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Research article

Oral disorders and ethnobotanical treatments: A field study in the central Middle Atlas (Morocco)

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ABSTRACT

The present study was conducted in the Moroccan central Middle Atlas in order to inventory the plants used in the treatment of oral diseases, as well as to document possible risks of intoxication. Thus, 58 herbalists in the region were surveyed to gather ethnomedical information about the plants used in natural remedies preparation. The expression of the data obtained was achieved through the calculation of different quantitative indices, such as: use value (UV), family use value (FUV), relative frequency of citation (RFC), fidelity level (FL), informant consensus factor (ICF) and plant part value (PPV). 29 plants were inventoried, among which, *Ruta montana* L. has the highest use value (UV) and fidelity level (FL) for the treatment of gingivitis, respectively, 0.431 and 43.10. *Marrubium vulgare* L. has the highest citation frequency (RFC = 0.448). Whereas, *Ammi visnaga* (L.) Lam. had the highest value of the informant consensus factor (ICF = 0.846) as the most used species for the treatment of high number of oral pathologies and dental abscesses. Furthermore, the leaves generally prepared by decoction and administered by gargle constitute the most used part of the plant (PPV = 54.05). But, several plants recommended for the treatment of oral diseases are dangerous; in fact, *Marrubium vulgare* L., *Atractylis gummifera* L., *Anacyclus pyrethrum* L., *Ruta montana* L. and *Peganum harmala* L. were reported to be toxic by all the respondents. So, in spite of the virtues of medicinal plants, the toxic potential of some of them requires great vigilance in their therapeutic use.

1. Introduction

According to the World Health Organization, oral health is an integral part of general human health [1]. Oral diseases and conditions include oral or pharyngeal cancer, oral infection or injury, periodontal disease, loosening and loss of teeth, and other diseases and disorders that limit a person's ability to bite, chew, smile and speak, and thus ensure their psychosocial well-being [1].

Oral conditions are often considered to be of a non-emergency nature, mainly tooth decay and periodontal disease, but they are considered a serious public health problem because of their relatively high prevalence and incidence [2] and their repercussions on the general state of health of individuals, by being possibly associated with some pathologies such as cardiovascular disease, gastropathy and certain neuralgia [3].

In 2016, the study on the global burden of morbidity revealed that half of the world's population (3.58 billion) suffers from oral diseases, and the permanent teeth decay as well as baby teeth decay are dominant, respectively, with 2.4 billion people and 486 million children [4].

Therefore, the treatment of various oral conditions represents a real economic burden, and care, both curative and preventive, requires an investment that many cannot afford, especially in developing countries.

In Morocco, particularly in mountainous areas, geographical isolation and difficulties of access to primary oral health care services and the low incomes of local populations are all factors favoring the use of traditional care, namely those based on plants to treat oral diseases [5, 6].

So, the objective of the present study is first to make an inventory of medicinal plants recommended in traditional herbalism for the oral infections treatment in the central Middle Atlas region; then, a particular interest is given to the eventual risks of intoxication inherent to this ethnomedication. Indeed, it is very interesting to extract from this ancestral knowledge some therapeutic alternatives with fewer side effects and bacterial resistance, and also to emphasize that the plants could be harmful and the control of their use is imperative.

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2. Materials and methods

2.1. The study area

The Middle Atlas is a mountain range that extends over 450 km and covers a total area of 27550 km^2 [7]. It constitutes the water tower of Morocco, with four watersheds of the largest Moroccan rivers: Sebou, Moulouya, Oum Rabia, and Bou Regreg. In the central Middle Atlas region, the flora and fauna are very rich, and contain many endemic, rare, and very remarkable species [8]. The vegetation is very diverse; the phytocenoses are rich due to precipitation of both rain and snow according to the altitude [9]. The forest is widespread and constitutes a strategic issue for the region as it's a protected and productive heritage, a genetic reservoir of biodiversity, an important socio-economic resource, in addition of being recreational and cultural space [10].

Our fieldwork was conducted in 6 of the main cities at the central Middle Atlas: El Hajeb in Elhajeb province, Azrou, Ifrane, and Timahdite in Ifrane province, Khenifra and M'rirt in Khenifra province (Figure 1).

2.2. The characteristics of the informants

To determine the sample size (N), we compiled a list of 290 herbalists in the study area, which corresponds to the parent population (P). To obtain a representative sample (N), the ratio (N/P) must be between 15% and 20% [11]. So, in our case we retained a ratio equal to 20%, and the sample size (N) was equal to 58 herbalists.

2.3. The choice of criteria

The inclusion and exclusion criteria used in this study concern three points: plants, cities and informants.

2.3.1. Inclusion criteria

The inclusion criteria of plants were based on the selection of plants that are either spontaneous or cultivated in the study area and used by the respondents to treat oral diseases. The criterion for inclusion of informants was based on their reputation in the field of herbalism. Those selected are native from the study area and have more than 10 years of experience in the practice of herbal medicine or the trade in aromatic and medicinal plants; so, they are likely to provide correct and original information on the use of medicinal plants. As for the inclusion criteria of the cities, only those belonging to the central Middle Atlas and known for their floral wealth and the ancestral knowledge of their local population in terms of phytotherapy were selected for this study.

2.3.2. Exclusion criteria

Plants unused by the respondents to treat oral diseases and those that do not grow in the study area were excluded. Also, informants with less than 10 years of experience or who are not herbalists or are not from the study area were excluded. Cities that do not belong to the central Middle Atlas were excluded from this study.

Furthermore, this study will allow us to transcribe the maximum of information held by herbalists and often transmitted orally, as well as on the flora richness of the study area, especially that the studies made in this direction are fragmentary and few.

2.4. Data collection and interview methods

In the present study, the free listing technique commonly used in social and behavioral sciences, ethnozoology, and ethnobotany was adopted [12]. The survey was conducted among 58 herbalists who were all from the study area and chosen based on their reputations in the field. For them, plants represent an integral part of their daily lives and the herbal medicine is a heritage based on ancestral knowledge transferred from one generation to the next.

