Ethnomedicinal use of plants by Ain Chkef (North Central Morocco) community to boost immunity and overcome SARS COV-2 infection

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Research

Abstract

Background: The appearance of the virus SARS-COV-2 in China, December 2019 has resulted in worldwide pandemic. In anticipation of the development of an effective vaccine against this virus, Moroccan people from different areas have used medicinal and aromatic plants (MAPs) to boost their immunity and overcome this pandemic. Thus, several surveys were performed in different Moroccan cities to gather data concerning MAPs used for this purpose. However, there is a lack of such studies in Moroccan rural communes where the use of herbal remedies is more dominant. Therefore, we have performed an ethnobotanical study in Ain Chkef rural commune to collect information related to MAPs used in this area during the pandemic COVID-19.

Methods: A survey regarding the use of MAPs by people of Ain Chkef area was performed. 149 people were interviewed. Collected data was analyzed using plant citation indexes. Multiple Components Analysis was performed to determine correlations between plants and humans' socio-demographic characteristics.

Results: A total of 23 plants species were cited, belonging to 15 botanical families. The dominant families were Myrtaceae and Rutaceae. Whereas the most cited species were *Eucalyptus globulus* Labill. and *Syzygium aromaticum* (L.). Leaves were used more frequently than the other plant organs, and fumigation was the preponderant preparation method.

Conclusion: The present study highlights MAPs used by people in Ain Chkef against COVID-19 during the pandemic. Thus, it constitutes an important database for researchers for the discovery of new bioactive compounds from MAPs, efficient against COVID-19.

Keywords: COVID-19; medicinal plants; Ain Chkef community.

Background

In December 2019, a dangerous virus responsible for a Severe Acute Respiratory Syndrome, named SARS-CoV-2 was reported in Wuhan, Hubei Province, China. This virus has led to an extremely infectious disease called COVID19 (Megersa *et al*. 2022).

Due to its speed spread, and its bad effect on human health, COVID19 has been declared by the world health organisation (WHO) as a pandemic with high risk on the global community especially in countries with vulnerable health systems (WHO 2020).

Treatment against COVID19 has been the objective, not only of many researchers who tried to develop vaccines against this dangerous disease, but also of several populations in different countries, who had used medicinal and aromatic plants (MAPs) to overcome this pandemic, through the preparation of different plant recipes aiming at strengthening the immune system and mitigating the symptoms of COVID-19 (Benkhaira *et al*., 2021a; Khadka *et al*., 2021; Villena-Tejada *et al*., 2021).

Indeed, since a long time, people had relied on the use of MAPs for the treatment of various ailments (Giannenas *et al*., 2020). This traditional use of MAPs as remedies was related to their efficient healing potential, in addition to their availability and easy access (Al-Adhroey *et al*., 2010).

The knowledge of MAPs used by several populations against different diseases is highly important for the development of ethnopharmacology (Süntar, 2020). Thus, the results of many ethnomedicinal surveys have allowed researchers to successfully develop MAPs-derived drugs (Zareef *et al*., 2023)

Furthermore, numerous surveys were carried out around the world to gather information about the use of MAPs by people to treat COVID19 (Cordoba-Tovar *et al*. 2022; Megersa *et al*. 2022; Pranskuniene *et al*. 2022). Moreover, different *in silico* studies based on molecular docking, molecular dynamic simulations and quantum computations were performed to identify potential phytochemicals from MAPs, efficient against COVID19 (Fitriani *et al*. 2020; Khan *et al*. 2021; Pandey *et al*. 2020).
In Morocco, the MAPs used during the pandemic COVID-19 were determined by surveys conducted in several cities (Belhaj and Zidane, 2021; Benkhaira *et al*., 2021; Chaachouay *et al*., 2021; Chebaibi *et al*., 2022; Flouchi *et al*., 2023; Ghanimi *et al*., 2022; Laaribya *et al*., 2022; Moujane *et al*., 2022; Najem *et al*., 2022). However, no survey has been carried out in Moroccan rural communes. Therefore, we carried out this survey of the MAPs used during this pandemic by a rural community of Ain Chkef area (North central Morocco) tightly attached to MAPs use against a wide range of diseases (Benamar *et al*. 2023b). The obtained list of used MAPs species may help researchers to discover new phyto-bioactive compounds effective against the SARS-COV-2.

Materials and Methods

Study area

Ain Chkef is a peri-urban commune of Fez-city (Fez-Meknes region: North central Morocco) characterized by an area of 146.352 Km2 at an altitude of 499 m, a geographical coordinate of 33° 57' N, 5° 1' 41'' W (DB-city. Com 2023) and a population density of 238 inhabitants / km2 (Ministry of urban planning and territory development: MUPTD 2014). This rural area presents a Mediterranean climate, with an average minimum and maximum temperatures of 4°C and 33.6°C, respectively. The average annual rainfall is 500 mm, concentrated mainly in winter. In addition to the easy access to different services through the urban network of the metropolis, Ain Chkef population profit from important agricultural potentialities involving the production of fodder and cereals (MUPTD 2014), this population benefits also from a planted forest known as 'forest Ain Chkef'; a green field of 60 hectars including a diversity of exotic and native plant species (Benamar 2011).

Data collection

In order to collect a maximum data regarding the MAPs used by the population of Ain Chkef during the COVID-19 pandemic, a total number of 149 persons were interviewed during September 2023. The semi- structured interviews including several questions concerning the Socio-demographic profiles of respondents, namely: the age, gender, educational level and socio-economic status, and the plants they used during the pandemic (plants local name, parts used, and preparation mode). The time spent for each interview varied between 10 and 15 minutes.

The study sample consisted of respondents randomly interviewed at the entrance and exit gate of the main weekly popular market (souk), in the Ain Chkef area.

The protocol followed in this work was previously validated by the Council of our Laboratory and applied in several published studies (Benamar *et al*. 2023b; El Hachlafi *et al*. 2020; Jeddi *et al*. 2021).

Species identification

Plant species cited by the interviewed population with their local names, were identified by referring to other surveys carried out in Morocco (El Hachlafi *et al*. 2020, Jeddi *et al*. 2021, Ouhaddou *et al*. 2014), as well as through the consultation of Moroccan botanical books (Bellakhdar 1997, Fennane *et al*. 1999, Sijelmassi 1993). Samples of the listed MAPs species are part of the national plants herbarium, affiliated to the Scientific Institute (Rabat, Morocco).

Data analysis

In order to analyse collected data, a descriptive statistical method including percentages and frequencies was used for data related to the Socio-demographic profile of respondents. While for botanical data, quantitative indices (RFC, FIV and PPV) were calculated.

