



(RESEARCH ARTICLE)



Ethnobotanical knowledge of wild food plants in Khenifra, a province in the Middle Atlas region of Morocco

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Abstract

The protection of plant food resources contributes to safeguarding their nutritional value, the culinary heritage as well as the sustainability of the traditional food that uses them. To contribute to the knowledge of wild edible plants (WEPs) used in traditional diet among the population of 7 communes in Khenifra province in a mountainous region of Morocco, an ethnobotanical survey was conducted on 206 local adult respondents, of both sexes, in rural (70%) and urban (30%) areas using a questionnaire and focus groups. Information on sociodemography, knowledge of WEPs and their current and past indigenous food and medicinal uses, culinary knowledge, recipes for their preparation as well as their toxic effects were collected.

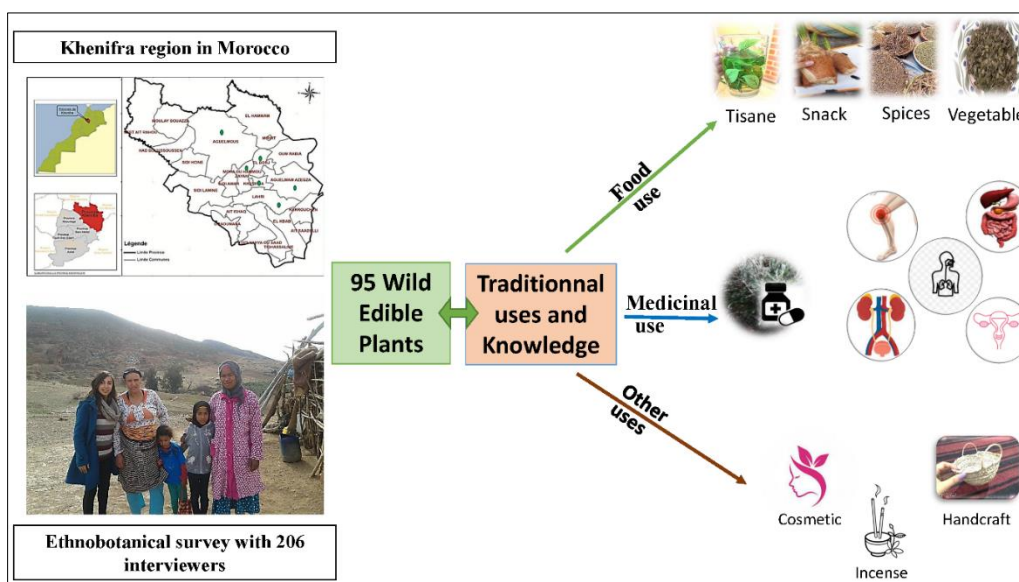
The results show a great food variety of more than 90 WEPs belonging to 40 families and that the local population still often uses different WEPs on a daily basis as food, in therapy or other uses in the study area. Over 50 traditional recipes were recorded, consumed presently and in the past with recipes consumed during times of food shortage. The study also reports that the local population has ethnobotanical information and knowledge of traditional cooking techniques allowing the safe use of WEPs. Dietary diversity linked to knowledge of biodiversity, traditions and culinary culture to use WEPs is observed in the study population. However, this knowledge is in decline, especially among younger generations, which draws attention to the importance of documenting and safeguarding this wealth.

Keywords: Wild edible plants; Biodiversity; Traditional dishes; Culinary culture; Khenifra Region (Morocco)

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Graphical Abstract



1. Introduction

The Maghreb countries represent important sites of biodiversity and important areas for the conservation of plant resources. Due to its geographical position between the Atlantic Ocean to the west, the Mediterranean Sea to the north, and the Sahara Desert to the south and east, Morocco benefits from one of the richest plant diversities in the Mediterranean basin [1]. The Atlas Mountains are characterized by a particularly high rate of endemism in the upper part of the Middle Atlas compared to the other mountains of the country. About 7000 species of 920 genera and 130 families, including 4500 species and subspecies of phanerogams vascular plants are found in the richest sites in local endemic species of Moroccan flora [2; 3; 4]. Morocco is indeed considered as a geographical crossroads having experienced the development of a diversified flora with a fairly high rate of plant endemism on the scale of the Mediterranean region [5] thanks to the coexistence of several types of bioclimates where rainfall levels are highly variable. In addition, the temperate climate prevailing in the country has also allowed the acclimatization of many alien plants [6]. Moreover, thanks to the diversity and richness of the origin of its flora, Morocco is ranked the second biologically diverse country in terms of species in the Mediterranean area after Turkey. The Kingdom has 162 sites with high biological diversity and identified as reserves within the framework of a national conservation strategy [7]. It constitutes a real phylogenetic crossroads which favors it to occupy an exceptional place among the Mediterranean countries with a long medical tradition and traditional know-how based on medicinal plants [8; 3]. The goal in this study is focused on wild edible plants (WEPs) which are part of this diversity, playing an important role in poverty eradication, food security and which can constitute an alternative source of income for several populations. [9; 10; 11]. These WEPs can also solve the problem of malnutrition given their nutrient content [12; 13; 14, 15]. WEPs can be used mainly in food, medicinal or other fields such as decoration, furniture manufacturing or in cosmetics.

Morocco has always been a human crossroads, welcoming populations of different origins, who came with their ethnobotanical knowledge and their traditions [8]. In each region of the kingdom there is a culture linked to the indigenous populations having their own culinary techniques which combine ethnobotanical knowledge, traditional knowledge related to the use of WEPs and culinary techniques. It is therefore a culinary cultural heritage of a region that is transmitted through generations. However, this tradition of using WEPs and the associated knowledge are in remarkable decline [16; 9; 17; 18], due to several factors including deforestation, urbanization, industrialization as well as changes accompanying globalization and modernization of traditions and the development of fast food as well as the lack of interest among the younger generation. All of these observations raise the need to document this valuable traditional knowledge before it is lost forever. Aware of this fact, the present work aims to collect information on the ancestral food ethnobotanical knowledge in the region of the Central Middle Atlas, more precisely the province of Khenifra, in order to first develop an ethnobotanical catalog and then valorize via in-depth scientific research, based on the physico-chemical, nutritional and bioactive characterization of some species of these plants in the study area.

2. Material and methods

2.1. Presentation of the study area

The province of Khénifra where the present ethnobotanical study was carried out is located in the Middle Atlas, the latter has an ecoregion covering 1,200,000 ha, on a altitude gradient ranging from 800 m in the South and 2000 m in in the North. The region geographical location gives it a remarkable bioclimatic variety, an interesting forest cover, offering a specific biological diversity [19] and a socio-economic, recreational and cultural space [20]. Through this forest potential, representing a strategic challenge, the region has a genetic reservoir of biodiversity and a protective and productive heritage. The study area climate is very hot in summer, very cold in winter, with fairly high snowfall and rainfall due to its elevated location relative to the surroundings. In addition, the water table in the area has deep water from wells and surface water, in particular that from rivers and springs, with a runoff based in particular on rains in winter and seasonal showers.