The interviews were conducted in Arabic language during seven month, from April 1st 2018 to October 31th 2018; the respondents were asked to list all the medicinal plants which they know and recommend. The surveys were rarely completed in a single visit because the informants didn't provide all the information in one session. So, we sometimes had to return several times to the informant and show patience and availability to collect the information that was directly relevant to our ethnobotanical survey.

The content of the questionnaire sheets was designed to collect as much information as possible. The questionnaire is divided into two parts: the first concerns the informants demographics (age of the respondent, sex, level of education, etc.) and the second refers to the ethno-medical data of each plant, including the local common name, the

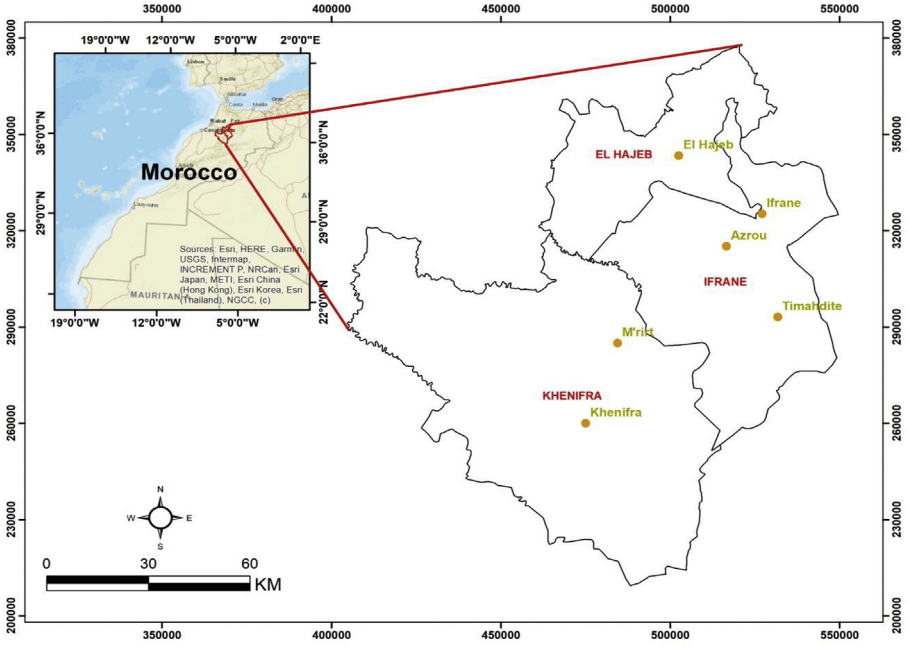

Figure 1. Study area (Red colour indicates provinces and green colour indicates cities or villages).

used part, the method of preparation, the route of administration, the dose, the diseases treated and the toxicity.

In order to limit bias, an attempt was made to be as neutral as possible to avoid making the respondent feel uncomfortable or influencing him to state his opinion. Also, value judgment that might guide the respondent's answers or cause bias on the part of the respondent himself, such as the tendency to give answers that may be perceived as acceptable, were avoided. In addition, the informant was first asked about general, then particular things, to avoid further bias in the results.

2.5. Plant species identification and preservation

Collection of voucher herbarium specimens is standard practice in ethnobotany [13]. Thus, samples the listed plants were collected during several field visits in the different regions of the study area. Each collected plant material was dried, numbered and preserved according to the standard method [14]. The taxonomic identification was carried out in the laboratory according to the manuals for the vascular plants determination "Flore pratique du Maroc" [15, 16, 17]. All specimens were deposited at the Herbarium of Environment & Soil Microbiology Unit, Moulay Ismail University of Meknes.

2.6. Statistical analysis

The data collected on the raw cards were analyzed by the statistical processing software SPSS Statistics 20 and Excel 2010. The analysis of the socio-demographic data of the respondents was performed by a descriptive and quantitative statistical method (ANOVA One-way and Independent Samples T-Test, P-values of 0.05 or less were considered significant).

2.7. Quantitative analysis of the ethnobotanical data

The collected data were used to calculate various quantitative indices, including the use value (UV), family use values (FUV), relative frequency of citation (RFC), fidelity level (FL), informant consensus factor (ICF) and plant part value (PPV).

2.7.1. Use value (UV)

The use value (UV) is used to demonstrate the relative importance of plants known locally. It is calculated using the following formula [18]:

$$UV = \sum_{i=1}^{i=N} Ui/N$$

where Ui = the number of use reports mentioned by each informant i for a given species and N = the total number of informants interviewed.

2.7.2. Family use values (FUV)

The family use values (FUV) are used to identify the significance of plant families, and are calculated using the following formula [19]:

$$FUV = (\sum UV_S)/Ns$$

where UV_s = the use value of species belonging to the same family and N_s = the total number of species present in a given family.

2.7.3. Relative frequency of citation (RFC)

The relative frequency of citation (RFC) shows the local importance of each species and it is given by the following formula [18]:

$$RFC = FC/N$$

where FC = the number of informants using a given species and N = the total number of informants interviewed.

2.7.4. Fidelity level (FL)

The fidelity level (FL) is used to determine the most ideal species used to treat a specific ailment [20]. It is calculated using the following formula [21]:

$$FL\ (\%) = (N_p/N) \times 100$$

where N_p = the number of the informants who reported using a given species to treat an illness and N = the number of informants who mentioned the species for any use.

2.7.5. Informant consensus factor (ICF)

The informant consensus factor is used to determine the agreement between informants about the use of plants for specific use categories. It is calculated using the following formula [22]:

$$ICF = (N_{ur} - N_t)/(N_{ur} - 1)$$

where N_{ur} = the number of use reports for a particular ailment category and N_t = the number of plants mentioned for the treatment of this particular ailment category.

