig. 2. Evolution of the epidemiological situation in Morocco and Salé prefecture [6].

sell all plants or parts of medicinal plants, fresh or dried, mixed or not, except poisonous plants listed in Codex” [12].

- **The Dahir of February 19, 1960 (corresponding to Chaabane 22, 1379 AH)**, with article 17: "Anyone with the herbalist certificate and authorized under the conditions of Article 2 will be able to hold and sell all plants or parts of medicinal plants, fresh or dry, except plants classified in the various tables of poisonous substances provided by the Dahir of December 2, 1922 [13].

2.4. Methodology

2.4.1. Ethnopharmacological data collection

A semi structured questionnaire was prepared in order to document indigenous anti-coronavirus plant use, traditional knowledge and the level of utilization of traditional medicinal plants for prevention and treatment of COVID-19. A total of 30 herbalists (24 male and 06 female) from different districts of the Prefecture of Salé, namely (Bab Lm-rissa: 10 herbalists, Tabriquet: 7 herbalists, Laayayda: 6 herbalists, Bet-tana: 4 herbalists and Bouknadel: 3 herbalists) participated. The data was collected through face-to-face interviews over the period of March 1st, 2020 to May 31st, 2020, ranging from 20 to 40 min. The interview period corresponded to the period when the coronavirus first began spreading in Morocco and in other parts of the world. The interviews were mostly carried in the local language (Arabic Moroccan dialect) spoken by the herbalists in the study area.

The inclusion criteria was that the herbalist had to be a qualified healthcare professional and had always lived in the area. Herbalists were excluded if they did not live in the study area. Although quarantine was imposed on all the inhabitants of Morocco; including the inhabitants of Salé Prefecture, the shops of herbalists remained open to their customers to buy necessities, which made it easier for us to visit them and conduct interviews on this subject. The information gathered during the present study included socio-demographic characteristics of the interviewed herbalists (age, gender, academic level, and experience in herbalism) and ethnopharmacological information, including the local and scientific name of the species, local names, plant parts used, modes of use, conservation method, administration mode and toxicity, all documented data were then translated into English and Latin (Appendix A).

2.4.2. Taxonomic identification of the species

Medicinal plants being mentioned by the herbalists were recorded with local names and photographed. Each reported medicinal plant species was gathered, compressed, dehydrated, and identified. The identification and nomenclature of the collected vegetal material was done first in the field and completed at the *Plant, Animal Productions and Agro-industry Laboratory* by our great Moroccan botanist Zidane L. These plant species mentioned by the sources were taxonomically identified using floristic and taxonomic references, especially ‘The medicinal plants of Morocco’ [14], ‘Practical flora of Morocco’, volumes I, II and III [15–17] and ‘Catalogs of vascular plants of northern Morocco’, including identification keys, volumes I and II [18]. Taxonomy and denominations of species were validated using “The Plant List 2020” database (<http://www.theplantlist.org>). All voucher specimens have been preserved during documentation and deposited in the Ibn Tofail University, Morocco Herbarium for future reference.

2.4.3. Ethical approval

The study was authorized by the ethical committee of Ibn Tofail University. Before starting data collection, we obtained oral informed permission in each case on a site level and then individually before each interview. We also informed herbalists that it was a student academic project and the investigation was only for our research purposes, not for any financial or other benefits. Herbalists provided verbal informed consent to engage in this study; they were free to withdraw their information at any point of time. Those informants accepted freely to the interview and consented to have their names and personal data to be published.

2.4.4. Data analysis

The data obtained from the field and collected from the herbalists were classified and examined with the statistical program IBM SPSS Statistics 21 Premium (SPSS 2019), to determine the proportions of different variables such as socio-demographics of the herbalists and ethnopharmacological data. Quantitative value indices were also calculated for the general uses of these medicinal plants using the use reports (UR) and medicinal use-value (MUV).

- **Use reports (UR) and Medicinal use-value (MUV)**

Table 1
Demographic characteristics of the informants (n = 30).