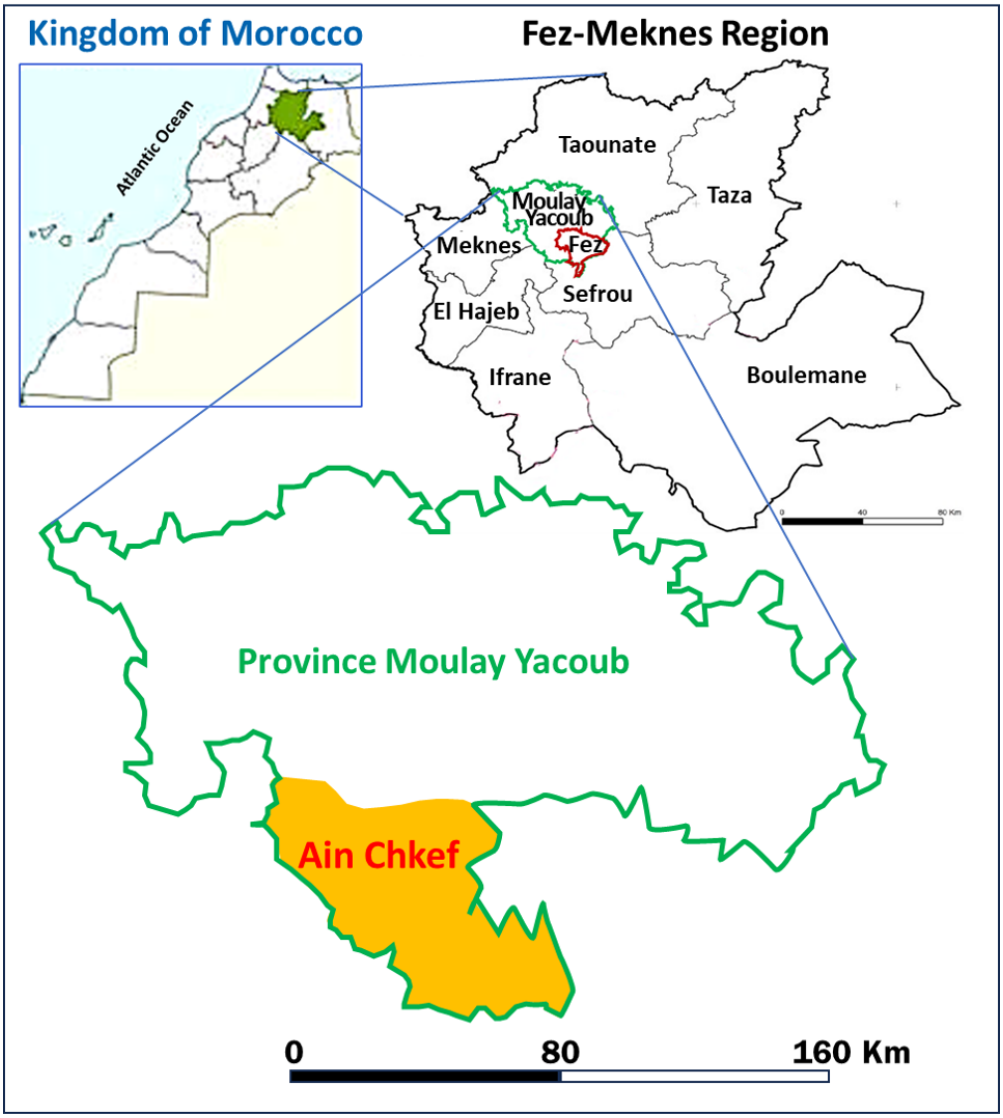

Figure 1. Maps of the geographical location of the studied area in Morocco

Besides, Jaccard Coefficient of Similarity was determined so that to compare the species cited in our survey, to those cited in previous surveys carried out in nearby locations.

Furthermore, multiple component analysis (MCA) was performed in order to understand relationships between the use of MAPs and people Socio-demographic characteristics (age, educational level, gender and marital status).

The softwares used for this statistical analysis were Microsoft Office "Excel 2013" and XLSTAT.

Relative frequency of citation (RFC)

This index shows the relative importance of each plant species cited by respondents. It's calculated according to Tardio and Pardode-Santayana (2008) formula**:**

(RFC= FC/ N)

by dividing the number of people using a particular plant species (FC), by the total number of people interviewed (N).

Family Importance Value (FIV)

FIV indicates the importance of the used plant families. It's calculated according to the formula of Sreekeesoon and Mahomoodally (2014):

FIV= FC family / Ns

FC family (RFC): the number of people citing a particular family; Ns: the number of cited species in this family.

Plant part value (PPV)

Plant part value reveals the use frequency of cited plant organs. It's calculated according to Gomez-Beloz (2002) formula:

PPV= RU plant part/ RU

RU plant part: the total number of uses mentioned for a given plant part.
RU: the total number of all cited plant organs.

Multiple component analysis (MCA)

In order to understand relationships between the use of MAPs and people Socio-demographic characteristics (age, educational level, gender and marital status), multiple component analysis was performed using XLSTAT software. To perform MCA which can be applied for qualitative variables, the quantitative variables (age of respondents and the number of MAPs they use), were converted to qualitative variables using different classes:

For the age:
- High-Age: Age > 40 years.
- Low-Age: Age < 20 years.
- Medium Age: 20 < Age < 40 years.

For the number of MAPs used:
- MAPs moderate use: 4 < MAPs used < 7.
- MAPs low use: MAPs used < 3.
- MAPs zero use: People not using MAPs.

Jaccard Coefficient of Similarity (JCS)

JCS is a calculated coefficient used by ethnobotanists in order to compare the species cited in a certain survey, to those cited in previous surveys carried out in nearby locations (Yaseen *et al*. 2015). JCS is calculated as follow:

JCS= c/ a+b+c

a: the number of cited species only in the surrounding areas.
b: the number of cited species only in the research region.
c: the number of cited species in surrounding areas and in the research region.

Review study

In order to highlight and explain the frequent use of the most cited species in our study during the pandemic COVID-19, a literature review was performed using different search engines namely Google Scholar, PubChem, and PubMed, Scopus, Science Direct and Web of Science. Indeed, the bibliographic research aimed at collecting data regarding the antiviral and pharmacological properties of these species, as well as at selecting some works conducted in different regions around the world, where the use of these species against COVID-19 was cited by the interviewed populations.

Results and Discussion

Use of MAPs by respondents

60% of the population interviewed used MAPs during the pandemic COVID-19. This result could be explained by the attachment of these people to their traditional heritage and their trust on the medical efficiency of MAPs (Benamar *et al*. 2023a). 40% of respondents didn't use MAPs during the pandemic COVID-19. This percentage include 7% of individuals who have never used MAPs, probably because they fear their toxicity, and 33% of people who usually use MAPs to treat various ailments, but have not exploited them to treat COVID-19, may be since they don't have a previous knowledge about this virus and how to deal with it through MAPs use. A similar result was obtained by Belhaj and Zidane (2021) who found that 67.04 % of respondents from different Moroccan cities used MAPs during the pandemic COVID-19 in order to boost their immunity, as well as to disinfect the air and to treat respiratory infections which could be related to coronavirus. Whereas 23 % didn't use MAPs during this pandemic. Other studies have also revealed the use of MAPs during the pandemic by citizens from Morocco (Benkhaira *et al*., 2021; Chaachouay *et al*., 2021; Najem *et al*., 2022) and from other countries (Khadka *et al*., 2021; Villena-Tejada *et al*., 2021).