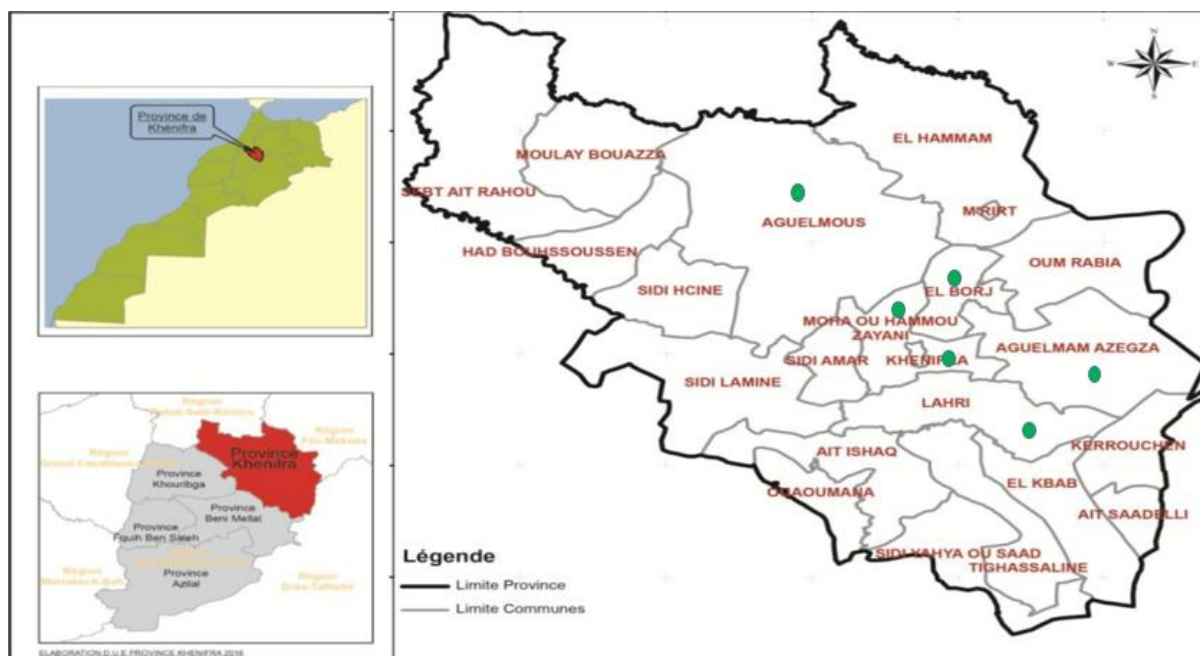


Figure 1 Study area (Khenifra Province)

2.2. Type and setting of the study

It is to study the biodiversity of the region, to collect as much information as possible on native food plants and to document local traditional recipes. In order to achieve these objectives, a field survey was carried out using a structured questionnaire.

2.3. Sampling

The survey respondents were sampled from 6 communes of the province of Khenifra (Figure 1 and Figure 2 A) in urban and rural areas including Khenifra center, Aguelmous, Lehri, Lborj, Aguelmam, Mouha Ouhamou Zayani (arougou) [21]. The sampling method adopted is cluster sampling. Within each commune, and during our random visits, in the fields, the weekly rural markets (called "Souks") or within the households, the members surveyed were chosen initially, according to their ethnobotanical knowledge in general and culinary in particular in order to answer the questionnaire. A second part of the survey used focus groups of 3 to 9 people among neighbors, farmers, herbalists and others. A number of 40 focus groups were surveyed, totaling a number of 206 people surveyed in this part. In parallel, samples were collected and photos taken in the field to illustrate and document this work.

Plant data was collected during different periods and seasons of winter, spring and summer of the years 2017, 2018 and 2019 depending on the availability of species.

2.4. Data collection tools and procedures

Questionnaire design: The questionnaire used in this survey included questions on:

- Sociodemographic and sociocultural characteristics including gender, age, origin, current place of residence, level of education, ethnicity and type of family
- The ethnobotanical knowledge, the traditional culinary knowledge of the WEPs as well as the dynamics of their use over time. Finally, for each species, the collection of the vernacular name, the name in French, the scientific name, the used edible part of the plant, the modes of use and the culinary preparations, and medicinal or other uses in daily life in the present and in the past have also been recorded.

In order to ensure the validation of the questionnaire, a pre-survey was carried out (on 20 interviewees) to test and improve the questionnaire sheet and reformulate the terms used in the questions when necessary.

Only the local plants in the regions studied and cited are retained [22]. The selection of informants interviewed was random based on assumptions adopted in ethnobotanical surveys suggesting that traditional knowledge increases with age [23].

The approach of the interviewed population was based on dialogue in the local language (darija). In the Focus Groups, the time spent per interview was approximately one hour.

2.5. Plant identification

The taxonomic identification of the species mentioned was carried out with the help of a botanist (Prof. Belahyan Abdelmonaim and a herbalist (Prof. Zrid Rachid) from the Department of Biology of the Faculty of Sciences of El Jadida, and the scientific names have been checked using certain works and references [24; 25; 26; 27; 28; 29] and the plant list database (www.theplantlist.org) and (www.ethnopharmacologia.org).

2.6. Data analysis

The recorded data was entered and processed using the Microsoft Excel software and presented in tables and graphs. The results obtained were analyzed using simple descriptive statistical methods. And using SPSS to analyze ethnobotanical knowledge according to age, sex and area of residency.

Furthermore, in order to determine the most known and widespread species, as well as to evaluate the local importance of each species, the Relative Citation Frequency Index (RFC) was calculated, according to the following formula [30]:

$$RFC = \frac{FC}{N} (0 \leq RFC \leq 1) \text{ with:}$$

FC = Number of informants mentioning the uses of the species.

N = Total number of informants in the study

3. Results and discussion

3.1. Sociodemographic characteristics

After eliminating uncompleted questionnaires, the final sample size that participated in the survey was 206 peoples from 6 urban and rural municipalities of Khenifra province (Figure 2 (A)).