The ICF range from zero to one. A value close to one indicates a high intracultural consensus (most of the informants used the same species to treat the same illnesses) and a value close to zero indicates a high variation in the use of species (the informants disagreed over which species was used for treatment within a category of illness) [22].

2.7.6. Plant part value (PPV)

Plant part value (PPV) is calculated using the following formula:

$$PPV = \frac{RU\ Plant\ part}{RU}$$

where RU = the number of uses reported for all plant parts and RU plant part = the sum of uses reported per part of the plant. The part with the highest PPV is the most used by the respondents [23].

3. Results and discussion

3.1. Socio-demographic data of interviewees

All the participants selected for this study answered all the questions in the questionnaire; so, 100% of the participants are respondents. In total, out of the 58 herbalists traditional medicine practitioners surveyed 87.40% were men and only 12.60% were women, with a sex ratio female/male of 0.14. It is clearly observable that in the study area, men dominate the practice of traditional medicine and the sale of medicinal plants, what is in agreement with the results of other studies in other study areas [24, 25]. Nevertheless, women's knowledge forms an original cultural creation, both in the knowledge of plants and in their medical applications. This knowledge is at the same time dynamic and constantly evolving under the pressure of modern society and culture [26]. Thus, in recent years, women's participation has become increasingly visible through the creation of associations, cooperatives and even pharmacies specializing in medicinal plants, which reflects a clear trend towards valuing women's work and society's recognition of their unquestionable contribution to the development process [27]. The practice of traditional medicine in the central Middle Atlas is widespread among the different age groups, with a dominance of those between 50 and 60 years (30.37%) and those over 60 years of age (24.36%), which shows that the practice of traditional medicine and the knowledge of medicinal plants and their properties require experience accumulated over the years [28]. Nevertheless, the rejuvenation of this field cannot be overlooked, demonstrating the sustainability of the transmission of knowledge from one generation to the next and the persistence of natural and traditional treatments given the difficulties of access to conventional care due to geographical and socio-economic difficulties and the inadequacy of health infrastructures in the rural municipalities of the central Middle

Atlas [5]. Analysis of the data obtained showed that the level of education of most of the respondents is secondary school (42%), 28% have primary school level, 12% have university level and 18% are illiterate. This illiteracy rate can be an obstacle to the documentation of their knowledge by themselves and can lead to the erosion of their knowledge or its false transmission since it will be essentially oral. However, academics can positively affect the development of the practice of herbal medicine in the study area. The indigenous knowledge of the surveyed traditional medicine practitioners regarding the plants involved in the treatment of oral diseases is not influenced by gender, age, education or occupation ($p > 0.05$) (Table 1).

3.2. Quantitative analyse

The survey conducted revealed that among 123 plants declared by traditional medicine practitioners in the central Middle Atlas to have medicinal virtues, 29 plants (23.57%) are used for the treatment of various oral diseases (Table 1).

3.2.1. Frequency of families and their use value

In the central Middle Atlas, plants used in the treatment of oral diseases are spread over 15 families; the Asteraceae family, predominates with 7 species, followed by the Lamiaceae (6 species), the Apiaceae (3 species) and the Rosaceae (2 species). The remaining families are each represented only by one species (Figure 2). Otherwise, the Asteraceae and Lamiaceae, in addition of being the most represented families in the Mediterranean countries [29, 30], contain many spontaneous plants [31] and toxic ones [6, 32].

The families with high FUV are Rutaceae (0.431), Apiaceae (0.425), Juglandaceae (0.276) and Anacardiaceae (0.224) (Table 2); however, these families are not represented by a large number of species. It therefore appears that the ethnobotanical use value of the families doesn't depend on their species richness, but rather on the importance and use value of the species themselves [6]. Also, the important FUV of these families would be mainly based on their richness in secondary metabolites which would endow them with various virtues, in particular, anti-inflammatory, antiviral, antibacterial, anti-allergic and anti-oxidant properties [33, 34].

3.2.2. Species citation frequency and use value

In the study area, the use value (UV) of plants recommended for the treatment of oral diseases varies between 0.431 and 0.017; the most important UV values are those obtained for *Ruta montana* L. (0.431), *Ammi visnaga* (L.) Lam (0.362), *Dittrichia viscosa* (L.) Greuter (0.207), *Marrubium vulgare* L. (0.207) and *Urtica urens* (0.207) (Table 2).

The lowest value, (0.017) is obtained for *Achillea millefolium* L., *Origanum compactum* Benth. and *Ficus carica* L. Similar studies carried out in other Moroccan regions have shown that high use values were obtained for others plants different from those in the present study; these include *Syzygium aromaticum* (0.94), *Acacia nilotica* (0.92), *Juglans regia* (0.75) in Casablanca city [35] and *Origanum compactum* Benth. (0.88), *Syzygium aromaticum* L. (0.82) and *Juglans regia* L. (0.78) in Meknes city [36].

In addition, high UV medicinal plants should be subjected to biochemical and pharmacological analyses to identify their active compounds in order to develop therapeutic alternatives with fewer side effects and less bacterial resistance. Plants with low UV should not be ignored in order to better ensure the transmission of ancestral knowledge to future generations [37].

On the other hand, the results show that the relative frequency of citation (RFC) of the plants used in the treatment of oral diseases varies between 0.448 and 0.034. The highest values are those of *Marrubium vulgare* L. (0.448), *Ruta montana* L. (0.431) *Atractylis gummifera* L. (0.379) *Olea europaea* L. (0.362) *Artemisia herba-alba* Asso. (0.293) *Laurus nobilis* L. (0.293) and *Juglans regia* L. (0.276). This indicates that they are very well known by traditional medicine practitioners related to their therapeutic virtues and their wide distribution in the study area [5]. The lowest value of RFC, (0.034), is obtained both for *Foeniculum vulgare* P. Mill., *Hyssopus officinalis* L. *and Rosmarinus officinalis* L..

