Ethnobotanical survey about the management of diabetes with medicinal plants used by diabetic patients in Region of Fez-Meknes, Morocco

Hamza Mechchate, Imane Es-safi, Fatima Zahra Jawhari, Amina Bari, Andriy Grafov, Dalila Bousta

Research

Abstract

Background: Diabetes mellitus is a major public health problem in Morocco with more than 1.6 million cases of diabetes in 2017 with an expectation to rise to over 2.7 million cases in 2045. The aim of this work is to provide ethnobotanical information on some of the medicinal plants used by diabetic patients to treat their illness in the region of Fez-Meknes (Morocco).

Methods: A semi-structured and simple questionnaire was carried out. A total of 422 interviews were conducted with diabetic patients presented to diagnosis in the Hassan II Hospital center in Fez in Morocco. The data were analyzed through use value (UV) and relative frequency of citations (RFC).

Results: In total, 50 plant species belonging to 27 families were reported. Lamiaceae (14%), Apiaceae (12%) and Fabaceae (12%) were reported as the most represented families. Among the collected species, 6 plants were reported for the first time as antidiabetic plants in Morocco. The most frequently cited plant species are Trigonella foenum graecum (8.41%), Olea europaea (7.71%) and Prunus amygdalus var. amara (7.71%). Almost 67% and 33% of diabetic patient use medicinal plants as a complement and alternatives to their medication respectively.

Conclusion: This study showed the importance of medicinal plants in the healthcare system for treating diabetes. Knowledge of the use of medicinal plants that are used to manage diabetes may contribute to their preservation and to undertake further pharmacological studies.

Keywords: Ethnobotanical survey, Diabetes, Management of Diabetes, Medicinal plant, Fez-Meknes, Morocco

Correspondence

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Background

Diabetes is a serious, chronic disease (WHO 1999). Raised blood glucose, a common effect of uncontrolled diabetes, may, over time, lead to serious damage to the heart, blood vessels, eyes, kidneys and nerves. More than 400 million people live with diabetes (WHO 2016). According to the International Diabetes Federation (IDF) there were 425 million people in the world with diabetes and this
is projected to increase to 629 million by 2045 (IDF 2017). In Morocco, diabetes mellitus is one of the most common metabolic diseases, there were over 1.6 million cases of diabetes in 2017 and it will rise to about 2.7 in 2045 (IDF 2017).

Diabetes occurs in two main forms, type 1 and type 2. Type 1 accounts for about 10% of diabetes cases, usually caused by an autoimmune attack on β-cells pancreatic, inducing a decrease in insulin secretion. Whereas type 2 is mainly due to insulin resistance (Marx 2002) and accounts about 90% of the cases. It is usually associated with obesity or age.

All forms of diabetes are associated with a number of complications such as retinopathy, nephropathy, neuropathy and cardiovascular disease (King et al. 1998). These complications are due in part to a chronic rise in blood sugar, leading to damage to blood vessels. Currently, diabetes treatment relies heavily on diet, sports, oral hypoglycemic and insulin (Mohler et al. 2009).

Morocco is known for its rich vegetation and plant biodiversity with more than 5200 species and subspecies of vascular plants including 900 endemic plants (Fennane and Ibn Tattou 2012) and over 743 taxa belonging to 101 families and 371 genera. Among these taxa, 40 are endemic to Morocco of medicinal plants (Jamaleddine et al. 2017). The use of medicinal plant and folk medicine date since immemorial time local folk medicine takes a huge part in Moroccan culture and it’s by far the most important source of remedies for primary healthcare (Bellakhdar et al. 1991).

Many studies showed how Moroccan deal with this chronic disease by using medicinal plants (Eddouks et al. 2002; El Amrani et al. 2010; Bousta et al. 2014; Skalli et al. 2019). However, the use of medicinal plants by diabetic patient for treatment of Diabetes in the region of Fez-Meknes has not been conducted. Therefore, the aim of this study was to explore and identify medicinal plant species used by diabetic patients in Region of Fez-Meknes.

Materials and methods

Study area

The study was conducted with 422 diabetic patients in the Hassan II Hospital center in Fez, Morocco (Figure 1). The main hospital who receives patients from all the region which cover a wide geographical area to respond to a population of over 4 million population. There by covering the entire new Fez-Meknes region, which covers an area of 40,075 Km² or 5.7% of the national territory. This region is located in the Plain of Saiss, halfway between the north and the south of the Kingdom of Morocco. The maximum average temperature is 37 °C and the minimum is 6 ° C. The region of Fez-Meknes is administratively two prefectures: the Prefecture of Fez and the Prefecture of Meknes and the seven provinces of Boulemane, El Hajeb, Ifrane, Moulay Yaâcoub, Sefrou, Taounate and Taza (Monographie Generale, 2015).
Data collection
An ethnobotanical survey was conducted from December 2018 to May 2019. The data were collected through a semi-structured and simple questionnaire (Annex A).

Plant identification
Local names, plant ‘props’ (freshly collected plant material or photographs) were used to identify the plants listed by the patients. Voucher specimens of each plant have been collected with the approval of patients and deposited at the herbarium of the Biotechnology laboratory and preservation of natural resources in the Faculty of Sciences, Dhar el Mahraz Fez. Identification of botanical names were undertaken in collaboration with Prof. Amina Bari (Botanist) and following the “Flore Practique du Maroc” (Practical Flora of Morocco) (Fennane et al. 1999).

Data analysis
Fidelity level (FL)
Fidelity level is useful for identifying the key informants’ most preferred species used for treating certain ailments. The medicinal plants that are widely used by the local people have higher FL values than those that are less popular. Fidelity level shows the percentage of informants claiming the use of a certain plant species for the same major purpose. This is designed to quantify the importance of the species for a given purpose.

\[
FL(\%) = \frac{NP}{N} \times 100,
\]

where \(NP\) is the number of informants that claimed a use of a plant species to treat a particular disease and \(N\) is the number of informants that used plants as a medicine to treat any given disease (Friedman et al. 1986).