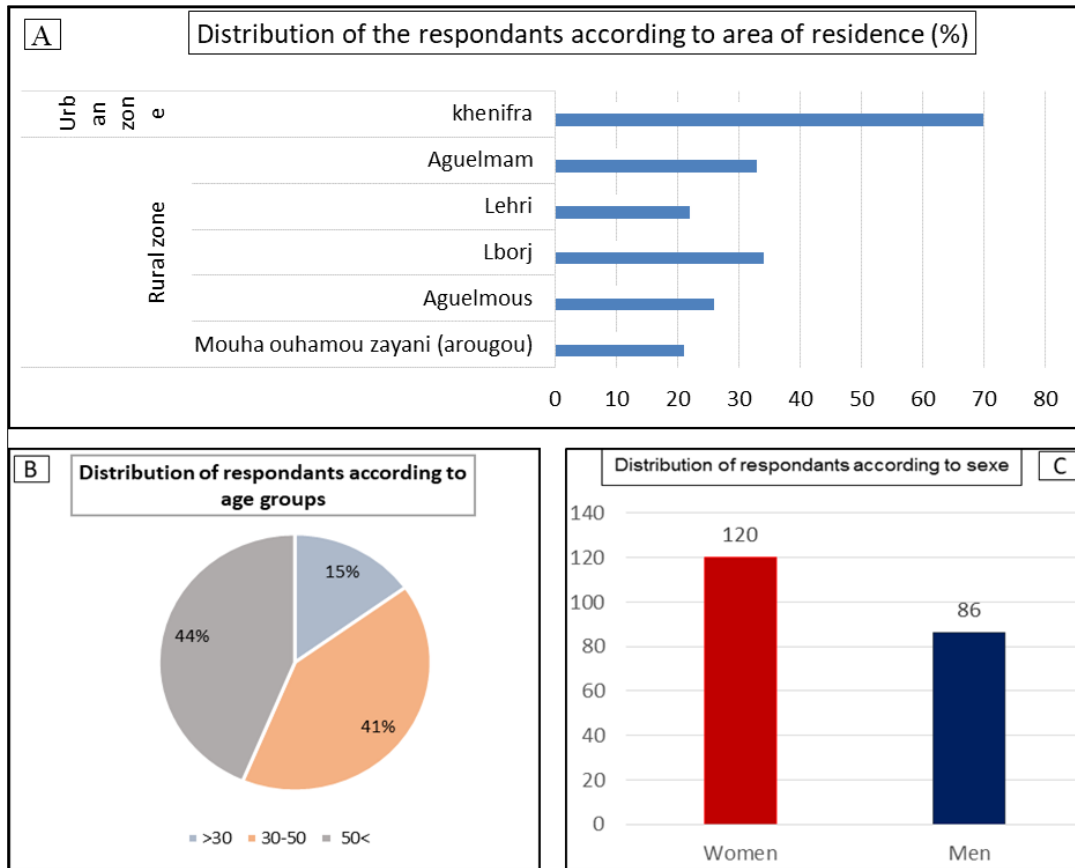


Figure 2 Breakdown of the population surveyed population from the Khenifra communes according to the place of residence (A), age (B) and sex (C)

The age of the respondents was between 22 and 76 years old, with 66.99% residing in rural and 33% in urban areas (Figure-2 (B) et (C)).

3.2. Botanical Data and Plant Uses

3.2.1. Presentation of WEPs identified in the surveyed municipalities of Khenifra province

Table 1 and Figure 3 present the inventory of spontaneous plant species, commonly used or underused in food, herbal medicine, cosmetics, or for other uses. A total of 95 vascular phanerogam species, belonging to 40 different families was identified in this study by the population of the Khenifra region.

Table 1 List of edible wild plants used in the study area

	Identification			Type of use&Traditional use				Method of preparation
	Wild plants, Vernacular names	Scientific names	Family	As food	As Medicine	Other uses	Part used	
1	Lmkhinza (LM52)	<i>Dysphania ambrosioides</i>	Amaranthaceae	Vegetables/ Arome	F/H	-	Leaves	F: Leaves are cooked in the soup, or added to other plants to make Bequoula recipe M: Infusion, or mixed with orange juice.
2	Therou, Dderou (DR41)	<i>Pistacia lentiscus</i> L	Anacardiaceae	-	Di-C-Ug	Cosmetic	Leave-stem-Root	M: Decoction, or Powder Cos: Decoction mixed with Henna for hair care.
3	Lbtem, Igg (BT33)	<i>Pistacia atlantica</i> Desf		-	Di-R-Rh-Ug	-	Leaves-Bark-Resin	M : Decoction
4	Bachnikha, tabchnikhet (BK42)	<i>Ammi visnaga</i> (L.) Lam.	Apiaceae	Arome	Ug problems - Against diarrhea	Decoration/ Dental Hygien	Flower-young Stems	F : Aromatisation M : Infusion of flowers O: Dried stems for dental Hygien
5	Lboubal (BL51)	<i>Ferula comminus</i>		Vegetables	-	-	Inflorescences	F : Used prepare the recipe of “Boubal” as a dish (the same methode of Bequoula’s dish)
6	Lbesbas lbouri (BS43)	<i>Foeniculum vulgare</i> P.Mill.		Vegetables/ Arome	Di/Asthma	-	Seeds-Stems-Leaves-Roots	F: Garnish in Tagine or couscous, seeds for seasoning, or in soup .M: raw, decoction
7	Tebch (TB53)	<i>Ridolfia segetum</i> Moris		vegetables/Snack/Spices	-	-	Fruits - Seeds	F: With Bequoula, raw, seasoning M: Infusion, or mixed with orange.
8	Aatrilal, IchOmlal (TR44)	<i>Ammi majus</i> L.		Spices/	Di- De	-	Fruit	F : Leaves and stems as a powder for seasoning M : Poultice of the entire plant
9	Defla, Alili (DF35)	<i>Nerium oleander</i>	Apocynaceae	-	Di/Hypoglycemic/hair loss /C	-	Leaves	M : Maceration of Leaves against hair loss, decoction of leaves as an hypoglycemic Inhalation against cold