Socio-demographic data of respondents

Age

Figure 2 shows that the major users of MAPs during the pandemic COVID-19 are people belonging to age groups 20-40 and >40 years (21.48 and 15.44 % respectively), followed by young people <20 years (2.68%). This result could be explained by the fact that elderly (20-40 and >40 years) have a higher conviction of the medicinal efficiency of MAPs than young people (<20 years), and a better knowledge on MAPs that can be used against diseases characterized by similar symptoms to those caused by COVID-19. Other surveys also revealed the frequent use of MAPs by elderly people (Belhaj and Zidane, 2021; Najem *et al*., 2022).

As for people not using MAPs during the pandemic COVID-19, they belong to different age groups (Fig. 2): <20 years (6.71%), 20-40 years (27.52%) and >40 years (26.17%). Those people include individuals who had never use MAPs because they fear their toxicity, and others who didn't use MAPs to treat COVID-19 probably because they didn't know which plant is suitable for this type of highly contagious virus.

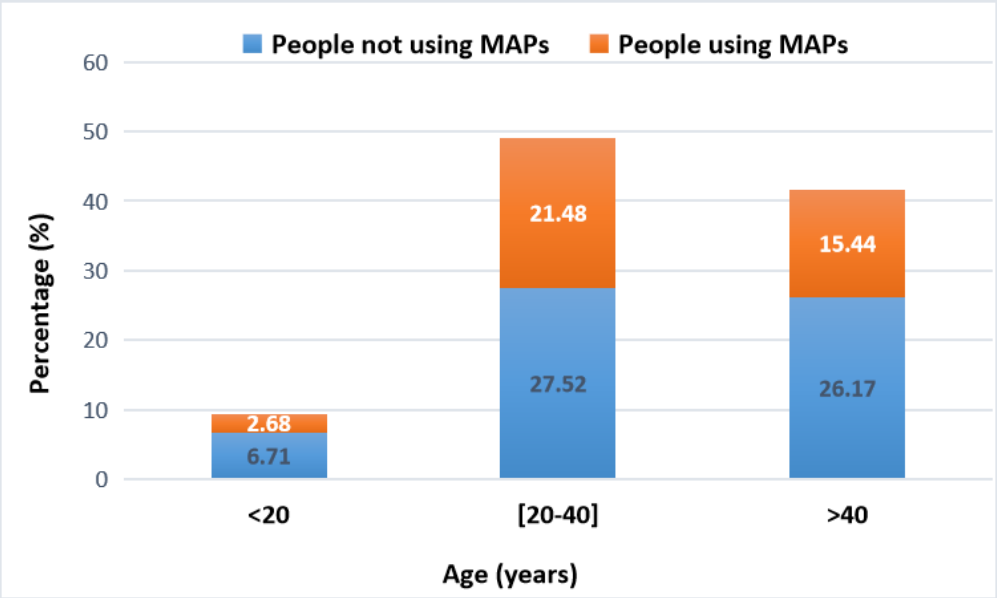

Figure 2. Distribution of respondents using or not MAPs during the pandemic COVID-19 according to their age

Gender

Figure 3 shows that the use of MAPs during the pandemic COVID-19 by respondents was spread among women (26.85%) more than men (12.75%), which is probably linked to the fact that women have a higher knowledge and conviction about MAPs use than men. This result confirms those of previous studies (Alaoui *et al*. 2018; Bencheikh *et al*. 2021).

Regarding people not using MAPs, they are composed of 56.38% of women who probably have been terrified by this pandemic and thought that COVID-19 cannot be fought by MAPs especially because they didn't have a previous knowledge of this dangerous virus.

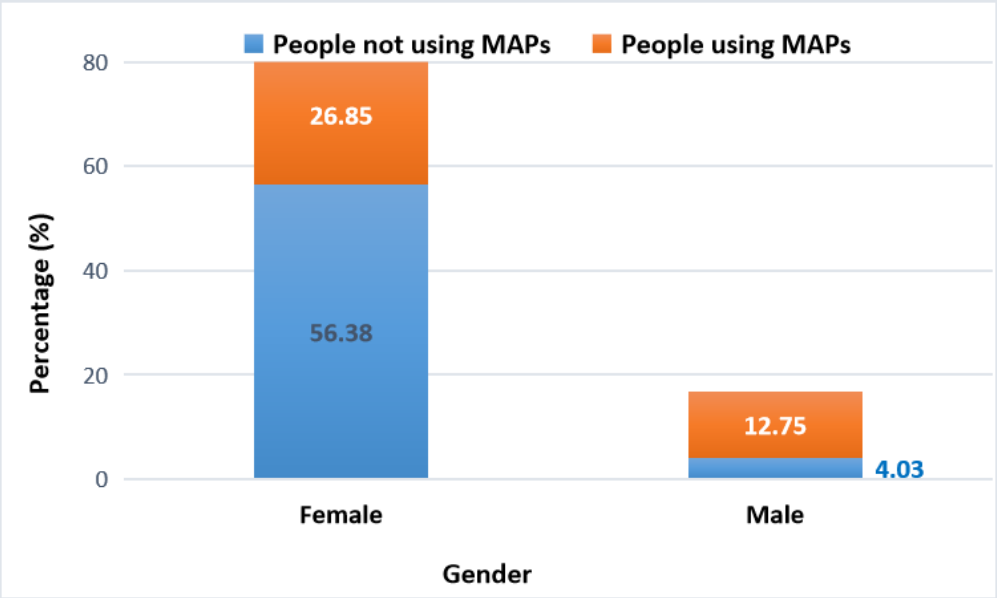

Figure 3. Distribution of respondents using or not MAPs during the pandemic COVID-19 according to their gender

Educational level

Figure 4 shows that people using MAPs are mostly illiterate (22.15 %). Such result was also obtained in other ethnobotanical surveys (Benamar *et al*. 2023b; El Hachlafi *et al*. 2020; Jeddi *et al*. 2021). Besides, it's important to draw the attention to the fact that, as these people are not aware of the possible dangers associated to the random use of MAPs (Benamar *et al*. 2023b), they could be exposed to their toxicity. As for people not using MAPs, they were also dominated by illiterate individuals (36.91%), who were probably unable to use MAPs, since this new disease doesn't have specific treatment in their traditional phytotherapy.