Use value (UV)
The use-value is a quantitative method that demonstrates the relative importance of species known locally, calculated using the following formula (Phillips et al. 1994):

\[
UV = \frac{\sum U}{N}
\]

Where, “U” refers to the number of uses mentioned by the informants for a given species and “N” refers to the total number of informants interviewed. If a plant secures a high UV score that indicates there are many use reports for that plant, while a low score indicates fewer use reports cited by the informants.

Relative frequency of citations
The relative frequency of citation shows the local importance of each species and it’s obtained by dividing the number of informants, who mention the use of the species, also known as the Frequency Citation (FC), by the number of informants participating in the survey (N) (Tardio and Pardo-de-Santayana 2008).

\[
RFC = \frac{FC}{N} (0 < RFC < 1)
\]

Statistical analysis
Raw data entries were carried out using Microsoft Excel 2016 for windows, Frequencies were calculated with JASP statistics version 0.9.2.0 for windows and figures were made with GraphPad Prism version 6.01 for windows.

Results and discussion
Socio-demographic profile of the diabetic patients
Our results (Table 1) indicate that women (83.65%) used medicinal plants more frequently than men (16.35%). This was also the result of other surveys conducted in different regions of Morocco (Ziyyat et al. 1997; Jouad et al. 2001; Eddouks et al. 2002; Tahraoui et al. 2007; Benkhnigue et al. 2014; Bousta et al. 2014; Skalli et al. 2019). This is related to the role of the women in the region in housekeeping and management of the house problems, having the knowledge of medicinal plants is by the time transmitted by mother and daughter and also by neighbor’s, family and friend. This knowledge could be sometime helpful with minor and major health problems. Women are more attached than men to everything traditional.

The age reparation of the patient interviewed was: for those between 50-65 (53.1%) followed by those between 35-49 (34.4%) and for the ages between 25-34 and more than 65 it was 5.7% and 6.8% respectively our study matched earlier studies that have shown that the use of medicinal plants was more important in age categories between 30 and 60 years (Ziyyat et al. 1997; Jouad et al. 2001; Barkaoui et al. 2017) this category is represented by mostly married women who unroll their main activities in their house.

Most of our interviewed were illiterate with a frequency of 65.7% and about 25.8% who attended elementary school and 7.6% attended the Middle school and only 0.9 attended the university. Same as many other surveys (Ziyyat et al. 1997; Jouad et al. 2001; Benkhnigue et al. 2014; Barkaoui et al. 2017; Skalli et al. 2019) High frequency of illiteracy because of the participation of the girls in the house
activity to transmit all their knowledge about housekeeping and also the use of medicinal plants in daily life to be prepared to roll their own house in the future. Of the participants 88.1% were married, 6.2 widower, 3.2% were single and 2.5% are divorced. In order to reduce their expenses, married people tend to use cheaper and effective alternative to deal with their different illness, medicinal plant appear to be the first and perfect choice to start with.

Table 1. Sociodemographic profile of the diabetic patients

<table>
<thead>
<tr>
<th>Variable</th>
<th>Subgroup</th>
<th>Number</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>Male</td>
<td>69</td>
<td>16.35</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>353</td>
<td>83.65</td>
</tr>
<tr>
<td>Age</td>
<td>25 - 34 years</td>
<td>24</td>
<td>5.70</td>
</tr>
<tr>
<td></td>
<td>35 - 49 years</td>
<td>145</td>
<td>34.40</td>
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<tr>
<td></td>
<td>50 - 65 years</td>
<td>224</td>
<td>53.10</td>
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<tr>
<td></td>
<td>&gt; 65 years</td>
<td>29</td>
<td>6.80</td>
</tr>
<tr>
<td>Educational level</td>
<td>Illiterate</td>
<td>277</td>
<td>65.7</td>
</tr>
<tr>
<td></td>
<td>Elementary</td>
<td>109</td>
<td>25.8</td>
</tr>
<tr>
<td></td>
<td>Middle school</td>
<td>32</td>
<td>7.6</td>
</tr>
<tr>
<td></td>
<td>University</td>
<td>4</td>
<td>0.9</td>
</tr>
<tr>
<td>Familial situation</td>
<td>Married</td>
<td>372</td>
<td>88.1</td>
</tr>
<tr>
<td></td>
<td>Single</td>
<td>13</td>
<td>3.2</td>
</tr>
<tr>
<td></td>
<td>Divorced</td>
<td>11</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>Widower</td>
<td>26</td>
<td>6.2</td>
</tr>
</tbody>
</table>

Sources of information
Their sources of information varied between Herboriste 6.2%, the internet 5.3%, books 1.7% explored by themselves 2.0% but their most important source was other experiences with 84.8% same as (Benkhnigue et al. 2014). This could be explained by the specialties of our society women tend to talk a with each other about their daily problems and this how many new medicinal plant knowledge is spread.

Reasons to use medicinal plants
Those who preferred the phytotherapical care justifying it by its effectiveness 69.2% and the 30.8% left were more convinced about its availability, low cost, and almost no side effect. In accordance with (Jouad et al. 2001) who find that the reasons for the use of medicinal plants are that these natural remedies are less cheap (53%) and more efficient than modern medicines.

Preference between modern and traditional healthcare
Almost the totality (421 of the 422) has indicated that they will consult medical personnel in case of sickness. This result reflects a good reasoning because the medical personnel is the only one who could provide true diagnosis.

Diversity of medicinal plants
In this ethnobotanical survey we recorded information on a total of 50 medicinal plant species, belonging to 27 families (Table 1). Information such as the local name of plant species, used parts, mode of preparation, ethnobotanical indices are provided for each species. Families with the most reported plant species were Lamiaceae (7 species, 14%), Apiceae (6 species, 12%) and Fabaceae (6 species, 12%) (Figure 2). This result is in agreement with previous reports where these families were the most represented families in diabetes mellitus treatment in Morocco (Benkhnigue et al. 2014; Barkaoui et al. 2017; Skalli et al. 2019). Dominance of these families could be attributed to their abundance in the Moroccan flora (Fennane and Ibn Tattou, 2012). Among the 50 collected species, 6 plants were reported for the first time as antidiabetic plants in Morocco and 5 were reported elsewhere (Table 2).