Variables	Categories	Number of informants	%
Gender	Male	24	80.00
	Female	06	20.00
Age	Less 30 years	1	03.33
	Between 30 - 50	7	23.33
	Above 50 years	22	73.34
Academic level	Illiterate	05	16.67
	Primary	08	26.67
	Secondary	16	53.33
	University	1	03.33
Years of experience as herbalist	Between 01-10 years	5	16.67
	Between 10-20 years	7	23.33
	Over 20 years	18	60.00

The use reports (UR) of a species or its importance in the culture of a community is denoted by its mentioning rate or its mention frequency by herbalists. The UR of the species of plants being utilized was evaluated using the formula: $UR = \frac{N_i}{n}$ [19]. Where, N_i is the number of times a particular species was mentioned, and n is the total number of times that all species were mentioned.

The MUV of recorded medicinal plants was determined by applying the following formula [20]: $MUV = \frac{\sum UR_i}{N}$. Where $\sum UR_i$ the total number of use reports per plants and N is the total of interviewees questioned for given medicinal species. The MUV rate will be more important if there are several useful records for a species, implying that the plant is significant, whereas they will be near 0 if there are few reports compared to its use [21].

3. Results

3.1. Demography data of informants

In total, 30 herbalists were interrogated using semi-structured questionnaires. 33.33% of the surveyed herbalists were from five Districts: Bab Lamrissa, 23.34% were from Tabriquet, 20% were from Laayayda, 13.33% were from Bettana and 10% were from Bouknadel (Table 1). In the Prefecture of Salé, both genders were interested in herbal medicines. However, the number of male participants was higher (24 herbalists) than females participants (6 herbalists). In this study, results showed that the utilization of medicinal species was widespread in all age groups. The majority of herbalists interviewed were over 50 years old (22), while 17 of the informants were between 30 and 50 years old. One of them was younger than thirty years old. Regarding the academic level, our results showed that more than half of the herbalists (53.3%) had secondary education, 26.7% had primary education, 16.7% were illiterate and only 3.3% of the herbalists had graduate education.

3.2. Botanical families of plants used

The present research showed that a total of 20 plant species belonging to 20 genera and 14 families were frequently used by herbalists from Salé Prefecture in the prevention and treatment of COVID 19. The family Lamiaceae was represented by the largest number of plant species (three species, 15%), whereas Apiaceae, Asteraceae, Fabaceae, and Myrtaceae contributed with two species to each family. The remaining nine botanical families were represented by one species in each. The vernacular names, scientific names of documented species, their families, mode of preparations, used parts, MUV, and UR were illustrated in Table 2.

3.3. Medicinal use plants (MUV)

Plants intended for medicinal use are utilized to find the most frequently used plant species in the study area. Its value ranged from

0.200 to 0.967 (Table 2). The calculated results of MUV showed that *Eucalyptus globulus* Labill. was ranked first (MUV=0.967) followed by *Azadirachta indica* A. Juss. (MUV=0.933), *Ziziphus lotus* (L.) Lam. (MUV=0.9), *Allium sativum* L. (MUV=0.867), and *Eugenia caryophyllata* Thunb. (MUV=0.833), while the lowest value was found for *Spinacia oleracea* L. (MUV=0.200).

3.4. Parts of the plant used

In our study area, different plant parts harvest for the preparation of herbal remedies (e.g., seed, root, flower, and leaf). The interview results revealed that leaves were the most frequently used part of the medicinal plants 28.43% of the total, followed by the seed (17.5%), whole plant (13%), bulb (11.27%), rhizome (8.4%), other parts (7.6%), flower (7%) and fruit (6.8%) (Table 2).

3.5. Modes and conditions of medicine preparation

In Salé Prefecture, the bulk of the herbal remedies (70.8%) were made from fresh material followed by their dried form (29.2%). Preparations in the most cases were obtained from individual plants, but some plant compounds were also reported. The preparation of ancestral medicine needs components and solutions. The major solvent was water, but milk, butter, tea, and honey, cereal oils and vinegar, were equally extensively used ingredients. Concerning the preparation of herbal medicine, herbalists employ various methods of preparation for COVID-19. The principal method of traditional medicine preparation reported was infusion (34.63%), followed by decoction (25.1%), powder (15.2%), and maceration (13.8%). The percentage of the other modes of preparation grouped (cataplasm, fumigation, cream, bath, and plaster) did not exceed 11.27% (Table 2).