3.2.3. Oral diseases treated, fidelity level and informant consensus factor

The survey revealed that the plants studied are used in the treatment of a wide range of oral conditions (Table 2) in addition to their recommendation by respondents for the treatment of other conditions, reflecting both the richness of the study area in medicinal plants and the local population's attachment to traditional medicine. Among the most frequent oral pathologies are dental caries, gingivitis and mouth ulcers. Caries are a global dental health problem for both adults and children [4]. Gingivitis is primarily related to interactions between oral bacteria and gingival epithelial cells, often involving anaerobic gram-negative bacteria such as, *Bacteroides forsythus*, *Campylobacter curvus*, *Eikenella corrodens*, *Fusobacterium nucleatum*, *Porphyromonas gingivalis* and *Prevotella intermedia* [38].

In addition, the calculation of the fidelity level (FL) gives an idea of the most recommended plants for the treatment of each type of oral disease [39]; Thus, the plant that registered the most important FL is *Ruta montana* L. (43.10%) for the treatment of gingivitis (Table 3). As for *Ammi visnaga* (L.) Lam, it is the most recommended species for the treatment of a high number of oral affections; it has the highest FL for the treatment of dental caries (3.45%), gum bleeding (10.34%) and bad breath (13.79%). Some pathologies are only treated by a single plant; this is the case of oral lesions treated only by *Origanum vulgare* L. (3.45%) and scurvy by *Rosa canina* L. (5.17%). The results also showed that some plants have a restricted spectrum of action, and are used against only one type of oral lesions; for example, *Pimpinella anisum* L. (8.62%) and *Foeniculum vulgare* P. Mill. (3.45%) for oral care, *Anacyclus pyrethrum* L. (12.07%) for toothache, *Dittrichia viscosa* (L.) Greuter (20.69%) for dental abscesses and *Urtica urens* L. (20.69%) for mouth ulcers.

Table 1. Socio-demographic features of the informants.

Variables	Categories	Percentages (%)	P-values
Sex	Female	12.60	0.306
	Male	87.40	
Age	<30 years	10.72	0.348
	30–40 years	20.31	
	40–50 years	14.24	
	50–60 years	30.37	
	>60 years	24.36	
Educational level	Illiterate	18	0.758
	Primary	28	
	Secondary	42	
	University	12	

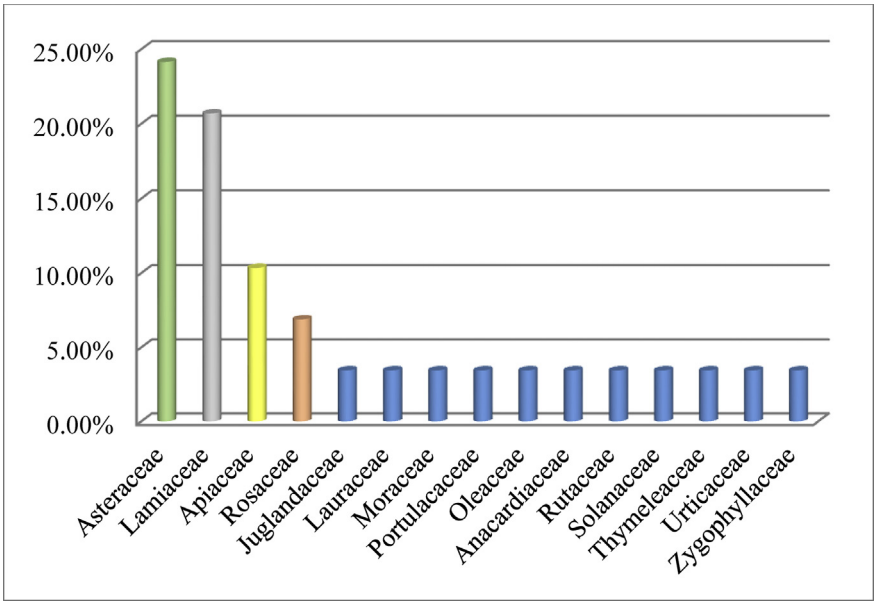

Figure 2. Family use value (FUV) of the listed medicinal plants.

The plants used for the treatment of oral diseases may be different from one country to another; for example, dental caries are treated in the Moroccan central Middle Atlas by *Ammi visnaga* (L.) Lam, *Pistacia atlantica* Dsf., *Juglans regia* L., while they are treated with *Uapaca guineensis* Muell. Arg., *Pycnanthus angolensis* L., *Musanga cecropioides* R. Br. and *Pterocarpus soyauxii* Hooker. by the Pygmy peoples of the Congo [40]. Similarly, toothache is generally treated in the central Atlas by *Marrubium vulgare* L., *Ammi visnaga* (L.) Lam and *Anacyclus pyrethrum* L.. However, in Congo, *Staudtia gabonensis* Warb, *Allanblackia floribunda* Oliv. and *Barteria fistulosa* Mast. are recommended [40]. Indeed, the differences in pharmacopoeia between regions are due to the particularity of the flora of each region and even socio-cultural differences.

The Informant Consensus Factor (ICF) reflects the homogeneity of information provided by different informants on the species used to treat a disease category [22]. Table 4 shows that the ICF value varies between 1 and 0.417; oral lesions and scurvy have the highest ICF (1) followed by dental abscesses (0.846), tooth whitening (0.8) and toothache (0.816). The disease category with the lowest ICF is stomatitis (0.417).

The high ICF value reflects agreement among respondents on the recommendation of certain plants to treat a given disease. Thus, plants with a high ICF value are considered effective in treating a particular category of oral disease and constitute a potential source for the discovery of new active molecules that would form the basis of dental bioproducts [6].

3.2.4. Parts of plants used for the treatment of oral diseases

In the central Middle Atlas, the part of the plant to be used depends on the traditional recipe recommended for oral diseases; over the years, the practitioners of this type of medicine seem to have acquired knowledge about the properties of each part, allowing them to know which one is the most effective, certainly in view of its content of active ingredients.