10	Deghmous, Zakkum (DG34)	<i>Caralluma europaea</i> (Guss.) N.E.Br.		-	Asthma-Genital tract Cysts	-	Stem- Leaves	M : Decoction of leaves and stems against asthma or a powder with honey for treatment of genital tract cysts
11	Aghaz (AZ72)	<i>Chamaerops humilis</i> L.	Arecaceae	Snack	Di	-	Fruit	F: Raw, M: Raw
	Jemmakh (JM72)			Snack	Di	Arts and crafts	Root-Aerial parts	F: Raw. M: Raw O: Decorations and artisanal fabrications
12	Bereztam (BZ45)	<i>Aristolochia paucinervis</i> Pome	Aristolochiaceae	-	Digestive poisoning- De	Induce abortion in women	Roots	M : Decoction of roots O: Decoction of roots
13	Ttafs (TF68)	<i>Pallenis spinosa</i> (L.) Cass.	Asteraceae	-	Di-Ug-Re	-	Flower	M : Decoction
14	Asafarn'sem :leachbadsem (ahechlafn'ssem) (AS65)	<i>Lactuca virosa</i> Habl		Drink (Tea)	Di-Anti Poison of snakes	-	Leaves	F : Decoction for detoxification M : Decoction
15	Lkherchouf lbeldi (KB48)	<i>Cynara scolymus</i>		Vegetable/snack	Hepatic disorder- Diuretic	-	Stems- Flower	F: Raw or cooked in Tagine M: Root decoction is recommended in the treatment liver disease
16	Tarrehla (TH64)	<i>Dittrichia viscosa</i> (L.) Greuter		-	De-Ci	-	Leaves- Roots	M : Powder of leaves and roots applied for burns, wound healing and skin disorder
17	Jemra (JM55)	<i>Calendula stellata</i> Cav		-	Ci-anti inflammatory	-	Flower	M : Decoction of dry flowers
18	Addad (AD37)	<i>Carlina gummifera</i> (L.) Less.		-	De-F/H-vertigo	Cosmetic/ anti-dandruff	Root	M : Root used in fumigation or powder Inhaled is used to treat fever and colds, and vertigo O : Powdered root, mixed with henna hair softener and anti-dandruff

19	Tifaf (TI63)	<i>Sonchus tenerrimus</i> L.		Snack	Diuretic-Mild laxative-Choleretic-Re-Anemia	-	Leaves-Roots	F : Raw or Cooked M : Infusion or decoction of Roots
20	Choukahemar, Taskra (TS49)	<i>Echinops spinosissimus</i> Turra		-	Di-Anemie-Ug	-	Flower-Root	M : Decoction of roots and flowers
21	Babounj lbeldi (BB66)	<i>Chamaemelum nobile</i> (L.) All.		Arome	Ocular affection -Di-insomnia - detoxifying	Decoration, and coloration of hair	Flower-stems	F : Infusion M : Decoction of flowers and stems O: Decoction of flowers mixed with henna powder
22	L'qôqlbeldi(QB59)	<i>Cynara scolymus</i>		Snack/vegetables	-	-	Flower	F : Ribs of leaves and young stems are consumed raw or cooked
23	Nejma (NJ54)	<i>Atractylis can</i> L.		-	Di- De	bird trap	Flower- fruit	M: The fruit of the plant after removing the thorns/ decoction of flower O : Latex is used as a bird trap or chewing gum
24	Agheddou/ taghdiouwet, Al Guernina (TG61)	<i>Scolymus hispanicus</i> L.		Snack	Di-Rhume-antidiabetic	-	Leaves-Stems	F : Raw leaves M : Raw leaves and stems, decoction of roots, Inhalation by exposure to water vapor containing the plant
25	Chiba (CB22)	<i>Artemisia arborescens</i> (Vaill.) L		Arome	Di-Ug-antidiabetic	-	Leaves- Stem	F : Infusion of leafy stem with Tea M : Decoction or Infusion of leaves and stems
26	Izri, Chih (CI81)	<i>Artemisia herba alba</i> Asso		-	Di- Vermifuge-Antidiabetic-Ug ailments	-	Leaves - stems	M : Decoction of leafy stems
27	Laattasa (AT67)	<i>Pulicaria arabica</i> (L.) Cass.		-	Di	-	Leaves - Flowers	M : Decoction
28	Akirkarha / Oud Laattass / Barkoukch Izghar (OA69)	<i>Anacyclus pyrethrum</i> (L.) Lag.		-	Di- Re- Ug-articular Rh	-	Root	M : Raw, Decoction or Powdered roots mixed with honey,

29	Isanlbegura : ers founas (EF75)	<i>Anchusa azurea</i> Mill.	Borraginaceae	-	Rh	-	Flower- Leaves	M : Infusion
30	Zeguzaw (ZG46)	<i>Brassica oleracea</i> L.	Brassicaceae	Vegetables	-	-	Leaves	F: Cooked as the “Beqoula” recipes or to garnish soup,
31	Khardal Aswad (KA39)	<i>Brassica nigra</i> (L.) K.Koch		Arome	Co	-	Seeds- Leaves	F : Seasoning (seeds) M : Infusion of leaves
32	Bouhemmou (BM5)	<i>Diploaxis harra</i> (Forssk.) Boiss.		Vegetable	Co-Asthma	-	Leaves- stems	F : Cooked as a vegetable to prepare beqoula dish M : Infusion
33	Guarnouch (GN32)	<i>Nasturtium officinale</i> R. Br.		Snack	Di-Co	-	Leaves- stems	F : Raw M : Raw
34	Sebbar, aknari, kermous ennsara, lkermous lhendi (AK88)	<i>Opuntia ficus-indica</i> (L.) Mill.	Cactaceae	Snack	Di- (Antidiarrhea)- De	Cosmetic	Fruit-stems	F: Raw. M: Raw. O: hair and face care also the rackets, rubbed on the internal surface as an anti-inflammatory and emollient poultice in painful bruises.
35	Lkebbbar, Taylalou (KB51)	<i>Capparis spinosa</i> L.	Capparaceae	Arome	Di- Diuretic- De	-	Seeds-Roots	F: Seeds are pickled in vinegar, or cooked to seasoning snail soup M : Powder of flower buds or roots boiled or decocted
36	Thawsarghine, Serghina (SG31)	<i>Corrigiolla telephiifolia</i> Pourr.	Caryophyllaceae	Arome	Di-Ug-Co-Rh	Cosmetic	Root	F : Powder of roots used as fortifying and aperitif, they are mixed with floor to make a bread M: The root, Decocted or pulverized and mixed with honey O: Roots in powder are for hair softening
37	Tighecht, Thighighet (TG47)	<i>Vaccaria hispanica</i> (Mill.) Rauschert		Vegetables	To rid the body of toxins- De	Washing of clothes & wool laundry	Leaves- Whole plant- Roots	F: Cooked as beqoula dish M: Decoction of the plant for detoxification or for excema O: Washing cloths
38	Herras lehjar (HL57)	<i>Herniaria hirsuta</i> L.		-	Kidney stones- De	-	Roots- Leaves	M : Decoction of roots, leaves or the entire plant, for dressing of wounds and ulcers

