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# Anticandidal Activity of Moroccan Medicinal Plants

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## Abstract

The prevalence of oral candidiasis has increased over recent years in patients with the compromised general condition. There are a large number of plant species that have been traditionally used for oral diseases by the Moroccan population. These species could provide a source for discovering new active principles of natural origin against *Candida albicans* involved in the appearance of candidiasis infections. Information was acquired using the electronic databases Web of Science, Scopus and PubMed. In the first part, this review presents the medicinal plants used by the Moroccan population for the treatment of oral disorders (Toothaches, gingivitis, ulcers, stomatitis, abscesses, ...). The second part describes different studies regarding the antifungal activity of essential oils and organic extracts of some Moroccan species against Candida albicans. Inhibition zone diameter (IZD), Minimum inhibitory concentration (MIC) and minimum fungicidal concentration (MFC) values of essential oils and plant's extracts were noted. The third part concerns Moroccan plants with the antifungal activity that can be used in medical and agricultural fields. Several species of Moroccan plant proved their effectiveness against *Candida albicans* and can be used for the treatment of oral candidiasis. Further research should be undertaken in the future to investigate the toxicity of essential oils and plant extracts with antifungal properties for clinical use. This review provided an update on Moroccan plants presenting antifungal activity and especially those active against *Candida albicans.*

## Keywords

Oral Candidiasis, Antifungal, Moroccan Plants, *Candida albicans*, Essential Oil, Plant Extracts

## 1. Introduction

Oral health is an integral part of general human health. Oral health disorders can

have consequences on mastication, phonation, and aesthetics, which can have an impact on psychosocial well-being [1].

Among the most common opportunistic infections in several high-risk patient groups is oropharyngeal candidiasis. Cancer radiation and/or chemotherapy, immunosuppression, immunodeficiency, diabetes, vitamin deficiency, hyposalivation, denture wear, patients under frequent topical antibiotic, glucocorticoid treatment and patients with anemia are predisposing factors for oropharyngeal candidiasis [2] [3] [4]. The pathogenic mechanism of Candida spp. depend on both Candida virulence and human host conditions. There has been an increased virulence of *Candida spp*. colonized in several groups of cancer and non-cancer population groups, such as diabetic patients, HIV-infected patients, hospitalized patients, and denture wearers. *Candida albicans* is the most common opportunistic fungal pathogen in humans. It causes superficial mucosal candidiasis or even disseminated candidiasis [2] [3] [4]. Antifungal drugs are the indicated treatment in the case of fungal infection. They are administered systemically or topically [4]. However, their usage is limited due to their side effects, in addition to the fact that Candida is becoming increasingly resistant [3]. That's why the search for new, less toxic, more effective and environment-friendly therapeutic approaches is becoming a necessity. Therefore, several types of research have been conducted on natural plant-based antimicrobials [5].

Plants have been utilized for centuries in folk medicine and there is a strong belief that herbal medicines are healthier and safer than drugs. Owing to their antimicrobial activities, efficacy, higher safety margins, ease of access, and economic feasibility, medicinal plants are used in developed as well as developing countries for primary healthcare.

Morocco, due to its geographical location and the variety of climates and microclimates, offers a rich and diversified vegetation [6] [7]. 4200 among 5000 species and subspecies listed in North Africa grow in Morocco of which at least 500 are potent medicinal and 250 are currently used [8] [9]. Its population is familiar with the use of plants [10]. Infusion, decoction, powder, and maceration of various parts of plants (Roots, flowers, fruits, seeds, leaves), and the whole plants have been used in the treatment of several diseases.

Morocco is one of the providers in the international market of aromatic and medicinal plants and their products, especially essential oils [11].

Essential oils plant-derived have proven their values as a source of molecules with antimicrobial effects [12]. Numerous studies have proven their antifungal effects [5] [13].

The action mechanism of essential oils is difficult to explain due to its complexity. It may be possible that every single component has its mechanism of action. The essential oil efficacy depends on the most abundant compound described [14]. According to Boukssaim *et al.* (2013), the inhibition of germs by essential oils is dependent on their chemical profiles and the structure of the cell membrane [11]. They are distinguished by their hydrophobicity, which helps

them to penetrate the membrane of cells and mitochondria, disrupting the cell structure and making it more permeable, resulting in cell death [15]. Many researchers have also explored their combinational effect with drugs to overcome microbial resistance and to decrease the minimum effective dose of conventional antimicrobial drugs [16] [17]. The knowledge of plants and the study of their properties, and their therapeutic effects are primordial, to discover new active principles [6] [15].

The aim of this article is to review Moroccan plants used for oral disorders and the anti-candidal activities of Moroccan plant essential oils and extracts.

## 2. Methodology

The literature on Moroccan plants and essential oil and plant's extract with antifungal activities from 2000 to 2022 were collected, and summarized in this review. The electronic databases Web of Science, Scopus, Pubmed were used to explore the published papers. The search terms used were antifungal, Moroccan plants, Candida albicans, and Essential oil. All published work in different languages (French or English) were cited in this review. Data provided in editorial/letters, symposiums, case reports, and conference papers were excluded.

The scientific names of all plants mentioned in this article were updated and verified using https://wfoplantlist.org/plant-list.