Fidelity level, Use value and relative frequency of citation of the medicinal plants
Values of collected plants species ranged from 28.57 to 100% (FL), 1 to 3.50 (UV) and 0.23 to 8.41 (RFC). The UV of Nigella sativa L. and Ficus carica were reported to cure all diseases basing on their religion as a result their UV and FL was not calculated. (Table 3). Of the 50 inventoried species 20 plant species were identified with FL greater than 0.60: Ammi visnaga, Coriandrum sativum, Foeniculum vulgare, Opuntia ficus-indica, Mill.Ceratonia siliqua,
Lupinus albus, Vicia faba, Lavandula stoechas, Marrubium Vulgare, Rosmarinus officinalis, Cinnamomum verum, Salvia officinalis, Linum usitatissimum, Myrtus communis, Olea europaea, Papaver rhoas, Pinus pinaster ssp. hamiltonii var moghrebiana, Loliurn multiflorum, Prunus amygdalus var. amara, Zygophyllum gaetulum.

The plants that have less UV indicated that the plants are significantly used to treat diabetes in the area. Accordingly, a total of 12 plant species have a UV equal or less than 1.50. These plants were: Ammi visnaga, Coriandrum sativum, Opuntia ficus-indica, Mill. Vicia faba, Lavandula stoechas, Linum usitatissimum, Myrtus communis, Olea europaea, Papaver rhoas, Loliurn multiflorum, Prunus Amygdalus var. amara, Zygophyllum gaetulum.)

Based on RFC values, the most frequently used plants to treat diabetes are Trigonella foenum graecum (8.41), Olea europaea (7.71), Prunus amygdalus var. amara (7.71), Caralluma europaea (6.31), Marrubium vulgare (4.44) and Zingiber officinale (3.97). Similar results were reported in other studies conducted in Morocco for Trigonella foenum graecum (Ziyay et al. 1997; Jouad et al. 2001; Eddouks et al. 2002; Benkhnigue et al. 2014; Bousta et al. 2014; Skalli et al. 2019), Olea europaea (Jouad et al. 2001; Tahraoui et al. 2007; Benkhnigue et al. 2014; Bousta et al. 2014; Skalli et al. 2019), Marrubium vulgare (Jouad et al. 2001; Eddouks et al. 2002; Barkaoui et al. 2017) and Caralluma europaea (Benkhnigue et al. 2014).

Previous laboratory analysis of Trigonella foenum graecum has shown that the plant has a dose-related hypoglycemic effect in normal and diabetic rats (Khosla et al. 1995; Abdel-Barry et al. 1997; Raju et al. 2001; Xue et al. 2007) and in type II diabetic patients (Gupta et al. 1984). It has an effect also on glucose homeostasis (Abdel-Barry et al. 1997; Raju et al. 2001; Xue et al. 2007), insulin resistance (Gupta et al. 1984), insulin mimetic effect (Baquer et al. 2011), antioxidant and protective effect (Tripathi and Chandra 2010; Kumar et al. 2012). Olea europaea has been also reported having a significant antidiabetic effect on diabetic rats (Eidi et al. 2009; Wainstein et al. 2012; El-Amin et al. 2013; Sangi et al. 2015) and on rabbits (Al-Azzawi and Alhamdani 2006). It attenuates early diabetic neuropathic pain (Kaeidi et al., 2011). It improves insulin sensitivity (de Bock et al. 2013). Therapeutic effect on lipidic and carbohydrate metabolism (Bennani Kabchi et al. 2000).

Plant parts used, mode of preparation and administration
Seeds were the most frequently used plant parts with a percentage of 33% followed by aerial part (31%) (Figure 3). Dried plants were mostly (59%) used to prepare the treatment and 41% used fresh plant parts. Decoction is the major preparation mode with a percentage of (39%), followed by powder (29%), raw (18%), juice (12%) and infusion (2%).

Plants used as complement or alternative medicine to conventional medicine
The use of medicinal plants were reported as complement (67%) and alternative (33%) to modern medicine (Table 3). Morocco is a country where the knowledge of traditional medicines is incorporated into its culture and is by far a very valuable heritage. Aside from sometimes its low efficacy which may explain the choice of conventional medicine by certain people over medicinal plants.

Conclusions
Several medicinal plants were being used in the study area to treat diabetes. Diabetic patients highly use medicinal plants as a complement and also as alternatives. Six plant species were reported for the first time in Morocco and 5 plants from elsewhere. The wide variety of medicinal plants that are used to treat diabetes and the frequency of citation support the important role of plants in the primary healthcare system of Moroccans. The wide variety of medicinal plants that are used to treat diabetes and the frequency of use among diabetic patients support the important role of plants in the primary healthcare system of Moroccans people. Development of the sector of medicinal plants is a major challenge to come for the scientific community from where the obligation to expand the research to validate or denied the use of certain plant against certain disease and aware people about their toxicity. Therefore, this documented information on the medicinal plants used in the region of Fez-Meknes may be used as baseline data for future pharmacological and phytochemical studies.

Declarations
List of Abbreviations: FL: Fidelity level; UV: Use value; RFC: Relative frequency of citations; F: Fresh; D: Dried; AP: Aerial part; S: Seed; R: Roots; Res: Resin; Epi: Epicarp; L: Leaves; Fr: Fruit; C: Complement; AM: Alternative medicine; ND: No data
Ethics approval and consent to participate: Before conducting interviews, prior informed consent was obtained from all participants. No further ethics approval was required.
Consent for publication: Not applicable
Conflict of interest: The authors declare that they have no conflict of interest.
**Table 2. Medicinal plants used for the treatment of diabetes in the region of Fez-Meknes Morocco**