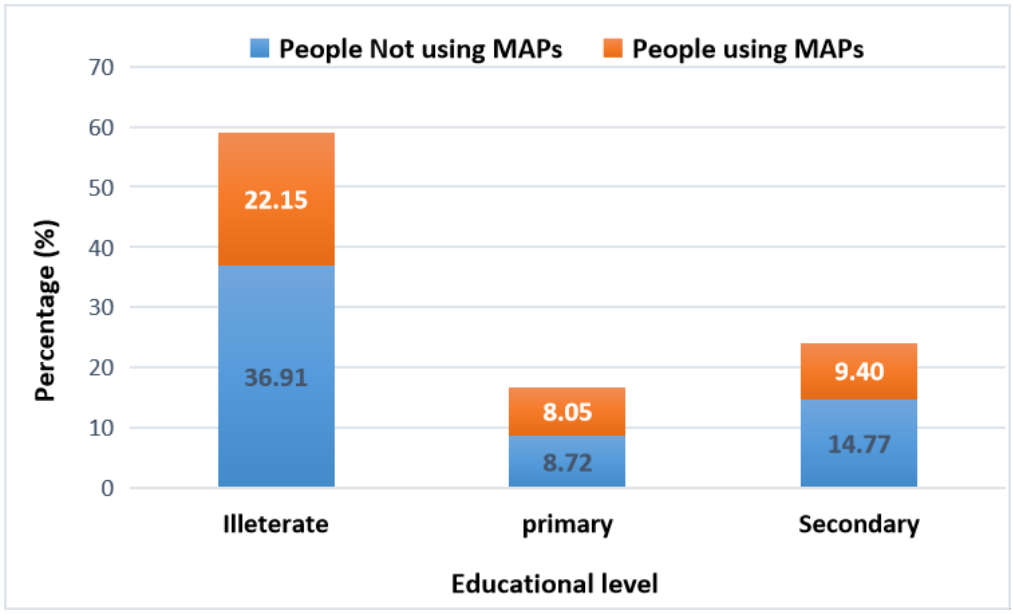

Figure 4. Distribution of respondents using or not MAPs during the pandemic COVID-19 according to their educational level

Socio-economic status

Most of people using MAPs in the study area have a medium socio-economic level (31.54%) followed by those with a low level (8.05%), while 0% had a high level (Figure 5). Our findings are consistent with those obtained in other studies (Benkhaira *et al*. 2021b; Jeddi *et al*. 2021). This may be explained by the use of herbal medicine by interviewed people, as an accessible and effective mean for the treatment of diseases. As for people not using MAPs, they are composed of only 0.67 % and 8.72 % of individuals having a high and low socio-economic level, respectively, while the majority of them (51.01%) have a medium level. This result suggest that the latter may be users of modern pharmaceutical treatments despite their cost.

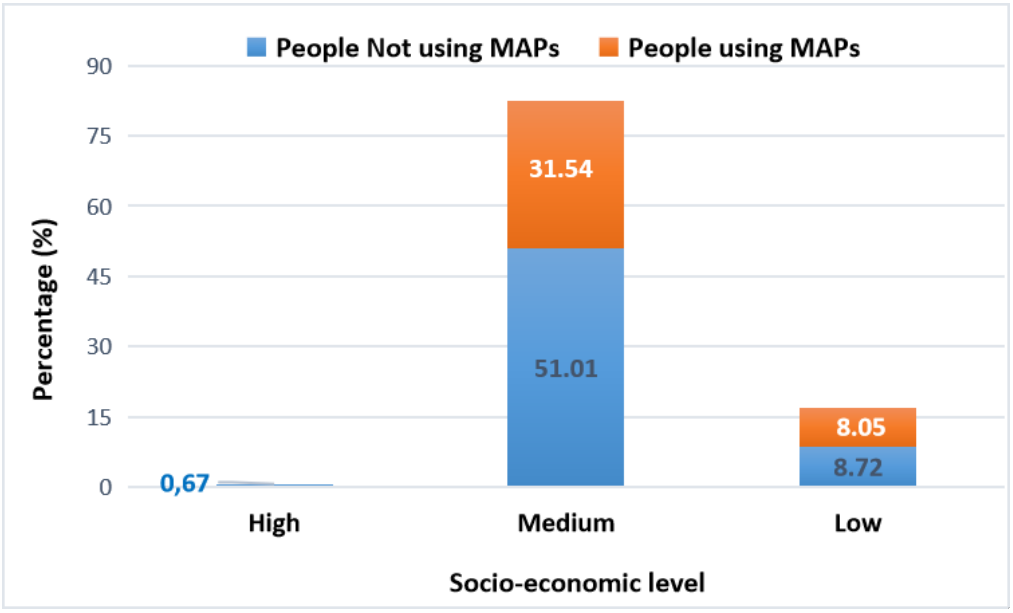

Figure 5. Distribution of respondents using or not MAPs during the pandemic COVID-19 according to their Socio-economic level

Marital status

Regarding the marital status of interviewed people, in both cases (people using or not MAPs), it can be noted that the majority of them are married, with 33.56% using MAPs and 48.32% not using them.

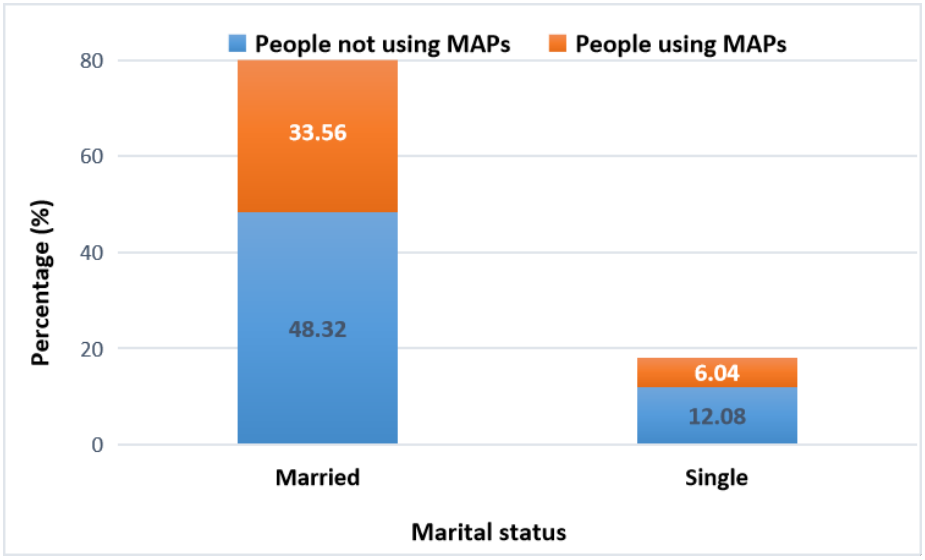

Figure 6. Distribution of respondents using or not MAPs during the pandemic COVID-19 according to their marital status

Multiple component analysis of collected data

Figure 7 shows the results of the Multiple component analysis (MCA).