39	Taqqua (TQ71)	<i>Juniperus oxycedrus</i> L.	Cupressaceae	-	Rh-Ci-Disinfectant	Parfum/agains t the snakes and scorpions	Leaves-Stems-Roots-Woods	M : By distilling the aged wood/Roots and leaves to get oil applied on the skin, O : Oil used to ward off scorpions/perfume the mugs
40	Tawalt (TW85)	<i>Juniperust hurifera</i>		-	Co-Purifying, Antiseptic	-	Fruits - Woods	M : Burning woods and berries to cleanse the atmosphere and against cold
41	Learaar (AR38)	<i>Tetraclinis articulata</i> (Vahl) Masters		Arome	Hypoglycaemic -Di-Diuretic-against bronchitis	Incense	Leaves-Woods	F : Seasoning M : Leaves used, in decoction or in infusion combined with rosemary, with lavender and pennyroyal. O : Perfuming
42	Sarw, Tara, Tghda Nwaman (SW23)	<i>Cupressus sempervirens</i> L.		-	Allergy- De	-	Resin - Entire plant	M : Powder of the plant
43	Arouk esaad (AS36)	<i>Cyperus longus</i> L.	Cyperaceae	-	Pulmonary Disease	Parfuming	Roots	M : Infusion and inhalation of vapor of the decoction O : parfuming
44	Kelib nessara (KN58)	<i>Hippocrepis multisiliquosa</i> L.	Fabaceae	-	Di	-	Pod	M : Decoction
45	Lfouila, Thabawcht (FL62)	<i>Erophaca baetica</i> (L.) Boiss.		-	Rh	-	Roots	M : Decoction of roots to do Massage or Cataplasme of fresh roots in knee and elbow diseases
46	Lkheroub (KR77)	<i>Ceratonia siliqua</i>		Snack	Di (diarrhea)-Ug	-	Pod	F : Raw M : Decoction of pods
47	Rtam (RT84)	<i>Retama raetam</i> (Forssk.) Webb		-	Headache	-	Leaves	M : Decoction of Leaves and Roots
48	Lktira (KT86)	<i>Astracantha gummifera</i>	-	De-Di-Ug-antidiabetic	Cosmetic	Resin- Roots	M : Decoction	

		(Labill.) Podlech						O : Decoction of resin mixed with water, the gel is applied on the skin or used for hair care and against hair loss
49	Lbellout (BT11)	<i>Quercus suber</i> L.	<u>Fagaceae</u>	Snack	Di-De	Cosmetic	Fruit-Bark	F : Raw M : Decoction of bark against stomach ailments and intestines, the bark Powder mixed with henna against hair loss and dermatological problems O : For tanification of hair or skin with henna
50	Sasnou, boukhennou (SS12)	<i>Arbutus unedo</i> L.	Ericaceae	Snack	-	-	Fruit	F : Raw
51	Aguesmir, Ssemmar, Azelaf (SM89)	<i>Juncus acutus</i> L.	Juncaceae	-	Rh- Kidney stones-Diuretic	Decoration	Leaves-stem-seeds	M : Decoction of seeds, associated with corn stigmas, flowers of Prickly pear and couch grass rhizomes O : Manufacture handmade of the traditional brooms and carpets
52	Lkhzama, Taymerza (KZ513)	<i>Lavendula angustifolia</i>	Lamiaceae	-	Co-Coughs, Asthma, Bronchitis	Against humidity-Inncense	Leaves - Flowers	M : Decoction of flowers O : Burning dry flowers for perfuming
53	Khyata (KY510)	<i>Salvia verbenaca</i> L.		Spices	Di+Ci	Cosmetic	Leaves	F: Powder for Seasoning M: Applied powder of leaves for Wound healing
54	Azukenni ou Zeitraa (ZK78)	<i>Thymus maroccanus</i> subsp. Rhombicus Villar		Arome/Spices	Co-Di	-	Leaves	F : Seasoning bread, soup or tea Tea with dry leaves M : Infusion
55	Morro = Mariouta (MR511)	<i>Marrubium vulgare</i> L.		Drink (Tea)	De-Ci- Intestinal parasites-Diabet-Co	-	Aerial part- Leaves	F : Infusion, M : Chopped plant used as a poultice on the temples for cicatrization, or Decocted leaves for other diseases
56	Salmiya (SL410)	<i>Salvia officinlis</i>		Drink (Tea)	Hormonal disorders - Di-	-	Leaves	F : Infusion of leaves M : Infusion of leaves

					Diabet- Anemia- Hypertension			
57	Mersita ,Thimrsad (MT412)	<i>Mentha suaveolens</i> Ehrh.		Arome	Di-Rh-Ug- Co- Re	-	Leaves	F: Powder of leaves for seasoning the pancakes M : Decoction of leaves, or on poultice or inhalation of some diseases
58	Fliou (FO512)	<i>Mentha pulegium L.</i>		Drink (Tea)	Co-Flu- bronchitis- cough- Abdominal pain	-	Leaves- Stems	F: infusion of leaves and stems M : The whole plant, inhaled, infused or decocted in milk or tea,
59	Chandgoura, ThifTalba (CG416)	<i>Ajuga iva (L.) Schreber</i>		Vegetables or arome	Cold	-	Root	F: Cooked as “Beqoula” dish or as a powder mixed with the bread flour; M : Decoction
60	Mardadouch (MD519)	<i>Origanum majorana L.</i>		-	Rhume- Di- Co	-	Leaves	M : Infusion of leaves
61	Manta (MA514)	<i>Clinopodium nepeta subsp. glandulosum (Req.) Govaert</i>		Drink (Tea)/Arome	Co-F/H-Di	-	Leaves	F : Infusion as refreshing drink M : Infusion of leafy stem used tea against fever, flu, stomach pains...
62	Zeater (ZR610)	<i>Origanum vulgare</i>		Arome/Spice s/ Drink (Tea)	Di- Co- Re- De- Desinfectant	-	Leaves	F : Flavoring Tea, soups, and other dishes with the powder of leaves M : Infusion or Decoction, Inhalation of vapor, also employed In gargle, against the affections of the mouth and, in inhalation, against the cold and the flu
63	Lhbeq (LQ79)	<i>Ocimum basilicum</i>		Spices/Arom e	Di-febrifuge- stimulant	Decoration	Leaves	F : Powder of leaves used for seasoning recipes M : Infusion as a heartburn indigestion and other indications O : In jars near windows as an Insect repellent
64	Izeri = lhelhal (IZ411)	<i>Lavandula stoechas L.</i>		-	Asthma-Re- Co- Hypoglecimic- Di	-	Leaves	M : Decoction of leaves and flowers