So, based on the plant part value (PPV) index, leaves (0.508) appear to be the most useful for the treatment of oral diseases in the study area, followed by flowers (0.179), fruits (0.108), roots (0.082), seeds (0.031), bark (0.026) and finally branches and sap (0.01) (Figure 3). The high frequency of the leaves use can be explained by the fact that they are both a source of photochemical reactions and a reservoir of organic matter derived from them; they provide the majority of alkaloids, glycosides and essential oils [41].

3.2.5. Preparation methods and routes of administration

In order to treat different oral diseases, and depending on the plant and the pathology treated, practitioners of traditional medicine in the central Middle Atlas use various methods of preparation; in fact, some methods of preparation make it possible to extract higher concentrations of active components than others; the best way of using a plant is that preserves its properties while allowing the extraction of all active elements [42].

Thus, in the study area, the remedies used by the respondents are mainly prepared by decoction (54.05%), in raw form (24.32%) or in the form of cataplasm (10.81%). The other methods of preparation (infusion, maceration, powder, fumigation) are each represented by only 2.70% (Figure 4). Indeed, the frequent use of the decoction can be explained by the fact that this method allows to collect the maximum of active components while reducing or even cancelling the toxic effect of certain recipes [43]. Ethnobotanical studies carried out in other regions of Morocco also confirm the frequent use of decoction [43, 44, 45, 46]; that reflects the effectiveness of decoction and reveals the exchange or the flow of information between practitioners of herbal medicine.

Finally, concerning the routes of administration, gargle comes first with a percentage of 40%, followed by rinsing (17.14%), brushing and chewing with a percentage of 14.29% each, oral and brushing with 5.71%, then inhalation (2.86%) (Figure 5). Gargle allows the remedies to reach the entire oral cavity, even the upper part of the throat. However, in other Moroccan regions, such as Meknes and Casablanca, similar studies have reported that rinsing is the most commonly used route [35, 47].

3.3. Inherent toxicity risks of phytotherapy in case of oral diseases

The ethnobotanical study revealed that 69% of the total of plants used in the central Middle Atlas to treat oral diseases are toxic (Figure 6) according to the statements of the traditional medicine practitioners surveyed (Table 2).

Plants are certainly an effective natural treatment, but this doesn't mean that they are harmless since they contain in their chemical composition, pharmacologically active substances which can induce serious or even fatal side effects [48].

Table 2. List of medicinal plants used to cure oral diseases in the central Middle Atlas region - Morocco-.

Family/Latin names	Local names	Herbarium specimen number	Used part	Method of preparation	Mode of administration	Treated diseases	Toxicity	RFC	UV	FUV
Anacardiaceae										0,224
Pistacia atlantica Dsf.	Lebtem	1810/IS/N°38	Resin	Crude	Masticatory	Bad breath Dental caries	Yes	0,155	0,224	
Apiaceae										0.425
Ammi visnaga (L.) Lam	Bachnikha/ khala	2024/IS/N°38	Flowers: Umbels Fruit	Crude Decoction	Gargle	Gingivitis Dental abscesses Toothache Dental caries Gingival bleeding Bad breath	Yes	0,362	1,155	
Foeniculum vulgare P. Mill.	Besbas	1991/IS/N°38	Fruit	Decoction	Gargle	Mouth Care	Yes	0,035	0,034	
Pimpinella anisum L.	Habat hlawa	46/PTM	Fruit	Decoction	Gargle	Mouth Care	Yes	0,086	0,086	
Asteraceae										0.207
Achillea millefolium L.	Khala	61/PTM	leaves Root	Decoction Crude	Gargle Masticatory	Gingival bleeding Mouth Care Toothache	Yes	0,017	0,052	
Anacyclus pyrethrum L.	Akirkarha	3145/IS/N°40	Root	Powder	The gum is rubbed with a cotton ball containing a little powder	Toothache	Yes	0,121	0,121	
Artemisia arborescens L.	Chiba	3213/IS/N°40	leaves	Decoction	Gargle	Toothache Mouth ulcers Gingival bleeding Gingivitis Herpes labialis Bad breath Stomatitis	Yes	0,035	0,190	
Artemisia herba-alba Asso.	Chih abiad	3207/IS/N°40	leaves Flowers	Decoction	Gargle	Bad breath Gingivitis Toothache Gingival bleeding Mouth ulcers Herpes labialis Stomatitis	Yes	0,069	0,293	
Atractylis gummifera L.	Dad	2828/IS/N°40	Root	Decoction	Rinsing	Tooth whitening Toothache Mouth ulcers Gingival bleeding Gingivitis Herpes labialis Bad breath Stomatitis	Yes	0,121	0,379	
Dittrichia viscosa (L.) Greuter	Terhala	2824/IS/N°40	leaves	Cataplasm	Direct application	Dental abscesses	No	0,207	0,207	
Matricaria chamomilla L.	Babounj lahmir	3161/IS/N°40	leaves Flowers			Toothache Mouth ulcers Gingival bleeding Gingivites Herpes labialis Bad breath Stomatitis	No	0,052	0,207	
Juglandaceae										0.276
Juglans regia L.	Swak	275/PTM	Root Bark	Decoction Cataplasm Crude	Gargle Brushing	Dental caries Gingivitis Toothache Mouth ulcers Gingival bleeding Herpes labialis Bad breath Stomatitis	No	0,035	0,276	
Lamiaceae										0.132
Hyssopus officinalis L.	Azoufa yabsa	2449/IS/N°38	leaves Flowers	Decoction	Gargle	Gingivitis	Yes	0,035	0,034	

(*continued on next page*)

Table 2 (*continued*)