3.6. Symptoms, and treatment of COVID-19

Herbalists (23) perceived the common COVID-19 as a combination of several symptoms. The most frequent ones were fever, tiredness, sore throat, loss of taste and smell, headache, and dry cough. The rest of the herbalists (7) presented other different combinations of described symptoms. Anecdotally, herbalists have claimed herbal medicines and kept them healthy or improved their symptoms. However, the bulk of research on these herbs used is inconclusive. Besides, herbalists believed that the treatment with herbal remedies for 7 days led to a marked improvement in the rate of recovery from symptoms, and the herbalists reported that the herbal capsules shortened the duration of fever by three days and symptoms of fatigue.

4. Discussion

Natural products have always been intriguing to scientists for drug research to develop novel candidates. COVID-19 caused by the novel coronavirus (SARS-CoV-2) is a deadly infectious disease against which no specific drug or vaccine is available, yet. Medicinal plants are considered very useful by traditional healers in many societies to prevent and to treat several diseases and ailments. Since the COVID-19 pandemic outbreak, various traditional herbal medicines have been used and resulted in positive health effects among COVID-19 patients, mainly in Salé Prefecture.

In this study, both genders are interested in herbal medicines. However, the numbers of male participants were higher than those of females. Men were predominantly represented in the sample because of their work. Females were rarely found at herbal markets during our interviews. These outcomes validate the findings of other ethnobotanical national and international studies [60,61] which have confirmed that men are predominantly knowledgeable in traditional herbs. Regarding the age groups, results showed that herbalists over 50 years

Table 2
List of plant species used to treat COVID-19 in the Salé Prefecture, Morocco.

Family	Scientific name	Collection number	Vernacular name	Part used	Mode of preparation	Bioactive compounds	Biological activities	MUV
Amaranthaceae	<i>Spinacia oleracea</i> L.	SAL08	Sabanikh: خنا بسل	Leaf	Infusion	Ta-Thkthionin, Ascorbic Acid, Vitamin C, phenols, Carotenoids, Flavonoids,	Antioxidants, Anti-Inflammatory, antibiotic, Anti-Cancer [22–24]	0.200
Amaryllidaceae	<i>Allium cepa</i> L.	SAL03	Basla: لصلبلا	Bulb	Other	Γ-Glutamyl Peptides, Diallyl Thiosulphinate, 2,2-Diphenyl-1-Picrylhydrazyl, quercetin, kaempferol	antiinflammatory, Antioxidant, antiviral, antibacterial, anticancer activities, antiproliferative [25]	0.467
	<i>Allium sativum</i> L.	SAL05	Touma: جوشلا	Bulb	Other	Flavonoids, organosulfur compound and saponins, essential oils, diallyl-Trisulfide, diallyl-Disulfide	antioxidant, dysentery, anti-inflammatory, antiviral, anticancer activities [26,27]	0.867
Apiaceae	<i>Petroselinum crispum</i> (Mill.) Fuss	SAL09	Maadnous: سرنوقبلا	Whole plant	Decoction	B-Phellandrene, luteolin Myristicin, 1,3,8-P-Menthatriene polyphenols, flavonoids	Antimicrobial, Larvicidal, pupicidal, Antifungal [22,28]	0.433
	<i>Pimpinella anisum</i> L.	SAL02	HbatHlawa: قوالح فبح	Seed	Infusion	(E)-Methyugenol, A-Cuparene, A-Himachalene, B-Bisabolene, P-Anisaldehyde, Trans-Anethole, Estragole, Petroleum Ether riedelan3-β-ol, artemetin, quercetagetin	Antispasmodic, antimicrobial, antifungal, antiviral, antioxidant, muscle relaxant, analgesic, anticonvulsant [29]	0.233
Asteraceae	<i>Artemisia annua</i> L.	SAL14	Chih: حيشلا	Leaf	Decoction	6,7,30,40-tetramethyl ether	Antimalarial, Antibiotic, SARS-CoV [30,31]	0.467
	<i>Matricaria recutita</i> L.	SAL11	Lbabounj: جنوبابلا	Whole plant	Infusion	Chamazulene (61.3%), Soppopyl Hexadecanoate (12.7%), Trans-Trans-Farnesol (6.9%), E-B-Farnesol (5.2%)	Spasmolytic, antimicrobial, Disinfective [32]	0.533
Fabaceae	<i>Glycyrrhiza glabra</i> L.	SAL07	Arq Sous: سوسورع	Rhizome	Decoction	glycyrrhizin, 18β-glycyrrhetic acid, glabrin A and B, isoflavones, Licochalcone A	anti-inflammatory, antimicrobial, Antioxidant, Antiviral, Antitussic, expectorant [33–35]	0.333
	<i>Trigonella foenum-graecum</i> L.	SAL16	Lhalba: قبالحلا	Seed	Decoction	Magnesium, Calcium, Vitamins A, B1, C, Nicotinic Acid, Alkaloids, Flavonoids	Fungicidal, antiviral, Analgesic, anti-inflammatory, antiradical, antioxidant [36–38]	0.700
Lamiaceae	<i>Rosmarinus officinalis</i> L.	SAL01	Azir: ريزالا	Leaf	Infusion	Bornyl Acetate (11.3–17.0%) And Verbenone (4.4–24.9%), While 1,8-Cineole (3.4–11.3%), Borneol (6.2–7.3%), Camphor	Antiviral, Anti-proliferative, antioxidant, antinociceptive [39–41]	0.267
	<i>Salvia officinalis</i> L.	SAL12	Salmya: قيل اسلا	Leaf	Infusion	Thyme; 12-O-Methyl Carnosol; Apianane, Terpenoid; Abietane Diterpenoid; Flavonoid	anti-inflammatory, Anticancer, Antioxidant, antimutagenic, antinociceptive [42]	0.400
	<i>Thymus vulgaris</i> L.	SAL10	Zaatar: رتعزلا	Whole plant	Infusion	Γ-Terpinene, Camphenilone, Tricyclene, A-Thujene, 1,8-Cineole	Antimicrobial activity, antioxidant, fungicidal, antimicrobial [43,44]	0.567