65	Sekkoum (SK612)	<i>Asparagus albus</i> L.	Liliaceae	Vegetable	Rh-Re-Anti Jaundice-Dental ailments	-	Aerial part - Root	F : Cooked alone or associated with other plants to prepare Bequoul's recipe M: Decoction of young shoots. As a gargle, against dental ailments
66	Lbessila/Laansal (BA73)	<i>Drimia maritima</i> (L.) Stearn		-	De	Cattle alimentation-Cattle ailments	Root	M : Raw bulb, or rubbing O : Raw
67	Lkhebiza = lbequoula (BQ318)	<i>Malva nicaeensis</i> All.	Malvaceae	Vegetables	-	-	Leaves-Stems	F: Cooked to prepare Bequoula's recipe, alone or with other plants
68	Lkalitos, Caliptus (KS82)	<i>Eucalyptus globulus</i> Labill.	Myrtaceae	-	Co-Re	-	Leaves	M : Inhalation of vapor, or Smoking leaves
69	Tazemourt = azemour (TZ83)	<i>Olea europaea</i> subsp. <i>europaea</i> var. <i>sylvestris</i>	Oleaceae	-	Ug	-	Leaves-Stems	M : Decoction of leaves
	Jebouj (JB83)			Oil snacking	Rh-Gallstone	Mouth Hygien	Seeds (oil)-fruit- Leaves	F : Oil from fruits, to eat with bread M : Apply the oil to the affected area/ decocted leaves against gallstone Chewing the leaves for mouth hygiene
70	Bellaman (BN413)	<i>Papaver rhoeas</i> L.	Papaveraceae	-	Di-Ug-C-Rh-De	Cosmetic	Flower	M : Infusion of flower, or poultice O : Hair and skin dyeing with dried flowers powder
71	Tammart oumghar (TO810)	<i>Evernia Prunastri</i>	Parmeliaceae	Snack	-	-	Whole lichen	F : Raw
72	Arz (RZ91)	<i>Cedrus atlantica</i> (endl.) <i>manetti ex carrière</i>	Pinaceae	-	De-Antiseptic-Hair care-Headache	Afforestation	Aerial part	M : Decoction of aerial parts (leaves, stems, bark)
73	Tanala (TN710)	<i>Sorghum bicolor</i>	Poaceae	Floor	-	-	Seed	F : Powder of seeds as a floor to prepar bread or patties
74	Illan (IL418)	<i>Panicum miliaceum</i>		Floor	Strengthening of bones- Rh	-	Seeds	F : Powder of decorticated seeds is used for bread making or soup M : Seed's powder cooked in the same preparations

75	Nnjem (NM614)	<i>Cynodon dactylon (L.) Pers.</i>		-	Rh-Chronic renal failure	-	Leaves-Rhizome	M : Decoction
76	Thibidhas (lhemida), tasse moumet (HD414)	<i>Rumex pulcher L.</i>	Polygonaceae	Snack	Di	-	Leaves	F: Raw M: Raw or infusion
77	Rajla (RJ317)	<i>Portulaca oleracea L.</i>	Portulacaceae	Vegetables	-	-	Leaves-stems	F: Used to prepare a traditional dish (alone or with other plants to make Bequoula dish)
78	Wden lhallûf (WH150)	<i>Ranunculus bullatus L.</i>	Renonculaceae	-	Di-Painful menstruation-Activation of childbirth	-	Roots	M : Decoction
79	Nbeg (sedra) (NG812)	<i>Ziziphus lotus (L.) Lam.</i>	Rhamnaceae	Snack	Di-Deworm	-	Fruit-Root	F: Raw M: Raw or ground powder drunked with water
80	Boursoud, Taghmamoucht, Lward (BR711)	<i>Rosa canina</i>	Rosaceae	-	De-Dewormer	Cosmetic	Fruit	M : Dried and pulverized flower buds are used, combined with myrtle, clove and henna for hair treatment/Decoction of fruit against intestinal worms
81	Tabgha, serrmû, Tût azzarb (TT814)	<i>Rubus ulmifolius Schott</i>		Snack	Di-Ca	-	Fruit	F: Raw M: Raw
82	Ademmam (DM819)	<i>Crataegus monogyna Jacq.</i>		Snack	Di	-	Fruit	F: Raw, M: Raw
83	Thikhfarth (TF712)	<i>Rosa sempervirens L.</i>		Snack	Di	-	Fruit	F: Raw M: Raw
84	Taroubia= lfouwa (FW515)	<i>Rubia peregrina L.</i>	Rubiaceae	Spices	Anemia	-	Roots-Stems	F: Seasoning recipes. M: Decoction or powder of roots
85	Iwarmi, Lfijel (FJ616)	<i>Ruta montana (L.) L.</i>	Rutaceae	-	Di- Duodenal Ulcer-Re	-	Roots-Aerial part dried	M : Decoction
86	Sefsaf (SF95)	<i>Populus alba L.</i>	Salicaceae	-	Di-Rh- Anti Inflammatory	-	Leaves-Bark	M : Chewing the leaves or decocting bark stems and leaves

87	Amrira (RR416)	<i>Viscum cruciatum</i> Sieber ex Boiss.	Santalaceae	-	Gastrointestinal and inflammatory disorders	Magic	Fruit- Aerial parts	M : Decoction O : For magic
88	Aberdoud eyizm (AY517)	<i>Verbascum sinuatum</i> L.	Scrofulariaceae	Spices	De-Di-Ocular problem	-	Leaves - flowers	F : powdered flowers used as condiment M: Infusion of flowers for deodenal ulcer/flowers and leaves are distilled and used as a drop for ocular problems
89	Tartiya, bidlghoul (BG518)	<i>Mandragora autumnalis</i> Bertol	Solanaceae	-	Abscesses/boils-Rh	Narcotic/for magic	Root-Leaves	M : Crushed roots applied as a poultice rhumatismal and dermacological disorder,
90	Sikran (SI611)	<i>Hyoscyamus albus</i> L.		-	Rh-Skin cancer pills- dental analgesic	For magic	Leaves-Seeds-Flowers	M : Decoction for rheumatismal problems/ Poultice of leaves for skin cancer
91	Lheddja, lheddj (DJ613)	<i>Solanum sodomium</i> L.		-	De-Antiepileptic-Hypotensive Against sterility of women	For toxicification	Fruit-Seeds	M : Half of a fruit, moistened with a little water, for the treatment of dermatoses/poultice of fruit for blood pressure/infusion of the fruits used against sterility of women
92	Enebeddib, Adil ouchen (ND615)	<i>Solanum nigrum</i> L.		Snack	F/H+Di	-	Fruit-Leaves	F: Raw M: Cooked or decocted leaves
93	Chdak Jmal (CJ617)	<i>Datura stramonium</i>			Meningitis-F/H-Insomnia-Asthma	Narcotic	Leaves-Seeds-Flowers	M : Decoction and inhalation of vapor for Headache and menangits O : Narcotic, Toxic
94	Arzaz (alezaz) (LZ520)	<i>Daphne gnidium</i> L.	Thymeliaceae	-	De	Cosmetic	Leaves	M: Ground powder O: Leaves, dried and pulverized, associated with henna for skin or hair care
95	Lherriga (RG318)	<i>Urtica dioica</i> L.	Urticaceae	Vegetable	Di+Rh+Co	-	Leaves	F: Cooked. M: Rubbing on the skin, or by infusion

F: food, M: medicinal, O: Others; Ca: Cardiovascular problems, Co: cold, Ci: Healing(Cicatrization), De :Dermatological problems, Di: Digestive disorder, F/H: fever and Headache, Re: Respiratory problems, Rh: Rheumatic problem, Ug : Urogenital disorder.