<table>
<thead>
<tr>
<th>Name of plants</th>
<th>Vernacular name</th>
<th>Citation</th>
<th>RFC</th>
<th>UV</th>
<th>FL</th>
<th>Citation in Morocco</th>
<th>Citation elsewhere</th>
</tr>
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<tbody>
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<td>Apiaceae</td>
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<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td><em>Ammi visnaga</em> (L.) Lam. BPRN20</td>
<td>Bechnikha</td>
<td>9</td>
<td>2.10</td>
<td>1.44</td>
<td>69.23</td>
<td>(Bousta et al., 2014; Eddouks et al., 2002; Jouad et al., 2001a, 2002; Tahraoui et al., 2007)</td>
<td>(Demoz et al., 2015)</td>
</tr>
<tr>
<td><em>Apium graveolens</em> L. BPRN25</td>
<td>Krafess</td>
<td>8</td>
<td>1.87</td>
<td>1.88</td>
<td>53.33</td>
<td>No Data</td>
<td>(Gutierrez et al., 2014; ROGHANI et al., 2008; Roghani et al., 2007)</td>
</tr>
<tr>
<td><em>Carum carvi</em> L. BPRN15</td>
<td>Karwiya</td>
<td>8</td>
<td>1.87</td>
<td>2.00</td>
<td>50.00</td>
<td>(Amrani et al., 2010; Barkaoui et al., 2017; Benkhnigue et al., 2014; Eddouks et al., 2002; El Jouad et al., 2001; Tahraoui et al., 2007)</td>
<td>(Eidi et al., 2010; Ene et al., 2008; Haidari et al., 2011)</td>
</tr>
<tr>
<td><em>Coriandrum sativum</em> L. BPRN28</td>
<td>Kassbour</td>
<td>12</td>
<td>2.80</td>
<td>1.41</td>
<td>70.58</td>
<td>(Aissaoui et al., 2011; Tahraoui et al., 2007)</td>
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<tr>
<td><em>Foeniculum vulgare</em> Mill. BPRN18</td>
<td>Hebet hlawa</td>
<td>8</td>
<td>1.87</td>
<td>1.62</td>
<td>61.15</td>
<td>(El-Hilaly et al., 2003; Tahraoui et al., 2007)</td>
<td>(Anitha et al., 2014; El-Soud et al., 2011; Mostafa et al., 2015; Özbek et al., 2003)</td>
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<tr>
<td><em>Petroselinum crispum</em> Mill. BPRN30</td>
<td>Maadnouss</td>
<td>5</td>
<td>1.17</td>
<td>2.80</td>
<td>35.70</td>
<td>(Tahraoui et al., 2007)</td>
<td>(Bolkent et al., 2004; Ozsoy-Sacan et al., 2006; Sener et al., 2003; Soliman et al., 2015; Tunali et al., 1999)</td>
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<tr>
<td>Apocynaceae</td>
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<tr>
<td><em>Caralluma europaea</em> Guss. BPRN64</td>
<td>Daghmous</td>
<td>27</td>
<td>6.31</td>
<td>1.85</td>
<td>54.00</td>
<td>(Benkhnigue et al., 2014)</td>
<td>(Dra et al., 2018)</td>
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<tr>
<td>Asteraceae</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><em>Artemisia absinthium</em> L. BPRN46</td>
<td>Chiba</td>
<td>3</td>
<td>0.70</td>
<td>2.00</td>
<td>50.00</td>
<td>(Benkhnigue et al., 2014; Eddouks et al., 2002; El Amrani et al., 2010; Jouad et al., 2001a; Tahraoui et al., 2007)</td>
<td>(Daradka et al., 2014)</td>
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<tr>
<td><em>Artemisia herba alba asso</em> L. BPRN16</td>
<td>Chih</td>
<td>15</td>
<td>3.50</td>
<td>2.33</td>
<td>42.85</td>
<td>(Benkhnigue et al., 2014; Eddouks et al., 2002; El Amrani et al., 2010; Jouad et al., 2001a; Tahraoui et al., 2007)</td>
<td>(Al-Waili, 1986; Awad et al., 2012; Boudjelal et al., 2015; Hamza et al., 2015; Taştékin et al., 2006)</td>
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<table>
<thead>
<tr>
<th>Family</th>
<th>Species</th>
<th>Village</th>
<th>Yield</th>
<th>Type</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Brassicaceae</strong></td>
<td><strong>Chamaemelum nobile</strong> L.</td>
<td>Babounj</td>
<td>8</td>
<td>1.87</td>
<td>(Eddouks et al., 2002, 2005a; Lemhadri, 2007)</td>
</tr>
<tr>
<td></td>
<td><strong>Lepidium sativum</strong> L.</td>
<td>Heb rchad</td>
<td>2</td>
<td>0.47</td>
<td>(Bnouham et al., 2002; Eddouks et al., 2005b; Eddouks and Maghrani, 2008; Jouad et al., 2001b; Tahraoui et al., 2007)</td>
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<td></td>
<td><strong>Raphanus sativus</strong> L.</td>
<td>Fjel</td>
<td>3</td>
<td>0.70</td>
<td>(Barkaoui et al., 2017; El-Hilaly et al., 2003; Jouad et al., 2001b; Mrabti et al., 2019)</td>
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<tr>
<td><strong>Burseraceae</strong></td>
<td><strong>Commiphora myrrha</strong> (Nees) Engl.</td>
<td>Lmorra</td>
<td>1</td>
<td>0.23</td>
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<tr>
<td><strong>Cactaceae</strong></td>
<td><strong>Opuntia ficus-indica</strong> (L.) Mill.</td>
<td>Hendia</td>
<td>7</td>
<td>1.63</td>
<td>(Berraouan et al., 2015; Jouad et al., 2001b; Tahraoui et al., 2007)</td>
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<tr>
<td></td>
<td><strong>Chenopodium ambrosioides</strong> L.</td>
<td>M'khinza</td>
<td>3</td>
<td>0.70</td>
<td>(Eddouks et al., 2002; El Amrani et al., 2010; Jouad et al., 2001b; Ziyat et al., 1997)</td>
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<tr>
<td><strong>Convolvulaceae</strong></td>
<td><strong>Ipomoea batatas</strong> (L.)</td>
<td>Batata hlouwa</td>
<td>3</td>
<td>0.70</td>
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<td><strong>Cucurbitaceae</strong></td>
<td><strong>Cucumis sativus</strong> L.</td>
<td>Khiyar</td>
<td>2</td>
<td>0.47</td>
<td>(Barkaoui et al., 2017; Hachi et al., 2016; Jouad et al., 2001b)</td>
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<td></td>
<td><strong>Cucumis melo var. flexuosus</strong> L.</td>
<td>Feqous</td>
<td>1</td>
<td>0.23</td>
<td>No data</td>
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</tbody>
</table>