Family/Latin names	Local names	Herbarium specimen number	Used part	Method of preparation	Mode of administration	Treated diseases	Toxicity	RFC	UV	FUV
Marrubium vulgare L.	Mariouta	2313/IS/N°38	leaves	Crude	Masticatory	Toothache Gingival bleeding Bad breath Gingivitis	Yes	0,207	0,448	
Origanum compactum Benth.	Zaatar tadlaoui	2428/IS/N°38	leaves Flowers	Decoction	Gargle	Mouth ulcers Gingivitis Dental caries	No	0,017	0,052	
Origanum vulgare L.	Mrou	2429/IS/N°38	Sap	Crude	Touching the lesions with a cotton pad soaked in fresh sap	Stomatitis Oral lesions	Yes	0,035	0,069	
Rosmarinus officinalis L.	Azir	2305/IS/N°38	leaves Flowers	Fumigation	inhalation	Toothache	Yes	0,035	0,034	
Thymus willdenowii Boiss.	Zaîtra	578/IS/N°38	leaves Flowers	Decoction Crude	Gargle Masticatory	Mouth infection Mouth ulcers Gingivitis Gingival bleeding Bad breath	No	0,035	0,155	
Lauraceae										0.173
Laurus nobilis L.	Wrak moussa	78/IS/N°36	leaves	Decoction	Gargle	Mouth ulcers Gingivitis Bad breath	Yes	0,190	0,293	
Moraceae										
Ficus carica L.	Karmous	205/IS/N°36	Fruit	Decoction Cataplasm	Gargle Direct application	Dental abscesses Toothache Gingivitis	No	0,017	0,052	
Portulacaceae										0.052
Portulaca oleracea L.	Rajla	340/IS/N°36	leaves	Cataplasm	Direct application	Dental abscesses	Yes	0,052	0,052	
Oleaceae										0.362
Olea europaea L.	Zitoune	360/PTM	leaves Branches	Decoction Infusion Crude	Gargle Brushing	Gingival bleeding Bad breath Gingivitis Toothache Mouth ulcers Herpes labialis Stomatite	No	0,086	0,362	
Rosaceae										0.095
Rosa canina L.	Nisrîne	1186/IS/N°36	Bark Fruit	Decoction	Rinsing Oral use	Scurvy Gingival bleeding	No	0,052	0,103	
Rubus ulmifolius Schott.	Tût azzarb, Serrmû	1151/IS/N°36	leaves	Decoction Crude	Rinsing Oral use Masticatory	Mouth infection Mouth ulcers	No	0,052	0,086	
Rutaceae										0.431
Ruta montana L.	Figel	1815/IS/N°38	leaves	Decoction	Rinsing	Gingivites	Yes	0,431	0,431	
Solanaceae										0.069
Hyoscyamus sp	Sikran	509/IS/N°38	Seeds	Decoction	Gargle	Toothache	Yes	0,069	0,069	
Thymeleaceae										0.069
Daphne gnidium L.	Alezzâz	1667/IS/N°38	leaves	Decoction	Gargle	Toothache	Yes	0,069	0,069	
Urticaceae										0.207
Urtica urens	Hariga	209/IS/N°36	leaves	Decoction	Rinsing	Mouth ulcers	Yes	0,207	0,207	
Zygophyllaceae										0.103
Peganum harmala L.	Lharmel	422/IS/N°38	Seeds	Maceration in vinegar Decoction	Gargle	Gingivitis Toothache Mouth ulcers Herpes labialis Bad breath Stomatitis	Yes	0,035	0,103	

Table 3. Fidelity level of medicinal plants used to treat oral diseases.

Illness category	Fidelity level of species (%)
Dental abscess	*Dittrichia viscosa* (L.) Greuter (20.69%), *Ammi visnaga* (L.) Lam (17.24%), *Portulaca oleracea* L. (5.17%), *Ficus carica* L. (1.72%), *Origanum compactum* Benth. (1.72%).
Mouth ulcers	*Urtica urens* L. (20.69%), *Laurus nobilis* L. (12.07%), *Olea europaea* L. (8.62%), *Artemisia herba-alba Asso.* (6.90%), *Matricaria chamomilla* L. (5.17%), *Rubus ulmifolius* Schott. (5.17%), *Artemisia arborescens* L. (3.45%), *Atractylis gummifera* L. (3.45%), *Juglans regia* L. (3.45%), *Thymus willdenowii* Boiss. (3.45%), *Peganum harmala* L. (1.72%).
Tooth whitening	*Atractylis gummifera* L. (8.62%), *Origanum compactum* Benth. (1.72%).
Dental caries	*Ammi visnaga* (L.) Lam (3.45%), *Pistacia atlantica* Dsf. (8.62%), *Juglans regia* L. (3.45%).
Gingivitis	*Ruta montana* L. (43.10%), *Ammi visnaga* (L.) Lam (20.69%), *Laurus nobilis* L. (10.34%), *Olea europaea* L. (8.62%), *Marrubium vulgare* L. (6.90%), *Artemisia herba-alba Asso.* (5.17%), *Atractylis gummifera* L. (3.45%), *Artemisia arborescens* L. (3.45%), *Hyssopus officinalis* L. (3.45%), *Juglans regia* L. (3.45%), *Thymus willdenowii* Boiss. (3.45%), *Ficus carica* L. (1.72%), *Matricaria chamomilla* L. (1.72%), *Origanum compactum* Benth. (1.72%), *Peganum harmala* L. (1.72%).
Gingival bleeding	*Ammi visnaga* (L.) Lam (10.34%), *Marrubium vulgare* L. (10.34%), *Olea europaea* L. (6.90%), *Rosa canina* L. (5.17%), *Artemisia herba-alba Asso.* (3.45%), *Atractylis gummifera* L. (3.45%), *Juglans regia* L. (3.45%), *Achillea millefolium* L. (1.72%), *Artemisia arborescens* L. (1.72%), *Thymus willdenowii* Boiss. (3.45%).
Herpes labialis	*Artemisia herba-alba Asso.* (6.90%), *Atractylis gummifera* L. (5.17%), *Artemisia arborescens* L. (3.45%), *Juglans regia* L. (3.45%), *Matricaria chamomilla* L. (3.45%), *Peganum harmala* L. (1.72%).
Mouth infection	*Rubus ulmifolius* Schott. (3.45%), *Thymus willdenowii* Boiss. (3.45%).
Oral lesions	*Origanum vulgare* L. (3.45%).
Bad breath	*Ammi visnaga* (L.) Lam (13.79%), *Pistacia atlantica* Dsf. (13.79%), *Atractylis gummifera* L. (6.90%), *Laurus nobilis* L. (6.90%%), *Marrubium vulgare* L. (6.90%), *Matricaria chamomilla* L. (5.17%), *Olea europaea* L. (5.17%), *Artemisia herba-alba Asso.* (3.45%), *Juglans regia* L. (3.45%), *Thymus willdenowii* Boiss. (3.45%), *Artemisia arborescens* L. (1.72%), *Peganum harmala* L. (1.72%).
Toothache	*Marrubium vulgare* L. (20.69%), *Ammi visnaga* (L.) Lam (13.79%), *Anacyclus pyrethrum* L. (12.07%), *Daphne gnidium* L. (6.90%), *Hyoscyamus* sp (6.90%), *Atractylis gummifera* L. (5.17%), *Juglans regia* L. (3.45%), *Matricaria chamomilla* L. (3.45%), *Olea europaea* L. (3.45%), *Rosmarinus officinalis* L. (3.45%), *Achillea millefolium* L. (1.72%), *Artemisia arborescens* L. (1.72%), *Peganum harmala* L. (1.72%), *Ficus carica* L. (1.72%).
Mouth Care	*Pimpinella anisum* L. (8.62%), *Foeniculum vulgare* P. Mill. (3.45%), *Achillea millefolium* L. (1.72%).
Stomatitis	*Artemisia arborescens* L. (3.45%), *Artemisia herba-alba Asso.* (3.45%), *Juglans regia* L. (3.45%), *Origanum vulgare* L. (3.45%), *Olea europaea* L. (3.45%), *Atractylis gummifera* L. (1.72%), *Matricaria chamomilla* L. (1.72%), *Peganum harmala* L. (1.72%).
Scurvy	*Rosa canina* L. (5.17%)