Most plants are available in the period from late winter to late spring. The common name of a plant may be the same for several species of the same genus. This is the case of the nettle, locally called “Harriga”, which corresponds to 3 species encountered in the study area *Urtica urens*, *Urtica membranacea*, and *Urtica pilulifera*. This is also the example of thyme locally named “Zaitra” corresponding to *Thymus atlanticus*, *Thymus zygis*, *Thymus satureioides*, *Thymus willdenowii* and *Thymus algeriensis* [31].

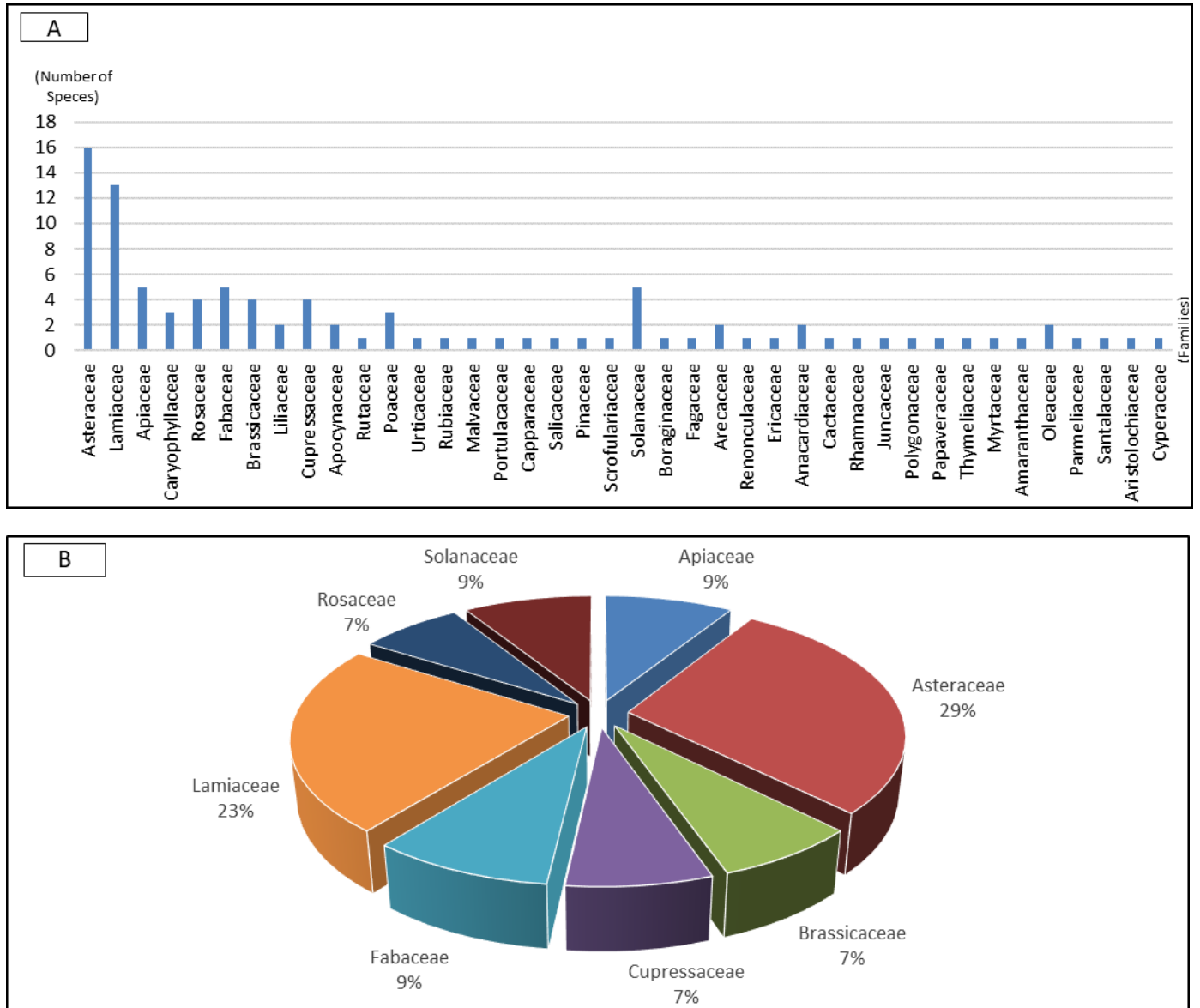


Figure 3 Wealth of botanical biodiversity with detail of number of species of each family (A) and the distribution of the main families of plants found in Khenifra survey region (B)

3.3. Parts used and method of preparation of wild plants for food use

As for the parts used to prepare traditional recipes, it appears that the leaves are the most exploited organs (46%), followed by the roots (15.5%) then the fruits (14.4%). Flowers, seeds and stems are used less and resin was rarely used. Different parts of the same plant are sometimes used either in the same recipe or for several other uses. Moreover, the same species can have several uses at the same time, it can be used as an ingredient in the preparation of food recipes or to treat several diseases, hence the interest in calculating the fidelity level index (RFC).

The WEPs used as food or medicinal plants mentioned by the respondents with at least one use and a very high relative frequency citation index (RFC) compared to the other species listed, included “lbequoula” *Malva sylvestris* L. (RFC= 0.99), “lbelout” *Quercus suber* L.(RFC=0.99), “Zaater” *Origanum vulgare* (RFC=0.98), “Nbeg” *Ziziphus lotus* (L.) Lam (RFC=0.95), “Rejla” *Portula caoleracea* L. (RFC =0.92), “Lmkhinza” *Dysphania ambrosioides*, (RFC=0.90), “Salmia” *Salvia officinlis*

(RFC=0.88), "Lboubal" *Ferula comminus* (RFC=0.86), "Jemmakh" *Chamaerops humilis* (RFC=0.80), "Akir Karha/Oud Lattas" *Anacyclus pyrethrum* L. (RFC=0.79), "Herraslehjar" *Herniaria hirsuta* L.(RFC=0.72), "Berezttem" *Aristolochia paucinervis* Pome (RFC=0.63). Some results found on medicinal plants, are in agreement with a previous ethnobotanical work in the region of Middle Atlas [31; 32; 33].