*Note: BPRN refers to the code for plant research network.*
### Fabaceae

<table>
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<tr>
<th>Genus</th>
<th>Species</th>
<th>BPRN</th>
<th>Alkharoub</th>
<th>6</th>
<th>1.40</th>
<th>1.66</th>
<th>60.0</th>
<th>(Barkaoui et al., 2017; Skalli et al., 2019)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceratonia silqua L.</td>
<td>BPRN61</td>
<td></td>
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<td></td>
<td></td>
<td>(Milek dos Santos et al., 2015; Rtibi et al., 2017b, 2017a; Yaniv et al., 1987)</td>
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<tr>
<td>Cicer arietinum L.</td>
<td>BPRN21</td>
<td></td>
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<td>2</td>
<td>0.47</td>
<td>3.0</td>
<td>33.33</td>
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<td>Glycine max (L.) Merr.</td>
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<td>Soja</td>
<td>5</td>
<td>1.17</td>
<td>1.8</td>
<td>55.55</td>
<td>(Barkaoui et al., 2017; Katiri et al., 2017; Mrabti et al., 2019; Tahraoui et al., 2007)</td>
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<td>Lupinus albus L.</td>
<td>BPRN41</td>
<td>Foul gnawa</td>
<td></td>
<td>9</td>
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<td>(Eddouks et al., 2002; Haddad et al., 2001; Jouad et al., 2001b)</td>
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<td>Helba</td>
<td>36</td>
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<td>49.31</td>
<td></td>
<td>(Barkaoui et al., 2017; Jouad et al., 2001b; Tahraoui et al., 2007; Ziyyat et al., 1997)</td>
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<td>Vicia faba L.</td>
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<td>No data</td>
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### Lamiaceae

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<th>2.00</th>
<th>50.00</th>
<th>(Eddouks et al., 2017; Jouad et al., 2001b; Lemhadri et al., 2004)</th>
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<td>Calamintha officinalis</td>
<td>Moench. BPRN14</td>
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<td>(Barkaoui et al., 2017; Benkhnigue et al., 2014; Tahraoui et al., 2007)</td>
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<td>BPRN56</td>
<td>Khzama</td>
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<td>6</td>
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<td>1.50</td>
<td>66.66</td>
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<td>1.57</td>
<td>63.33</td>
<td>(Benkhnigue et al., 2014; Eddouks et al., 2002; El Amrani et al., 2010; Jouad et al., 2001a; Tahraoui et al., 2007; Ziyyat et al., 1997)</td>
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<td>2.28</td>
<td>43.75</td>
<td>(Boudjelal et al., 2015; Elberry et al., 2015; Herrera-Arellano et al., 2004; Vergara-Galicia et al., 2012; Yaniv et al., 1987)</td>
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<td>Origanum compactum Benth.</td>
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<td>3.50</td>
<td>28.57</td>
<td>(Eddouks et al., 2002; Jouad et al., 2001a; Ziyyat et al., 1997)</td>
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(Barkaoui et al., 2017; Jouad et al., 2001a; Ziyyat et al., 1997)
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<th>Plant Family</th>
<th>Species</th>
<th>BPRN</th>
<th>Azir</th>
<th>Ziitra</th>
<th>Karfa</th>
<th>Bassla</th>
<th>Touma</th>
<th>Salmiya</th>
<th>Zeriat el Ketan</th>
<th>Reman</th>
<th>Tine</th>
<th>Notes</th>
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<tr>
<td><strong>Lamiaceae</strong></td>
<td><em>Rosmarinus officinalis</em> L.</td>
<td>BPRN37</td>
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<td>Azir</td>
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<td>(Eddouks et al., 2002; Jouad et al., 2001b; Tahraoui et al., 2007; Ziyyat et al., 1997)</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>(Benkhnigue et al., 2014; Eddouks et al., 2002; Jouad et al., 2001a; Tahraoui et al., 2007)</td>
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<td><strong>Lauraceae</strong></td>
<td><em>Cinnamomum verum</em> J. Presl</td>
<td>BPRN63</td>
<td></td>
<td></td>
<td>Karfa</td>
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<td></td>
<td></td>
<td></td>
<td>(Al-Hader et al., 1994; Bakirel et al., 2008; Emam, 2012; Rachid et al., 2012; Ramadan et al., 2013)</td>
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<td><em>Allium cepa</em> L.</td>
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<td>Bassla</td>
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<td></td>
<td></td>
<td></td>
<td>(Aljarah and Hameed, 2018; Koohi-Hosseinabadi et al., 2015; Telli et al., 2016)</td>
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<td><em>Allium sativum</em> L.</td>
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<td></td>
<td>(Benkhnigue et al., 2014; Eddouks et al., 2002; El Amrani et al., 2010; Jouad et al., 2001a; Tahraoui et al., 2007; Ziyyat et al., 1997)</td>
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<tr>
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<td></td>
<td></td>
<td></td>
<td>(Ashraf et al., 2011; Eidi et al., 2006; Islam and Choi, 2008; Mostofa et al., 2007)</td>
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<td><em>Salvia officinalis</em> L.</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td>(Barkaoui et al., 2017; Bousta et al., 2014; Eddouks et al., 2002; El Amrani et al., 2010; Errajraji et al., 2010; Orch et al., 2015; Tahraoui et al., 2007; Zayneb et al., 2015; Ziyyat et al., 1997)</td>
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<td><em>Linum usitatissimum</em> L.</td>
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<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>(Eidi and Eidi, 2009; Eidi et al., 2005; Kianbakht and Dabaghian, 2013; Lima et al., 2006)</td>
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<td></td>
<td>(Das et al., 2001; Huang et al., 2005; Jafri et al., 2000; Li et al., 2005; Radhika et al., 2011)</td>
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<td><strong>Moraceae</strong></td>
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<td></td>
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<td></td>
<td>(Benkhnigue et al., 2014; Jouad et al., 2001b; Tahraoui et al., 2007; Ziyyat et al., 1997)</td>
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<td></td>
<td>(Abo et al., 2008; Rachid et al., 2012)</td>
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**Notes:**
- No data
- ND: Not determined
- Ethnobotany Research and Applications
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<th>R</th>
<th>C</th>
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<td><strong>Myrtaceae</strong></td>
<td><em>Myrtus communis</em> L.</td>
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<td><em>Eucalyptus globulus</em> Labill.</td>
<td>Kaliptus</td>
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<td>2.00</td>
<td>50.00</td>
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<td><strong>Oleaceae</strong></td>
<td><em>Olea europaea</em> L.</td>
<td>Zitoune</td>
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<td>7.71</td>
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<td>73.33</td>
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<td>0.23</td>
<td>1.00</td>
<td>100.00</td>
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<td><em>Sesamum indicum</em> L.</td>
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<td>50.00</td>
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<td>33.33</td>
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<td>2.10</td>
<td>ND</td>
<td>ND</td>
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<td><strong>Rhamnaceae</strong></td>
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<td>1.40</td>
<td>2.16</td>
<td>46.15</td>
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Notes:
- (Eddouks et al., 2002; Jouad et al., 2001b; Tahraoui et al., 2007; Ziyyat et al., 1997)
- (Elfellah et al., 1984; Sepici et al., 2004)
- (Mahmoudzadeh-Sagheb et al., 2010; Rachid et al., 2012; Telli et al., 2016)
- (Benkhnigue et al., 2014; Bousta et al., 2014; Eddouks et al., 2002; El Amrani et al., 2010; Jouad et al., 2001b; Orch et al., 2015; Tahraoui et al., 2007; Zayneb et al., 2015; Ziyyat et al., 1997)
- (Amin et al., 2013; A. Eidi et al., 2009; Eidi et al., 2004; Sato et al., 2007)
- (Eddouks, 2017; Eddouks et al., 2002; Jouad et al., 2001b; Tahraoui et al., 2007)
- (Benammar and Baghdad, 2014; Glombitza et al., 1994)
Table 3. Formulation and information about medicinal plants used for the treatment of diabetes in the region of Fez-Meknes, Morocco