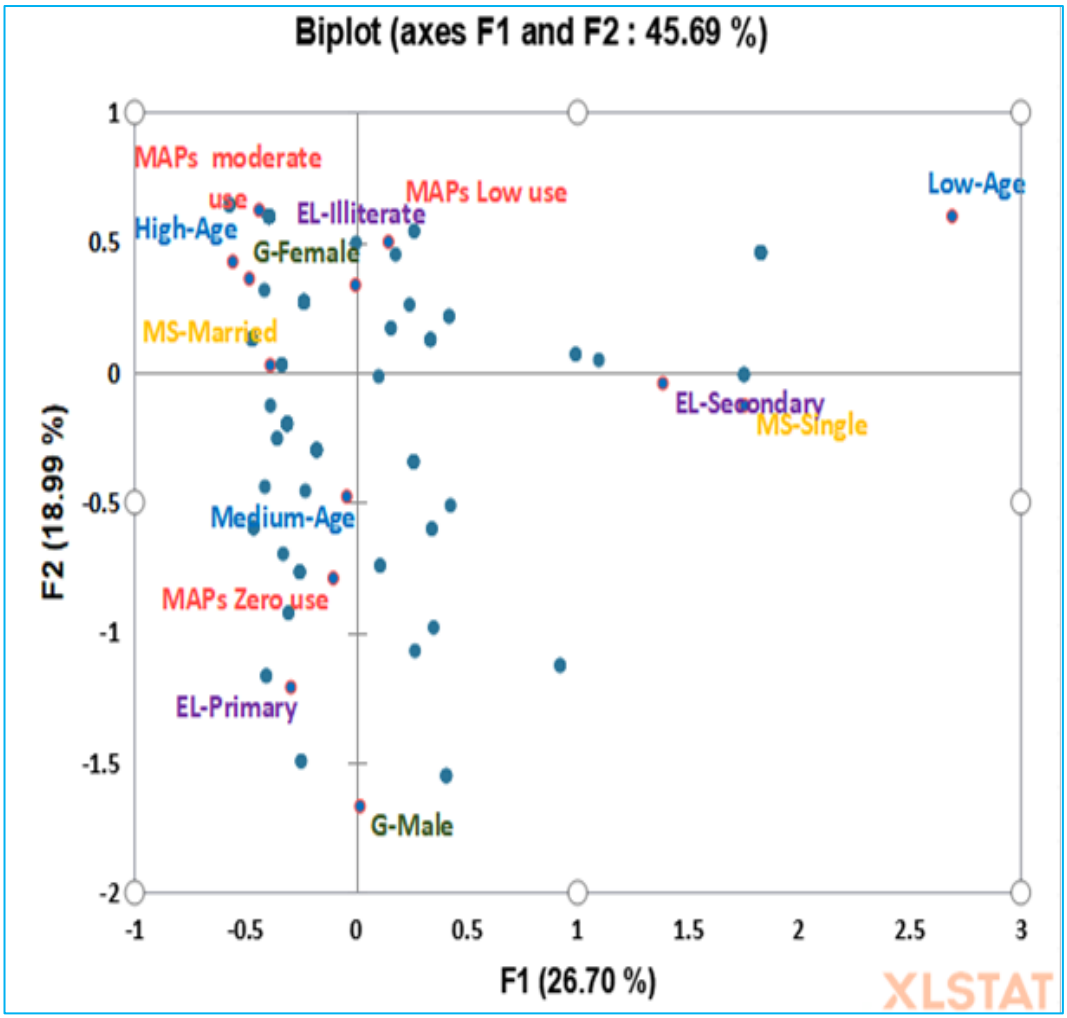

Figure 7. Biplot of multiple component analysis applied to different variables related to the respondents
Low-Age: < 20 years, Medium-Age: 20 < age < 40 years, High-Age : > 40 years; MAPs zero use : People not using MAPs, MAPs Low use: MAPs used < 3, MAPs Medium use: 4 < MAPs used < 7, ; G: gender; EL: educational level; MS: marital status.

F1 and F2 axes present 45.69 % of the total variation in our data. F1 accounts for 26.70 % of the total variation and separates people according to: their use of MAPs (MAPs zero use, MAPs low use «MAPs used<3», MAPs moderate use « 4<MAPs used<7»), their marital status (MS-Married/MS-Single) and according to their age (Medium-Age, High-Age/Low-Age). F2 accounts for 18.99 % of the total variation and separates people according to their Gender (G-Female/G-Male).
In fact, it can be noted that the surveyed people belong to three different categories:

- People without any utilization of MAPs (MAPs zero use) characterized by: G-Male, Age-Medium, MS-Married, and have primary educational level.
- People with low use of MAPs (MAPs low use) characterized by: G-Female, Age-Low, MS-Single, and have a secondary educational level.
- People using MAPs moderately (MAPs moderate use) characterized by: G-Female, Age-High, MS-Married, and are illiterate.

It can be concluded that men didn't tend to use MAPs against COVID-19, probably because they don't have enough knowledge on the traditional uses of MAPs against diseases, whereas women, regardless their age, marital status and educational level, have used MAPs against COVID-19, may be since they have an important knowledge concerning the traditional use of MAPs in the treatment of diseases having similar symptoms than COVID-19.

Floristic analysis

The survey carried out in Ain Chkef area revealed the use of 23 plant species as a remedy against COVID-19 disease, belonging to 15 botanical families. The different plants cited are presented in table 1, in which are shown the following informations: the scientific and local names of plant species and families, plant parts used, preparation and administration modes as well as the calculated indices: FC, RFC and FIV.

Among the 15 botanical families cited by informants, the most representative are Myrtaceae (FIV= 0.305), Rutaceae (FIV= 0.134) and Asteraceae (0.046) (Fig. 8). Other studies conducted in different regions of Morocco revealed also the dominant use of Asteraceae in addition to several botanical families including Lamiaceae and Zingiberaceae (Benkhaira *et al*. 2021a; El Alami *et al*. 2020). Our findings are also consistent with those of different surveys on MAPs used during the COVID-19 conducted in other countries (Rankoana 2021; Sen 2021).

Table 1. Some traits of MAPs used by respondents in Ain Chkef area during the pandemic COVID-19: Scientific and local names, parts used, preparation (Prepar.) and administration (Admin.) modes; FC, RFC and FIV indexes

Scientific name	Vernacular name	Parts used	Mode of:		Indices		
Families Species			**Prepar**	**Admin**	**FC**	**RFC**	**FIV**
Amaranthaceae							**0.006**
Beta vulgaris L.	**L-barba**	R	C	O	1	0.006	
Apocynaceae							**0.013**
Nerium oleander L.	**Defla**	L	F	E	2	0.013	
Asteraceae							**0.046**
Artemisia herba-alba Asso	**Chih**	L	D, F	O, E	7	0.046	
Chenopodiaceae		L	R (juice)	O	1	0.006	**0.006**
Dysphania ambrosioides (L.) Mosyakin & Clemants	Mkhinza						
Cupressaceae							**0.033**
Tetraclinis articulata (Vahl) Mast.	**El'ar'ar**	L	F	E	5	0.033	
Fabaceae							**0.020**
Trigonella foenum- graecum L.	**Halba**	S	I	O	3	0.020	
Lamiaceae							**0.040**
Lavandula officinalis Chaix	**Lakhzama**	Fl	D, F	O, E	6	0.040	
Marrubium vulgare L.	**Merriwta**	L	D	O	1	0.006	
Mentha pulegium L.	**Fliyyo**	L	I, D, F	O, E	11	0.073	
Origanum compactum Benth.	**Zaâter**	L	M, D, F	O, E	12	0.080	
Rosmarinus officinalis L.	**Azir**	L	D, F	O, E	5	0.033	
Salvia officinalis L.	**Ssâlmya**	L	D	O	1	0.006	
Lauraceae							**0.013**
Cinnamomum verum J. Presl	**Qarfa**	B	R, M	O	2	0.013	
Laurus nobilis L.	**Wrak sidna Moussa**	L	F	E	2	0.013	
Liliaceae							**0.040**
Allium cepa L.	**Bassla**	Bu	R	O	8	0.053	
Allium sativum L.	**Touma**	Bu	R	O	4	0.026	
Lythraceae							
Punica granatum L.	**Er-rummân**	Fr	R	O	2	0.013	
Myrtaceae							**0.305**
Eucalyptus. globulus Labill.	**Kalitos, Kalitous**	L	F	E	70	0.469	
Syzygium aromaticum (L.) Merr. & L.M. Perry	**Qronfel**	Fl	I, M, D, F, R	O, E	21	0.140	
Oleaceae							**0.006**
Olea europea L. subsp. europea	**Zeitoun**	Fr	R	O	1	0.006	