3.4. Trend of exploitation of wild edible plants

The data from this survey also reveal a decline in the consumption of the majority of food and/or medicinal species, particularly among young people. The several reasons of this decline mentioned by survey respondents, included the abundant availability of varieties of cultivated plants, industry processed foods and pharmaceuticals with faster and more effective effects compared to wild plants. This result has also been confirmed by other researchers reporting the increasing use of pharmaceutical products among indigenous populations as the main determinant of the decrease in the exploitation of medicinal plants [34]. Moreover, certain agricultural practices, including the massive use of herbicides against certain wild plants, considering them as weeds, are also among these factors of the reduction in using these WEPs, not to mention the implication of climate change in the reduction of the availability of some varieties. These factors have also been reported in recent years by several studies [35; 36; 37] claiming that in times of resources scarcity, people were in the obligation to consume wild plants to fight hunger and meet their food and medical needs, while with the abundance of food resources today, they are turning to industrialized food products, which consequently reduces and impoverishes food diversity. However, some species of wild plants are not affected and are still frequently used to this day, including *Portula caoleracea* L. (Rejla), *Malva sylvestris* (Beqoula), *Origanum vulgare* (Zaatar), *Mentha pulegium* L. (Fliou), *Chenopodium ambrosioides* (Mkhinza), *Chamaemelum fuscatum* (Lbabounj) and *Cynara humilis* (Lkoq lbeldi), *Ziziphus lotus* (L.) Lam. (Nbeg).

3.5. Therapeutic use and toxicity of some plants in the study region

The study on the population of Khenifra revealed that ethnobotanical knowledge was held more by women, the elderly and in rural communes compared to males, young surveyed people and in urban communes (Table 2).

Table 2 Ethnobotanical knowledge according to age, sex and area of residency

Characteristics		Mean ± SD	p-value
Age categories (years)	<30	14.89 ± 0.77	0.0001
	30-50	22.27 ± 0.59	
	>50	32.64 ± 0.88	
Sex	Females	27.15 ± 0.83	0,016
	Males	23.96 ± 1.01	
Area of residence	Urban	20.74 ± 0.85	0.0001
	Rural	27.98 ± 0.79	

Among thees knowledges, those related to the more or less secure use of wild food and/or medicinal plants. Indeed, it is necessary to bear in mind that the Moroccan flora contains a large number of more or less toxic plants and that it is sometimes possible to confuse them with edible species [29,38].

An example of such plants is 'ferula comminus' locally called 'lboubal' (Figure 4), which was edible and frequently eaten in the past and continues to be so in the present. This plant was cited by participants in this survey as being a poisonous plant that should not be eaten even by cattle. On the other hand, the respondents also insisted on the mode of preparation of this plant which requires cooking immediately its inflorescences with steam in the top of a couscoussier to eliminate its toxicity. Previous studies have actually demonstrated the presence of toxicity due to the high content of alkaloids in this plant.

There are varieties that are very dangerous and harmful to consumption even if they can be used for their therapeutic effects such as *Citrullus colocynthis* (L.) with the vernacular name of "Hedja." It is a plant known for its pharmacological, purgative, febrifuge and vermifuge effects. Its toxicity is due to the presence of variable concentrations throughout the plant of cucurbitacins which are tetracyclic triterpenes. The species *Aristolochia paucinervis* locally called

"Bereztam" is also used for medicinal purposes to treat intestinal ailments, skin diseases, burns and snakebites. This plant is also harmful to pregnancy, it exposes consumers to the risk of carcinogenicity [39], causes limb paralysis, kidney damage and hematuria [40].

Other plants mentioned have also been declared as toxic such as *Atractylis gummifera* (Addad), *Datura stramonium* L. (chdek jmel), *Caralluma europaea* (deghmous), *Nerium oleander* (Defla).

3.6. Example of local traditional recipes

In the same way as for ethnobotanical knowledge, culinary knowledge and preparation techniques play a very important role in keeping the features and the taste of traditional Moroccan dishes in Morocco in general and in the Khenifra region in particular. As already mentioned before, the present study results show that older women were the ones who knew more information and were the vehicle for transferring this knowledge to the next generation. More than 50 traditional recipes frequently consumed before and/or consumed in times of food shortages and still consumed today, were recorded in this study. Many of these recipes where WEPs are ingredients are grain-based. Among these recipes, a type of pancake locally called "Hercha btimrdsa" prepared with *Mentha suaveolens* Ehrh., a couscous locally called "couscous bchekwa" including goat meat traditionally prepared with butter and different plants including *Origanum vulgare* (Zaater) and *Mentha pulegium* L. (fliou), another recipe known as "Hesouwa blaachoub" is a type of soup prepared with several plants (*Thymus vulgaris*, *Foeniculum vulgare*, *lepidium sativum*) and a very common dish named "Lbequoula" mainly including *Malva nicaeensis* All. or added to other wild plants. All of these recipes were eaten in the past, are still eaten frequently today and/or were eaten in times of food shortages. An example of a recipe based on a local wild plant (ferule) is presented in Figure 4.



Figure 4 The ferrule wild edible plant and the recipe based on a local wild plant (ferrule)

Edible wild plants are a factor for food diversification. Indeed, they are used in addition to a number of other ingredients and spices that are different according to the culinary preparation in a given population and area. This is illustrated by one of these dishes prepared with ferule. The ingredients used in the preparation of this recipe as described by the study respondents are, Bunch of ferules, Cumin, Garlic, Olive oil, Red paprika, Hot pepper and Lemon juice. All these components contribute with their nutritional and functional value in addition to that of the plant taken alone.

Abbreviation

- WEPs: Wild Edible Plants,
- RFC: Relative Frequency Citation index

4. Conclusion

The Khenifra studied region has an abundant diversity of wild plant species with more than 90 species documented in this work used as food and/or medicines. In this region the population has used wild plants in daily life thanks to the knowledge of elderly women who have been able to preserve and transmit the traditional knowledge on a large number of varieties and their use in the culinary and therapeutic field and in a secure way. However, this traditional knowledge is now threatened with extinction, due to several factors including rural migration, lack of interest among younger generations and the declining status of several species frequently used in the study area. Hence there need to protect this heritage and safeguard this richness in biodiversity through more additional research on the WEPs in this region and other regions of the Kingdom and develop methods and strategies to preserve these WEPs. This work also recommends collaborating with the media to produce documentaries on the transmission of ethnobotanical knowledge and traditional techniques relating to their use. It would also be interesting to enhance them by determining their nutritional and pharmacological potential and their biological activities to benefit from their virtue to balance the diet and diversify the dishes, thus contributing to fight against malnutrition which represents high costs for governments.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare no conflict of interest.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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