<table>
<thead>
<tr>
<th>Name of plants</th>
<th>Part used/ State</th>
<th>Formulation, preparation and dosage</th>
<th>Other ethnopharmacological uses Reported</th>
<th>Complement or alternative medicine</th>
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<tr>
<td><strong>Rosaceae</strong></td>
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<tr>
<td><em>Prunus amygdalus</em> Stokes var. amara L.</td>
<td>BPRN17</td>
<td>Louze Imor 33 7.71 1.24 80.48 (Eddouks, 2017; Jouad et al., 2001b; Merzouki et al., 2003) No data</td>
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<tr>
<td><em>Zingiber officinale</em> Rosc.</td>
<td>BPRN62</td>
<td>Skinjbir 17 3.97 1.82 54.83 No data (Al-Amin et al., 2006; Islam and Choi, 2008; Mahluji et al., 2013)</td>
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<td></td>
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<td><strong>Zygophyllaceae</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td><em>Zygophyllum gaetulum</em> Emb. &amp; Maire</td>
<td>BPRN15</td>
<td>Aagaya 1 0.23 1.00 100.00 (Eddouks et al., 2002; Jaouhari et al., 2000, 1999; Jouad et al., 2001a; Tahraoui et al., 2007) No data</td>
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<td>Part(s)</td>
<td>Preparation</td>
<td>Quantity</td>
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<td>Cactaceae</td>
<td>Opuntia ficus-indica (L.) Mill.</td>
<td>Epi/F or D</td>
<td>Juice, variable quantity mix with water, 1-2 C/D</td>
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<tr>
<td>Chenopodiaceae</td>
<td>Chenopodium ambrosioides L.</td>
<td>AP/F</td>
<td>Juice, variable quantity mix with water, lemon juice 1-2 C/D</td>
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<tr>
<td>Convolvulaceae</td>
<td>Ipomoea batatas L.</td>
<td>R/F</td>
<td>Raw, 1-2 pieces/D</td>
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<tr>
<td>Cucurbitaceae</td>
<td>Cucumis melo var. flexuosus L.</td>
<td>Fr/F</td>
<td>Raw, 1-2 pieces/D</td>
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<tr>
<td>Fabaceae</td>
<td>Ceratonia siliqua L.</td>
<td>Fr/D</td>
<td>decoction of powder, handful quantity in 1L of water 1-2 C/D</td>
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<tr>
<td></td>
<td>Cicer arietinum L.</td>
<td>S/D</td>
<td>Raw fraiche seeds 10-20 pieces/D</td>
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<tr>
<td></td>
<td>Glycine max (L.) Merr.</td>
<td>S/F</td>
<td>Raw dried seeds 10-15 pieces/day; powder 1-3 TS/D</td>
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<tr>
<td></td>
<td>Trigonella foenum-graecum L.</td>
<td>S/D</td>
<td>Infusion, handful quantity in 1 L of water soaked overnight 1-2 C/D; Powder 1-3 TS/D</td>
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<td>Lamiaceae</td>
<td>Calamintha officinalis auct.</td>
<td>AP/F</td>
<td>Decoction, handful quantity in 1 L of water, 1-2 C/D</td>
<td></td>
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<tr>
<td></td>
<td>Lavandula dentata L.</td>
<td>AP/D</td>
<td>Decoction, handful quantity in 1 L of water, 1-2 C/D; hydrolates 1-2 C/D</td>
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<td></td>
<td>Mentha pulegium L.</td>
<td>AP/F or D</td>
<td>Decoction, handful quantity in 1 L of water, 1-2 C/D; hydrolates 1-2 C/D; powder, 1-2 TS/D</td>
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<tr>
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<td>Rosmarinus officinalis L.</td>
<td>AP/F or D</td>
<td>Decoction, handful quantity in 1 L of water, 1-2 C/D; hydrolates 1-2 C/D; powder, 1-2 TS/D</td>
<td></td>
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<tr>
<td></td>
<td>Thymus. vulgaris L.</td>
<td>AP/F or D</td>
<td>Decoction, handful quantity in 1 L of water, 1-2 C/D; hydrolates 1-2 C/D; powder, 1-2 TS/D</td>
<td></td>
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<tr>