(continued on next page)

Table 2 (continued)

Family	Scientific name	Collection number	Vernacular name	Part used	Mode of preparation	Bioactive compounds	Biological activities	MUV
Lauraceae	<i>Cinnamomum zeylanicum</i> Blume	SAL28	قفرقولا: Lqarfa	Seed	Powder	Hydrocinnamaldehyde, Benzaldehyde, 3-Phenylpropyl Acetate, N-Heptadecane, 2-Hexadecanone	Antimicrobial, fungicidal, antibiotic, SARS-CoV [45,46]	0.633
Meliaceae	<i>Azadirachta indica</i> A.Juss.	SAL22	ميميزلا: Neem	Leaf	Infusion	Ethanol, Methanol, Acetone, Alkaloids, Phenolic	antimicrobial activities against human pathogenic bacteria (<i>Salmonella typhi</i>) [47,48]	0.933
Myrtaceae	<i>Eucalyptus globulus</i> Labill.	SAL33	لقاليتوس: Lqalitous	Leaf	Infusion	Myricetin, linalool, urosolic acid, apigenin, quercetin, narasin	SARS-CoV, antiviral, coxsackievirus, hepatitis B and C virus [49,50]	0.967
	<i>Eugenia caryophyllata</i> Thunb.	SAL19	لفغفرقولا: Lqronfel	Flower	Maceration	2-Phenyl Ethanol, Benzyl Alcohol, Eugenol, Chavicol, 4-Hydroxy, 3-Methoxy-Benzeneacetic Acid, Hexadecanoic Acid	Anti-inflammatory, Antimicrobial, Antioxidant [51,52]	0.833
Oleaceae	<i>Olea europaea</i> L.	SAL15	زيتون: Zitoun	Leaf	Decoction	Flavonoids, Flavone Glycosides, Flavanones, Iridoids, Triterpenes, Biophenols	antioxidant, antiviral, antimicrobial, anti-diabetic, influenza, cardioprotective effects [53]	0.600
Ranunculaceae	<i>Nigella sativa</i> L.	SAL31	حباربلكا: Hbatlbarka	Seed	Powder	Nigellidine, Nigellicine, Carvacrol, Thymol, A-Hederin	anti-inflammatory, analgesic, antipyretic [54]	0.500
Rhamnaceae	<i>Ziziphus lotus</i> (L.) Lam.	SAL23	ردسلا: Sedr	Other	Decoction	Alkaloids, Flavonoids, Terpenoids, Saponin, Pectin, Triterpenoic Acids, Lipids	Anti-inflammatory, analgesic, antioxidant, antimicrobial [55,56]	0.900
Rutaceae	<i>Citrus limon</i> (L.) Osbeck	SAL24	لحاماح: Lhamed	Fruit	Maceration	hesperetin, eriodictyol and naringenin, 3-Cyclohexene-1-Methanol (11%), 2-Isoprenyl-5-Methylhex-4-Enal (10%), Limonene (9%), B-Citral (8%)	Antibacterial, fungicidal, influenza, Haemolytic [57,58]	0.800
Zingiberaceae	<i>Zingiber officinale</i> Roscoe	SAL19	ليبيجنزلا: Sqinjbir	Rhizome	Powder	Zingiberenol, Zingiberene, Hexanol, γ -Terpinene, Menthol, B-Caryophyllene, Trans-Linalool Oxide	Antimicrobial, Anti-inflammatory, antimicrobial properties, antioxidant, Hepatoprotective [59]	0.667