Ranunculaceae							**0.013**
Nigella sativa L.	**Sanouje, Habba sawda**	S	R	O	2	0.013	
Rutaceae							**0.134**
Citrus limon (L.) Osbeck	**El-hammed**	Fr	R (juice)	O	20	0.134	
Verbenaceae							**0.013**
Verbena officinalis L.	**Louiza**	L	D	O	2	0.013	

Preparation modes: Prepar: preparation; C: cooked; F: fumigation; D: decoction; R: raw; I: infusion; M: maceration
Administration modes: Admin: administration; O: oral; E: externally
Parts used: L: leaves; S: seeds; Fl: flowers; Fr: fruit; B: bark; Bu: bulb

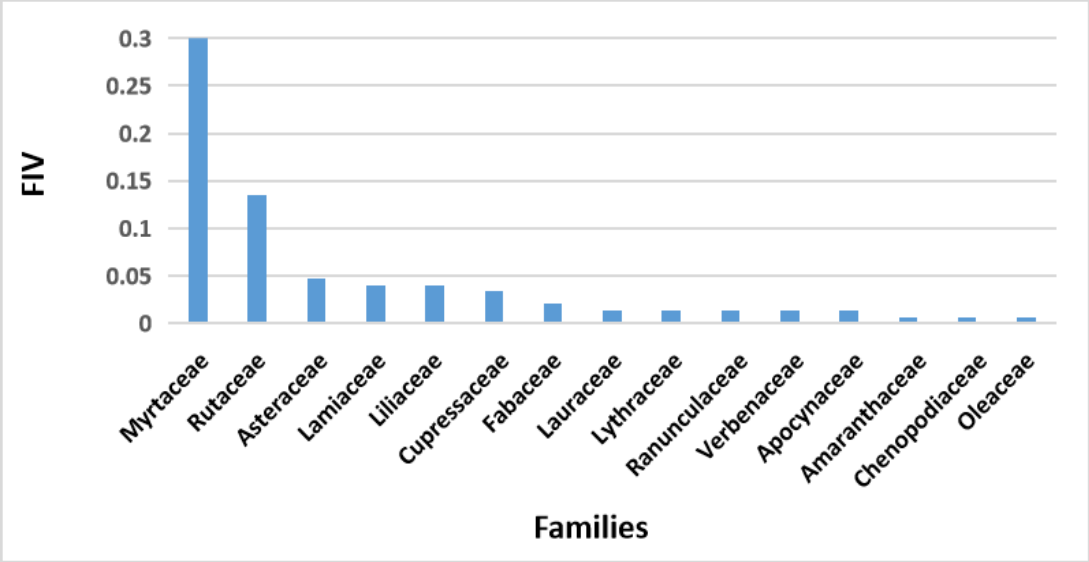

Figure 8. Distribution of plant families cited by respondents according to their FIV.

As regard the use frequency of cited plant species which is revealed by RFC index, figure 9 shows that the most used species are: *Eucalyptus globulus* Labill. (RFC=0.469), *Syzygium aromaticum* (L.) Merr. & L.M. Perry (RFC=0.140), *Citrus limon* (L.) Osbeck (RFC=0.134), *Origanum compactum* Benth. (RFC=0.080), *Mentha pulegium* L. (RFC=0.073) and *Allium cepa* L. (RFC=0.053). The frequent use of these plants species during the pandemic may be explained by the trust of respondents on their efficiency in boosting immunity and their ability to treat the different symptoms related to COVID-19 including cold, fever and cough. Furthermore, the most cited species (*Eucalyptus globulus* Labill.) was also found frequently used during COVID-19 pandemic in other Moroccan regions including North, South and Center Morocco cities (Belhaj and Zidane, 2021). The large use of this species could be associated to its richness in eucalyptol and its effectiveness in sanitizing the air and treating respiratory diseases (Belhaj and Zidane, 2021).

Plant parts used

According to figure 10, different parts of MAPs were used by respondents during the pandemic COVID-19. However, leaves were the most used parts (PPV= 58.45%), followed by fruits (PPV= 13.52%), flowers (PPV= 13.04%), bulb (PPV= 11.59%), seeds (PPV= 2.41%) and bark (PPV= 0.96%). The dominant use of leaves has been reported in other works (Jaadan *et al*. 2020; Jeddi *et al*. 2021), and could be explained by their richness in bioactive molecules (El Hachlafi *et al*. 2020), and the ease of their collection (Salhi *et al*. 2010).

Preparation mode

During the pandemic COVID-19, several preparation modes of MAPs have been made by respondents of Ain Chkef area in order to benefit from the plant active compounds. Fumigation was the most used preparation mode (54.87%), followed by raw (22.56%), decoction (11.28%), infusion (6.15%), maceration (4.61%) and cooking (0.51%). The frequent use of fumigation could be related to the trust of people on the potential of this method to extract the active compounds from plants and its ability to induce a good disinfection of the air. In this context, it's important to mention that the use of *Nerium oleander* by people of *Ain Chkef* through fumigation helped them for air disinfection, and didn't cause a toxicological effect because of its external use.

Najem *et al*. (2022) also found that fumigation was among the dominant preparation modes used by Moroccan people of Meknes city during the pandemic COVID-19. However, in other Moroccan areas, a variety of MAPs preparations modes were adopted during this pandemic (Benkhaira *et al*., 2021a; Chaachouay *et al*., 2021; Flouchi *et al*., 2023). This diversity of MAPs preparation modes reveals a richness of ethnomedicinal knowledge in different regions of Morocco.