<td>Lauraceae</td>
<td>Cinnamomum verum J. Presl</td>
<td>Bark/D</td>
<td>decoction of powder, 1-2 in 500 ml of water 1-2 C/D</td>
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<tr>
<td>Liliaceae</td>
<td>Allium cepa L.</td>
<td>Bulb/F</td>
<td>Raw 1-2 pieces/D</td>
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<td>Allium sativum L.</td>
<td>S/F</td>
<td>Raw 3-9 pieces</td>
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<tr>
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<td>Salvia officinalis L.</td>
<td>L/ F or D</td>
<td>Decoction, handful quantity in 1 L of water, 1-2 C/D</td>
<td></td>
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<tr>
<td>Linaceae</td>
<td>Linum usitatissimum L.</td>
<td>S/D</td>
<td>powder, 1-4 TS/D</td>
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<td>Family</td>
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<td>Form</td>
<td>Preparations</td>
<td>Uses</td>
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<td>------------------------------------------</td>
<td>------</td>
<td>--------------------------------------------------</td>
<td>----------------------------------------------------------------------</td>
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<td>Lythraceae</td>
<td><em>Punica granatum</em> L.</td>
<td>Epi/D</td>
<td>Decoction, handful quantity in 1 L of water, 1-2 C/D, include with bread preparation</td>
<td>Kidney problems, Detox</td>
</tr>
<tr>
<td>Moraceae</td>
<td><em>Ficus carica</em> L.</td>
<td>L/D</td>
<td>Decoction, variable quantity in 1 L of water, 1-2 C/D</td>
<td>All diseases</td>
</tr>
<tr>
<td>Myrtaceae</td>
<td><em>Myrtus communis</em> L.</td>
<td>L/F or D</td>
<td>Decoction, handful quantity in 1 L of water, 1-2 C/D</td>
<td>No other uses mentioned</td>
</tr>
<tr>
<td>Oleaceae</td>
<td><em>Eucalyptus globulus</em> Labill.</td>
<td>L/F or D</td>
<td>Decoction, handful quantity in 1 L of water, 1-2 C/D</td>
<td>Flu, Respiratory problems</td>
</tr>
<tr>
<td>Oleaceae</td>
<td><em>Olea europaea</em> L.</td>
<td>L/F</td>
<td>Decoction, handful quantity in 1 L of water, 1-2 C/D</td>
<td>Cholesterol, Cardiovascular problems, dental care</td>
</tr>
<tr>
<td>Papaveraceae</td>
<td><em>Papaver rhoeas</em> L.</td>
<td>S/D</td>
<td>powder, 1-2 TS/D</td>
<td>No other uses mentioned</td>
</tr>
<tr>
<td>Pedaliaceae</td>
<td><em>Sesamum indicum</em> L.</td>
<td>S/D</td>
<td>powder, 1-3 TS/D, include with bread preparation</td>
<td>Bloating, Digestion problems</td>
</tr>
<tr>
<td>Pinaceae</td>
<td><em>Pinus pinaster</em> ssp. <em>hamiltonii</em> var <em>moghrabiana</em> H. del Villar</td>
<td>Eco/D</td>
<td>Decoction, 1 TS in 1 L of water, 1-2 C/D</td>
<td>gastric ulcer, hair care</td>
</tr>
<tr>
<td>Poaceae</td>
<td><em>Lolium multiflorum</em> Lam.</td>
<td>S/D</td>
<td>powder, 1-2 TS/D</td>
<td>No other uses mentioned</td>
</tr>
<tr>
<td>Ranunculaceae</td>
<td><em>Nigella sativa</em> L.</td>
<td>S/D</td>
<td>Powder 1-2 TS, include with bread preparation</td>
<td>All disease</td>
</tr>
<tr>
<td>Rhamnaceae</td>
<td><em>Zizyphus lotus</em> L.</td>
<td>S/D</td>
<td>Decoction, handful quantity in 1 L of water, 1-2 C/D</td>
<td>Kidney problems</td>
</tr>
<tr>
<td>Rosaceae</td>
<td><em>Prunus amygdalus</em> var. <em>amara</em> L.</td>
<td>S/D</td>
<td>Raw dried seeds 3-7 pieces/day</td>
<td>Aesthetic, Stomach ache</td>
</tr>
<tr>
<td>Zingiberaceae</td>
<td><em>Zingiber officinale</em> Rosc.</td>
<td>Rhi/F or D</td>
<td>Juice of fresh rhizome, variable quantity in water, 1-2 C/D, Powder of dried rhizomes 1-3 TS/D</td>
<td>flu, tiredness and anticancer</td>
</tr>
<tr>
<td>Zygophyllaceae</td>
<td><em>Zygophyllum gaetulum</em> Emb. &amp; Maire</td>
<td>AP/D</td>
<td>Decoction, handful quantity in 1 L of water, 1-2 C/D</td>
<td>No other uses mentioned</td>
</tr>
</tbody>
</table>