old had more experience with traded medicinal species, while herbalists younger than 30 years old were less informed about it. It is due to the high secrecy of ancestral information by older people; these factors are very interesting in determining the transmission of traditional knowledge from one generation to another in a Prefecture. Concerning the academic level, our results revealed that more than half of the informants (53.33%) had secondary education. None of the herbalists participating in our survey had a certificate or diploma in herbalism. While the Dahir of February 19, 1960, with Article 17 stipulates that to hold and sell the plants or parts of medicinal plants, whether fresh or dry, except plants classified in the various tables of poisonous substances, the person concerned must provide a herbalist certificate and authorized under the conditions provided in Article 2 of the same Dahir. This indicates that with a greater level of instruction, the experience of traditional herbal medicine decreases. Therefore, advanced instruction reduces the ancestral therapeutic knowledge of the young generation [62]. Previous ethnobotanical studies [63–67] report similar findings. All stated that they had acquired their traditional knowledge and experience in medicinal plants from their parents, friends, and elderly relatives. 41.18% of the herbalists had experience as herbalists over 20 years.

The present study revealed that a total of 20 medicinal species relating to 19 genera and 14 botanical families were generally utilized by herbalists in the prevention and treatment of COVID 19. The Lamiaceae family was present in a high number of medicinal plants (3 species, 15%). The calculated results of MUV showed that *Eucalyptus globulus* Labill. was ranked first (MUV =0.967) followed by *Azadirachta indica* A. Juss. (MUV =0.933), and *Ziziphus lotus* (L.) Lam. (MUV =0.9). These results are similar to international work, particularly in Pakistan. These medicinal species having high MUV must be further assessed for phytochemical, pharmacological, and toxicological studies to identify their active constituents for an effective and non-toxic drug extraction.

The interview results revealed that leaves are the most frequently used part of the medicinal plants 28.4% of the total, followed by the seed (17.5%), and the whole plant (13%). The choice of leaves was due to its easy availability, collection, and simplicity in drug preparation. Furthermore, photosynthesis takes place in the leaves, and sometimes the storage of the secondary metabolites is effective for the biological characteristics of the medicinal plant. Comparable conclusions showed leaves as a main principal plant part in Morocco [68–71] and in Africa [72–74] for herbal medicine preparation.