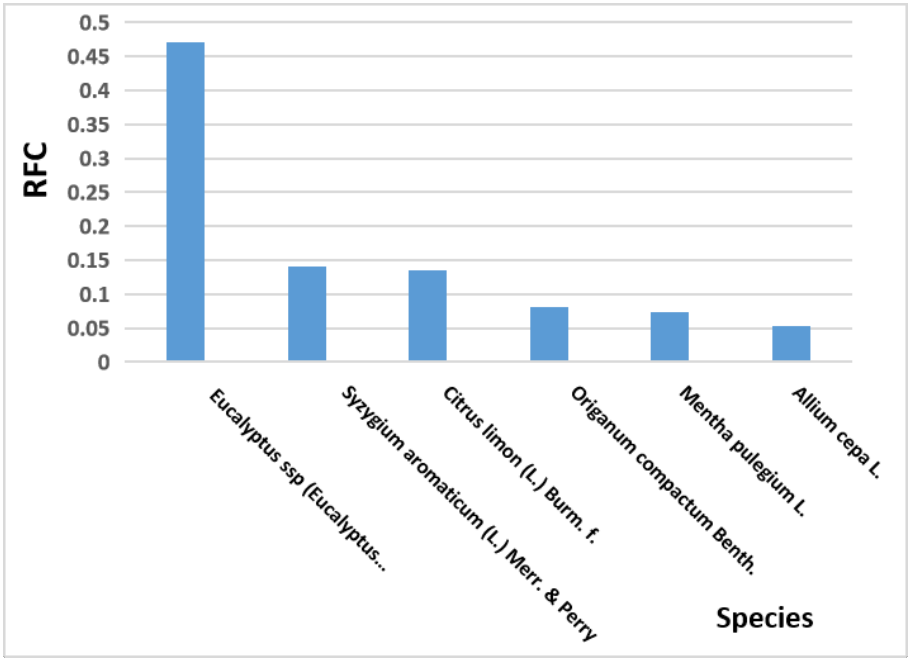

Figure 9. Distribution of the most cited species by respondents according to their RFC

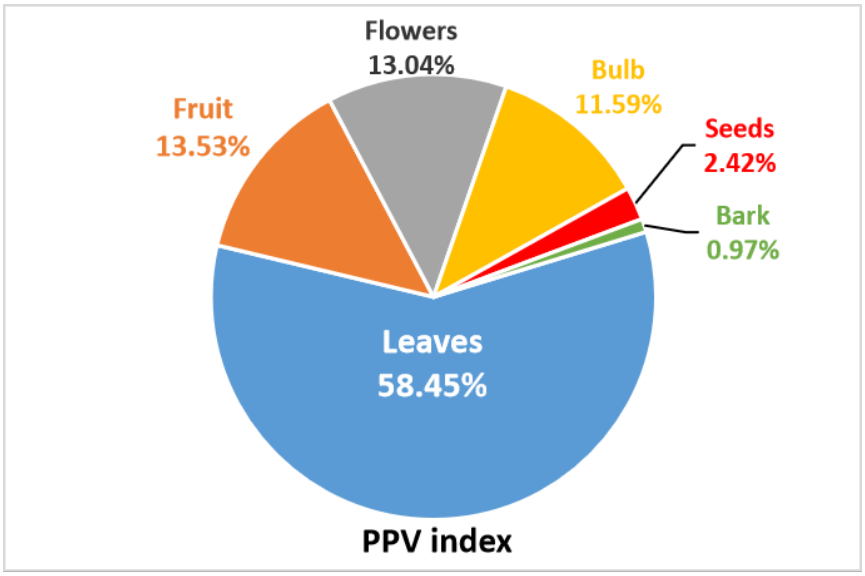

Figure 10. PPV index of plant organs used by respondents

Jaccard Coefficient of Similarity (JCS)

JCS allows to make comparisons between plant species cited in the present work and those reported in other studies carried out in adjoining areas (Ullah *et al.* 2023). A few surveys regarding the use of MAPs in response to COVID-19 in Fez-Meknes region, were found after a deep literature research that we conducted using different Web search engines: Google Scholar, Scopus, Science Direct, Web of Science and JSTOR (Table 2). The highest JCS value was 28 %, followed by 21% and 17%, obtained after comparing the cited species in our study to those reported in the published studies performed by Najem *et al*. (2022); Flouchi *et al*. (2023); Benkhaira *et al*. (2021a), respectively. A high value of JCS calculated between two neighbouring regions, may be related to the common knowledge about uses of MAPs against diseases between the populations of these regions.

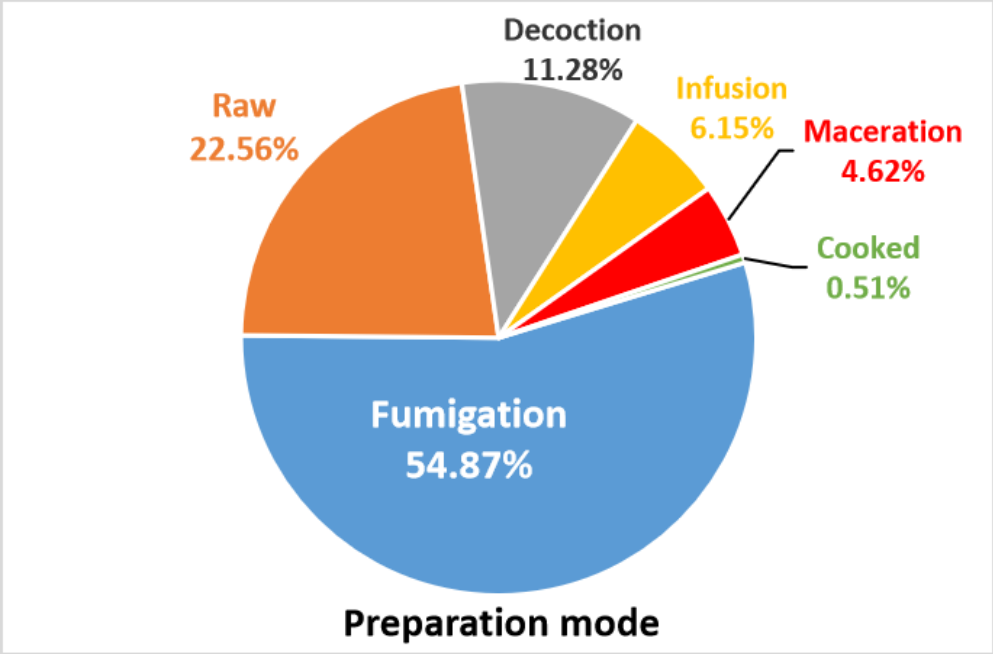

Figure 11. MAPs preparation modes used by respondents during the pandemic COVID19

Table 2. Jaccard Coefficient of Similarity (JCS) of study area

Previous study area	References	Total species in adjoining area	Total species in present study	Plants cited only in adjoining area (a)	Plants cited only in study area (b)	Plants cited in both areas (c)	a + b + c	JCS	JCS%
Meknes	Najem *et al*. (2022)	36	23	23	10	13	46	0.28	28
Taza	Flouchi *et al*. (2023)	17	23	10	16	7	33	0.21	21
Fez	Benkhaira *et al*. (2021a)	43	23	33	13	10	56	0.17	17

a: plants cited only in adjoining area; b: plants cited only in study area; c: plants cited in both areas; JCS: Jaccard coefficient of similarity

Review study

The results of our review study showed that other surveys carried out in different regions around the world revealed the use of the most cited species (RFC>0.053) during the pandemic COVID-19 (Table 3). Moreover, several studies demonstrating the antiviral properties of these plant species could explain their use in order to treat COVID-19. Indeed, *Eucalyptus* (RFC= 0.469; table 3) was revealed to have a potential effect against influenza virus A, Herpes Simplex Virus (HSV) 1, mumps virus (Mieres-Castro *et al*. 2021) and also against SARS-CoV-2 according to docking studies (Fitriani *et al*. 2020).