F: Fresh; D: Dried; AP: Aerial part; S: Seeds; R: Roots; Res: Resin; Epi: Epicarp; L: Leaves; Fr: Fruit; C: Complement; AM: Alternative medicine
Financing: This study did not receive funds.

Author contributions: Hamza Mechchate: Conceptualization, investigation, Writing - Original Draft Imane Essafi: investigation, Writing Fatima Zahra Jawhari: Data curation Amina Bari: Data curation Andriy Grafov: Review & Editing Dalila Bousta: Conceptualization, Methodology, supervision.

Acknowledgements
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Gray AM, Flatt PR. 1999. Insulin-secreting activity of the traditional antidiabetic plant Viscum album


Ludvik B, Hanefeld M, Pacini G. 2008. Improved metabolic control by Ipomoea batatas (Caiapo) is associated with increased adiponectin and decreased fibrinogen levels in type 2 diabetic subjects. Diabetes, Obesity and Metabolism. 10(7):586-592.


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Annex A : Ethnobotanical questionnaire

Université Sidi Mohamed Ben Abdellah- Fès Institut National des Plantes Médicinales et Aromatiques

Modèle-Questionnaire d’Enquête Ethno-pharmacologique Prof D. BOUSTA

<table>
<thead>
<tr>
<th>Fiche n° :</th>
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</thead>
<tbody>
<tr>
<td>Classement (par thème, ordre alphabétique, région ou autre) :</td>
</tr>
<tr>
<td>.................................. ……..</td>
</tr>
<tr>
<td>Documents annexées (photos, diapositives, herbiers…) : ...............................................</td>
</tr>
</tbody>
</table>

### 1- RENSEIGNEMENT SUR L’INFORMATEUR

- **Sexe** : Femme ........................................... Homme ....................................................
- **Age** : 18-24 □ 25-34 □ 35-49 □ 49-65 □ 65≥ □
- **Origine ethnique** : ......................................................................................
- **Commune** : ......................................................................................
- **Niveau d'instruction** : Néant □ Primaire □ Secondaire □ Universitaire □
- **Situation familiale** : Célibataire □ Marié □
- **Métier** : Herboriste ................. Guérisseur ........................................ Autres..........................
- **Comment vous avez eu ces connaissances ?** Lui-même □ Expérience des autres □ Herboriste □
  - Livres □ Occasionnellement □ Autres □ ..............................................................
- **Exerce t-il d'autre pratique médicinale traditionnelle ?** Si oui, les quels ? ..........................................................................................
- **Que préférez-vous ?** les soins médicaux □ Les soins phytothérapeutiques □
- **Pourquoi?** ..........................................................................................
- **Qui consultez-vous en cas de maladie ?** : Personnel médical □ Guérisseur □
- **Autres** ..........................................................................................

### 2- RENSEIGNEMENT SUR LE PRATICIEN

- **Nom** : ............................................. **Prénom** : ............................................ **Age** : ..............................
- **Lieu de Naissance** : .............................. **Lieu d’établissement** : ..............................
- **Appartenance ethnique ou origine régionale** : ..........................................................

---
## Qualification et compétence du praticien :

- **Niveau d'instruction:**
- **Depuis quand exerce-t-il le métier de guérisseur:**
- **Qui l’a formé:**
- **S’il s’agit d’un praticien lettré, quels livres de médecine arabe possède-t-il ?**
- **Est-il polyvalent ou exerce une spécialité ?**
- **Est-il spécialisé dans le traitement d’une maladie ?**
- **A-t-il formé quelqu’un ?**

## 2 – RENSEIGNEMENT SUR LE PRODUIT

### 2-1 Simple :

- **2.1.1 - Caractéristiques de l’habitat de la plante**
  - **Sol:**
  - **Relief:**

- **Climat:**

- **Action anthropique:**

- **Aire de répartition:**

### 2.2 – Systématique

- **Famille:**
- **Genre:**
- **Espèce:**

### 2.3 Dénominations locales :

-
### 2-1 Plante : (Seule)

<table>
<thead>
<tr>
<th>Parties utilisées</th>
<th>Tige</th>
<th>Fleurs</th>
<th>Fruits</th>
<th>Graine</th>
<th>Écorce</th>
<th>Rhizome</th>
<th>Bulbe</th>
<th>Latex</th>
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</thead>
<tbody>
<tr>
<td>Feuilles</td>
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<tr>
<td>Plante entière</td>
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<tr>
<td>Autres combinaisons</td>
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</table>

État de la plante : Fraîche □ Desséché □

Forme d’emploi : Tisane □ Poudre □ Huiles essentielles □

Lieu de récolte : ........................................... Lieu d’acquisition:..............................

Produit : local □ sauvage □ local □ cultivé □ importé □

Autres : ............................................................................................................................................................

Conditions et modalités de la récolte : (saison, période du jour, etc.)

Autres utilisations médicinales :


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### 2-2 Mixte : (recette)

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<th>Parties utilisées</th>
<th>Tige</th>
<th>Fleurs</th>
<th>Fruits</th>
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<th>Écorce</th>
<th>Rhizome</th>
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<td>Plante entière</td>
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<td>Autres combinaisons</td>
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</table>

État de la plante : Fraîche □ Desséché □

Lieu de récolte des plantes

Lieu d’acquisition

Produit : local □ sauvage □ local cultivé □ importé □

Autres : ............................................................................................................................................................

Conditions et modalités de la récolte : (saison, période du jour, etc.)

Traitement reçu par le produit: (séchage, pulvérisation)

Indications (si celles-ci varient en fonction des parties, faire une fiche pour chaque partie)........................................................................................................................................
**Autres utilisations médicales**:

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**Toxicité, effets secondaires** : toxicité pour l’homme et/ou le bétail, risque et effets indésirables :

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**Dose** :

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**Mode de préparation** :

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**Autres □** :

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**Posologie** :

- Pour les nourrissons: 1fois/jour □ 2fois/jour □ 3fois/jour □ Autres □ : .................
- Pour les enfants: 1fois/jour □ 2fois/jour □ 3fois/jour □ Autres □ : ....................
- Pour les Adultes: 1fois/jour □ 2fois/jour □ 3fois/jour □ Autres □ : ....................
- Pour les personnes âgées: 1fois/jour □ 2fois/jour □ 3fois/jour □ Autres □ : ....................
Durée d’utilisation (durée de traitement) :

□ Un jour  □ Une semaine □ Un mois □ Jusqu’à la guérison □

Mode d’administration :

……………………………………………………………………………………………………………………………………
……………………………………
……………………………………………………………………………………………………………………………………
……………………………………………………………………………………………………………………………………

Utilisation Comme :

□ Complément au médicament

□ Alternative

Associations :

……………………………………………………………………………………………………………………………………
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Autres informations :

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