In Salé Prefecture, most of the drugs (70.8%) were prepared from fresh substances. The research carried by Abdurrahman [75] registered that 86% of products were in a fresh form, [76] declared that most of (64%) plant species were employed in fresh form and 36% in freeze-dried form. Jima et al., [77] indicated that the preponderance of the drugs (78.6%) were prepared from fresh pieces of plant species. The dependency of herbalists on fresh substances is often due to the effectiveness of fresh plant species in therapy as the ingredients are not lost before practice related to the dried plant forms.

The main method for herbal medicine preparation described was infusion (34.63%). The frequent employment of the infusion can be justified by the fact that it makes it possible to accumulate the multiple effective components and attenuates or eliminates some remaining poisonous ingredients. Ethnobotanical studies conducted in other parts of Morocco found that the majority of informants prepared herbal remedies by infusion and decoction [78–80]. This result corroborates the fact that there is an ongoing transfer of knowledge on the effectiveness of plant species between the inhabitants of Morocco.

These medicinal plants contain a wide variety of bioactive compounds including flavonoids (quercetin, kaempferol, hesperetin, eriodictyol, naringenin, and luteolin), alkaloids (pyrrolidine, pyridine, quinoline, isoquinoline, indole, and quinazoline), saponins (escinidin, glycyrrhizin, saikosaponin B2), terpenes (curcumin, betulinic acid, savinin, iguesterin, dihydrotanshinone I, cryptotanshinone, 3 β -friedelanol, chrysanthemum B), coumarins (leptodactylone, xan-

thoangelol E), organosulfur compounds, glycosides, secoiridoid, tannin, mucus, lignans, anthraquinones, aromatic constituents, phenolic lipids, carotenoids, steroids, and many other compounds. The plant species in this mixture also include a large number of essential oils.

A large number of chemicals and compounds extracted from different higher plants is responsible for many pharmacological effects [81–83] such as antiviral, antibacterial, antifungal, anti-inflammatory, antioxidant, antipyretic antiseptic, antibiotic, analgesic, antitumor, anticancer, antiallergic, antiatherogenic, antimutagenic, and antinociceptive activities.

A variable number of alkaloids such as emetine, tylophorine, and mycophenolate mofetil have been reported to be very significant antiviral compounds [84,85]. Chloroquine is a good candidate, asynthetic derivative of quinine for the development of an effective drug to treat COVID-19 because of its DNA-intercalating properties [86]. The isoquinoline alkaloids tetrandrine, fangchinoline, and cepharanthine could inhibit the expression of spike and nucleocapsid proteins in SARS-CoV- OC43 in human lung cells [87].

Essential oils (Chamazulene, Limonene, Thymol, Eucalyptol, Verbenone, γ -Terpinene, Sabinene, trans-Anethole, Caryophyllene, Linalool, Disulfide, Myrcene, Camphenilone, Camphene, Camphor, Borneol, Menthol, Eugenol, Carvacrol, Myrtenol, Verbenone, etc.) from many medicinal plants such as *Artemisia annua* L., *Rosmarinus officinalis* L., *Salvia officinalis* L., *Pimpinella anisum* L., *Citrus limon* (L.) Osbeck, *Eugenia caryophyllata* Thunb., and other aromatic plants with antiviral activities were well documented by several researchers [83,88–90]. Eucalyptol, a vital essential oil from *Eucalyptus globulus* Labill. was identified as an effective antiviral compound against coronavirus, especially COVID-19 because this major component of eucalyptus oil consists of ether (-O), ketone (=O), and hydroxyl (-OH) groups which play the main inhibitory role against SARS-CoV-2 [91]. Essential oils can insert nonspecifically into the lipid double layer of the viral envelope, which alters the fluidity of the membrane [89].