The major compounds of *Eucalyptus* species essential oils «1,8-Cineole and α-Pinene» could be responsible for their antiviral properties (Mieres-Castro *et al*. 2021). Moreover, *Syzygium aromaticum* (RFC= 0.140; table 2) was found to possess antiviral activities against HSV virus (Yadav *et al*. 2020), as well as against the virus causing COVID-19 demonstrated by in silico investigations (Pandey *et al*. 2020).

These activities are probably related to the major compound «Eugenol» of *Syzygium aromaticum* essential oil (Kaur *et al*. 2019). Concerning *Citrus limon* (RFC= 0.134; table 2), it was proven that it has an important effect against Newcastle Disease (ND) virus (Mtambo *et al*. 1999), Hepatitis A virus (Battistini *et al*. 2019) and against COVID-19 through in silico studies (Khan *et al*. 2021). This effect could be attributed to the major compounds of *Citrus limon* "Limonene and neral" (Paw *et al*. 2020).

Table 3. Worldwide use of the most cited species to treat COVID-19 according to different surveys.

Plant species	RFC	Reported use in different regions around the world to treat COVID-19	References
Eucalyptus ssp. (*Eucalyptus globulus* Labill.)	0.469	- Cusco, Peru	Villena-Tejada et al. (2021).
		- Colombia	Cordoba-Tovar et al. (2022).
		- Morocco	Belhaj & Zidane (2021)
		- Pasvalys District, Lithuania	Pranskuniene et al. (2022).
		- Ethiopia	Megersa et al. (2022).
		- Fez city, Northern Morocco	Benkhaira et al. (2021a).
Syzygium aromaticum (L.) Merr. & Perry	0.140	- Nepal	Khadka et al. (2021).
		- Fez city, Northern Morocco	Benkhaira et al. (2021a).
Citrus limon (L.)	0.134	- Colombia	Cordoba-Tovar et al. (2022).
		- Pasvalys District, Lithuania	Pranskuniene et al. (2022).
		- Ethiopia	Megersa et al. (2022).
Origanum compactum Benth.	0.080	- Morocco	Belhaj & Zidane (2021).
Mentha pulegium L.	0.073	- Morocco	Belhaj & Zidane (2021).
		- Fez city, Northern Morocco	Benkhaira et al. (2021a).
Allium cepa L.	0.053	- Nepal	Khadka et al. (2021).
		- Morocco	Belhaj & Zidane (2021).
		- Colombia	Cordoba-Tovar et al. (2022)
		- Pasvalys District, Lithuania	Pranskuniene et al. (2022).
		- Ethiopia	Megersa et al. (2022).
		- Fez city, Northern Morocco	Benkhaira et al. (2021a).

Regarding *Origanum compactum* Benth. (RFC= 0.080; table 2), it was shown that it acts against feline calicivirus (Azizkhani *et al*., 2013), in addition, carvacrol was revealed to be the main active compound in *Origanum compactum* essential oil (Baghouz *et al*. 2022). As for *Mentha pulegium* L. (RFC=0.073; table 2), Parsania *et al*. (2017) showed that it has antiviral properties against HSV 1, moreover, Ćavar Zeljković *et al*. (2022) demonstrated in vitro its activity against SARS-Cov-2. Pulegone and menthone were found to be the major active compounds of *Mentha pulegium* essential oil (Nickavar & Jabbareh. 2018). Furthermore, *Allium cepa* (RFC= 0.053; table2) exhibited antiviral activities against ND virus (Harazem *et al*. 2019), Dengue virus (Ansori *et al*. 2020), and also against COVID-19 proved by molecular docking studies (Adegbola *et al*. 2021; Fitriani *et al*. 2020). Finally, Oleanolic acid was the recommended compound against COVID-19 through an *in-silico* approach (Fitriani et al. 2020).

Conclusion

This study reveals the MAPs used among the local population of Ain Chkef against COVID-19.

The MCA analysis showed that men didn't tend to use MAPs against COVID-19, probably because they don't have enough knowledge on the traditional uses of MAPs against diseases, whereas women, regardless their age, marital status and educational level, have used MAPs against COVID-19, may be since they have an important knowledge concerning the traditional use of MAPs in the treatment of diseases having similar symptoms than COVID-19.

Besides, 23 plants species were cited, belonging to 15 botanical families. The dominant families were Myrtaceae (Family Importance Value (FIV) = 0.305), Rutaceae (FIV= 0.134) and Asteraceae (0.046). Whereas the most used species were *Eucalyptus globulus* (RFC= 0.469), *Syzygium aromaticum* (RFC=0.140), *Citrus limon* (RFC=0.134), *Origanum compactum* Benth. (RFC=0.080), *Mentha pulegium* (RFC=0.073) and *Allium cepa* (RFC=0.053). In addition, despite the low RFC values of the species *Beta vulgaris* L. (0.006) and *Tetraclinis articulata* (Vahl) Mast. (0.033), to the best of our knowledge, it's the first time that their use against COVID-19 was revealed. Hence, further studies regarding the antiviral properties of these species are required.

Moreover, Leaves were the most exploited plant's parts (PPV=58.45%), and fumigation was the preponderant preparation method (54.87%). The literature review performed presents the antiviral properties of the most cited species. Besides, it shows different in silico and in vitro works demonstrating the efficiency of these plants; and highlighted the most important major compounds in these plants that could be responsible for their activities.

However, further in vitro and in vivo studies are required to confirm the potential of MAPs used during the pandemic COVID-19, against the dangerous virus SARS-CoV-2.

Furthermore, since rural areas are characterized by a dominant use of MAPs for therapeutical purposes, a further survey about MAPs used during the pandemic COVID-19 are needed in such areas in order to contribute to the development of antiviral MAPs-derived drugs.

Declarations

List of abbreviations: WHO: World Health Organization; MAPs: Medicinal and Aromatic Plants; RFC: Relative Frequency of Citation; FIV: Family Importance Value; PPV: Plant Part Value; FC: Frequency of citation; N: Total number of people using MAPs; Ns: Total number of cited species in each family; L: Leaves; S: Seeds; Fl: Flower; Bu: Bulb; C: Cooked; O: Oral; F: Fumigation; I: Infusion; D: Decoction; M: Maceration; E: Externally; Fr: Fruit; B: Bark; R: Raw; Prepar; Preparation; Admin: Administration; JCS: Jaccard Coefficient of Similarity; G: Gender; EL: Educational level; MS: Marital status; MCA: Multiple component analysis.

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

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.

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