Table 4. ICF values by categories for treating oral diseases.

Illness category	N_t	N_{ur}	ICF
Dental abscesses	27	5	0,846
Toothache	11	6	0,5
Mouth ulcers	43	11	0,762
Tooth whitening	6	2	0,8
Dental caries	9	3	0,750
Gingivitis	69	15	0,794
Gingival bleeding	28	10	0,667
Herpes labialis	14	6	0,615
Mouth infection	4	2	0,667
Oral lesions	2	1	1
Bad breath	42	12	0,732
Toothache	39	8	0,816
Mouth Care	8	3	0,715
Stomatitis	13	8	0,417
Scurvy	3	1	1

N_{ur} = the number of use reports for a particular ailment category.
N_t = the number of plants mentioned for the treatment of this particular ailment category.

The present study reveals that some plants with very important RFC are highly toxic; it is the case of *Ruta montana* L., which contains toxic active ingredients, notably furanocoumarins [49] having mutagenic and carcinogenic activities [50]. This species is also responsible for digestive and neurological disorders, and can cause kidney and liver failure that can lead to death [51, 52]. Similarly, the roots of *Atractylis gummifera* L. recommended by traditional medicine practitioners in the central Middle Atlas are the most toxic part of the plant [53], due to their content of diterpenic heterosides: atractylosides, carboxyatractylosides, parquine and carboxiparquine [50] which inhibit oxidative phosphorylation and the Krebs cycle [54] and cause digestive disorders [55], a multi-visceral disorder whose prognosis is mainly linked to the occurrence of fulminant hepatitis and acute renal failure [56]. Similarly, *Marrubium vulgare* L. can cause skin and mucous membrane irritation through psoralen [57, 58]. Moreover, the risks incurred with the use of certain plants should not be neglected despite their low RFC; such is the case of *Foeniculum vulgare* P. Mill. which can cause neurological disorders [59], hepatotoxicity and nephrotoxicity [60].

Otherwise, in addition to the chemical composition, the dose is a determining factor in herbal therapy; indeed, during our survey, it was clearly observable that practitioners of traditional medicine don't use exact doses, and have mainly resorted to the handle, the spoon, and rarely, the pinch. However, a plant with medicinal virtues turns onto poisonous material if the dose is not respected. Also, some false traditional knowledge conveyed by some people, such as the incorrect use of plants due to ignorance of the correct method of preparation (infusion, decoction, etc.) [46] or the ignorance of the method of use (internal or external) may be the cause of unexpected side effects [61]. Likewise, the

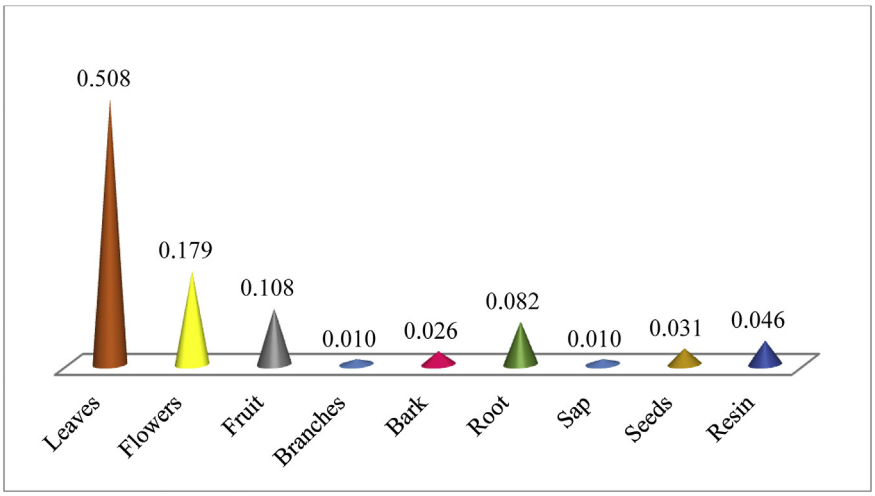

Figure 3. Plant part value (PPV).