The antimicrobial activity of alkaloids has been extensively reviewed [92,93]. Recently, Özçelik et al., [94] published another comprehensive review on this subject. The review considered many alkaloids, flavonoids, and phenolic acids with antimicrobial activity and reported that bioactive alkaloids could be found within acridone-, aporphine-, benzophenanthridine-, bisbenzylisoquinoline-, indole-, isoquinoline-, piperidine-, protoberberine-, quinoline-, terpenoid- and steroid-type alkaloids. Flavonoid derivatives have also been reported to possess antiviral activity against a wide range of viruses such as HSV, HIV, Cocksackie B virus, coronavirus, cytomegalovirus, poliomyelitis virus, rhinovirus, rotavirus, poliovirus, sindbis virus, and rabies virus [95,96]. Phenolic compounds, polyphenols, steroids, terpenoids, other active phytochemicals, and their derivatives are common plant secondary metabolites that contain aromatic rings with 1 or several hydroxyl groups. For a wide range of viruses, several studies confirmed the abovementioned activity of several phenolic antiviral compounds such as curcumin, luteolin-7glucoside, epicatechin gallate, catechin, demethoxycurcumin, bava-chinin, apigenin-7 glucoside, silvestrol, hypericin, psoralidin, mycophenolate mofetil, corylifol, and tomentin [85,97,98]. According to Wink [90], polyphenols are capable of binding easily with the lipoproteins of the virus envelope, which can prevent the viral invasion in host cells.

Even though herbal remedies may seem harmless, if misused, they could increase a person's risk for COVID-19. We may find that certain herbs are effective in preventing and treating COVID-19 for some people, however, there currently is not enough data regarding the use of herbal remedies for the novel coronavirus. According to the World Health Organization, there are no medicines that have been shown to prevent or cure COVID-19.

5. Limitations

There is no information provided about the pharmacological efficacy of the medicinal plant species in this study. These are the reported herbs

that were being used for COVID-19 symptoms, the effects of which remain unknown.

6. Conclusion

Our study showed that medicinal plants continue to play an essential role in the fundamental healthcare system for the local people living in the Salé Prefecture. Herbalists appear to have a beneficial role in the healthcare of the local population, despite the revolution in modern health technology. The abundance of plant species documented for the prevention and treatment of COVID-19 is a major indication of the potential that exists locally, so long as the scientific procedure is added to the indigenous knowledge. Furthermore, additional research on the sustainable use and conservation of medicinal species is highly suggested. Finally, pharmacological, phytochemical, and toxicological investigations on medicinal plant species with possible anti-COVID-19 effects are carried out for laboratory validation of the ancestral uses of these plants and to obtain the traditional medicines bios. A combination of natural products or herbal mixtures with validated anti-COVID-19 drugs may constitute a promising preventive and therapeutic alternative but should be assessed.

Author contributions

NC: Methodology, investigation, compiled the literature sources, data analysis, evaluation, and interpretation, realization manuscript, helped in data, and made a substantial contribution to data analysis. **AD:** Performed data analysis and drafted the manuscript. **LZ:** Review & editing, designed the research and identification of plant species. All contributors understand and accepted the final document.

Financial support

This study did not receive any particular gift from funding companies in the public, commercial, or not-for-profit sectors.

Declaration of Competing Interests

We declare that there is no conflict of interest with any business organization concerning the study.

Acknowledgments

We are thankful to the herbalists in Bab Lamrissa, Tabriquet, Bettana, Laayayda, and Bouknadel Districts for their valuable help in the documentation of indigenous ethnopharmacological knowledge. We also extend my acknowledgments to all those who contributed to the realization of this work.

Appendix A. Questionnaire card N°

Section A

Date	District	Age	Sexe	Academic level			
.....	Illiterate	Primary	Secondary	University
.....

Section B

		Botanical name	Scientific name	Names: Arab/Amazigh				
Years of experience as an herbalist		Between 01-10 years	Between 10-20 years	Over 20 years				
Mode of preparation	Decoction	Infusion	Fumigation	Powder	Cream	Bath	Plaster	Other
	.....	.....	.....	Maceration	.....	.....	.....	.....
Part used	Root	Leaf	Seed	Fruit	Bulb	Rhizome	Flower	Whole plant

Plant Type		.....					
Conservation method		.....					
What is covid-19		.....					
Symptoms of covid-19		.....					
Form of employment		.....					
Administration mode		.....					
Duration of the treatment		.....					
Dose used		.....					
Expiration date		.....					
Toxicity		.....					

Section C

	Botanical name	Scientific name	Names: Arab/Amazigh
Plants associated
Period, Mode, Dose, Amount, Nature

Data availability

Supplementary material related to this article can be obtained from the corresponding author on request.

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