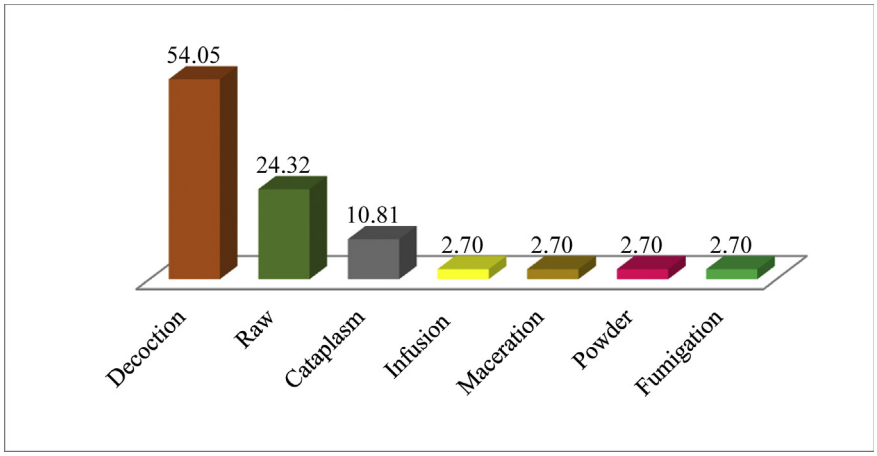

Figure 4. Frequency of the different methods of preparation.

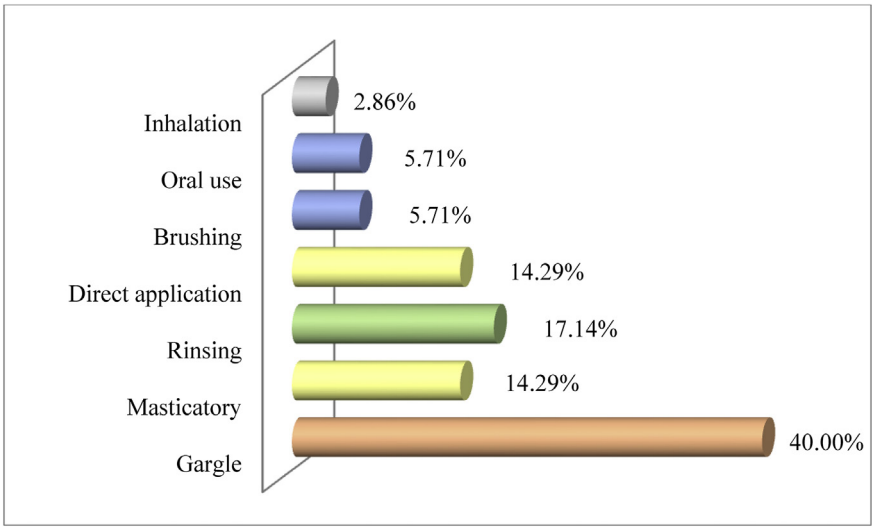

Figure 5. Frequency of different routes of administration.

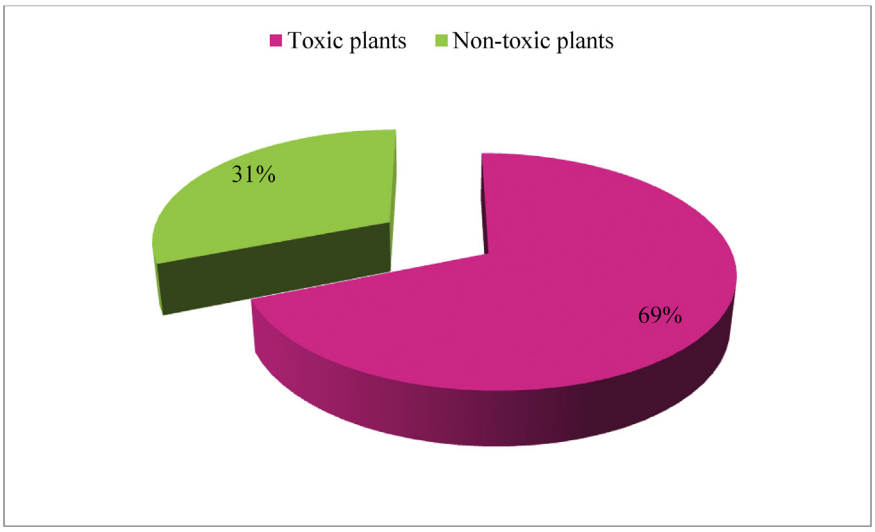

Figure 6. Percentage of toxic plants.

lack of scientific evidence in favour of the efficacy of certain plants and the rarity of clinical studies on the side effects and toxicity of medicinal plants increase the risks associated with phytotherapy [62].

4. Conclusion

The study carried out in Moroccan central Middle Atlas with 58 practitioners of traditional medicine reveals the importance of phytotherapy in the treatment of oral diseases; this is due, in addition to the effectiveness of plants, to some socio-cultural and economic factors. Paradoxically, most of these plants with therapeutic virtues also represent a real danger due to their toxicity and their usage must be used regulated and controlled. Also, pharmacological studies and toxicological tests must be undertaken to translate the knowledge of using traditional plants into scientifically based one.

4.1. Study limitations

This study was limited to one region in Morocco (central Middle Atlas), similar and complementary studies in the other regions are suggested.

Declarations

Author contribution statement

M. Najem: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

H. Harouak: Analyzed and interpreted the data.

J. Ibijbijen: Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data.

L. Nassiri: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

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Competing interest statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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