## 3. Results and Discussion

### 3.1. Plants Traditionally Used in Morocco for the Treatment of Oral Disease

The data presented in **Table 1** show several species of plants, their local name and their method of use, frequently used in Moroccan for the treatment of oral diseases. Lamiaceae are widely used in traditional medicine by the Moroccan population to treat several diseases [18].

*Thymus saturejoides* [18], *Thymus Capitatus [19]*, *Marrubium vulgare* L [20], *Rosmarinus officinalis* L. *Ficus carica* L, *Olea europaea* L, *Hyoscyamussp, Peganumharmala* L [1], *Daphne gnidium [21]*, *Pinus halepensis* L [8], *Allium sativum* L, *Pistacia lentiscus* L, *Hedera helix* L, *Tetraclinis articulata* (Vahl) Masters, *Anacyclus pyrethrum* (L.) Link [21], *Ammi visnaga* (L.) Lam, *Pimpinella anisum [20]*, *Cedrus atlantica* (Endl.) Manettiex Carrière, *Populus nigra* L, *Acacia nilotica* L, *Juglans regia* L. *Euphorbia officinarum* subsp. Echinus (Hook. F. &Coss.) Vindt, *Commiphora africana* (A. Rich.) Engl., *Heliotropium curassavicum* L, *Rhus albida schousboe* [22] are used to heal toothache.

*Thymus saturejoides* Coss. [18], *Thymus willdenowii* Boiss, *Origanum compactum* Benth, *Marrubium vulgare* L, *Laurus nobilis* L, *Ficus carica* L, *Olea europaea* L, *Ruta montana* L, *Peganum harmala* L [1], *Calendula arvensis* L. [21], *Melissa officinalis, Laurus nobilis* L, *Cinnamomum zeylanicum*, *Ammi visnaga* (L.) Lam, *Coriandrum sativum* L. *Chamaemelum nobile* L, *Artemisia herba alba*

Table 1. Plants used by the Moroccan population for the treatment of oral pathology.

| Plant family | Plant species | Local name | Used parts | Indication according to the population | The method of preparation (Mode of use) | References |
|---|---|---|---|---|---|---|
| Lamiaceae | *Thymus maraccanus* Ball | Azukni | Leave and Flowers | Mouth affections | Infusion and maceration | [21] |
| | *Thymus saturejoides* Coss. | Tazouknit | Leave and Flowers | Gum, Toothache Gingivitis Mouth ulcer | Infusion, Decoction | [18] |
| | *Thymus willdenowii* Boiss | Zaîtra | Leaves Flowers | Mouth infection Mouth ulcer Gingivitis Gingival bleeding Bad breath | Decoction (Gargle, Masticatory) | [1] |
| | *Thymus Capitatus* | | Aerial parts | Toothache | Infusion, decoction (external Application, massage, washings) | [19] |
| | *Marrubium vulgare* L. | Mariouta | Leaves | Toothache Gingival bleeding Bad breath Gingivitis | Crude (Masticatory) | [1] [20] |
| | *Origanum compactum* Benth | Zaatar tadlaoui | Leaves Flowers | Mouth ulcers Gingivitis Dental carie | Decoction (Gargle) | [1] |
| | *Origanum vulgare* L. | Zaater | Sap | Stomatitis Oral lesions | Crude (Touching the lesions with a cotton pad soaked in fresh sap) | [1] [20] |
| | *Rosmarinus officinalis* L. | Azir | Leaves Flowers | Toothache | Fumigation (Inhalation) | [1] [20] |
| | *Ocimum basilicum* L. | Hbak | Leaves | Oral ulcer | Decoction (Mouthwash) | [20] |
| | *Melissa officinalis* | Naanaa soufi | Leaves | Gum | Decoction (Mouthwash) | [20] |
| Lauraceae | *Laurus nobilis* L. | Wrak moussa | Leaves | Ulcers Gingivitis Bad breath | Decoction (Gargle) | [1] |
| | *Cinnamomum zeylanicum* | Karfa | Bark of the trunk | Gum Mouth ulcer | Decoction, Essential oil (Mouthwash, Direct application) | [20] |
| Apiaceae | *Ammi visnaga* (L.) Lam. | Bechnikha | Fruits | Gum disease Toothache | Raw/Decoction (Mouthwash, Direct application) | [20] |
| | *Coriandrum sativum* L. | Kozbore | Leaves | Toothache | Raw (Direct application) | [20] |
| | *Pimpinella anisum* | Nafae | Seeds | Gum disease | Decoction/ Infusion (Mouthwash) | [20] |
| Moraceae | *Ficus carica* L | Karmous | Fruit | Dental abscesses Toothache Gingivitis | Decoction Cataplasm (Gargle, Direct Application) | [1] |

**Continued**

| | | | | | | |
|---|---|---|---|---|---|---|
| Portulacaceae | *Portulaca oleracea* L | Rajla | Leaves | Dental abscesses | Cataplasm (Direct Application) | [1] |
| Oleaceae | *Olea europaea* L. | Zitoune | Leaves Branches | Gingival bleeding Bad breath Gingivitis Toothache Mouth ulcer Herpes Stomatitis | Decoction, Infusion, Crude (Gargle Brushing) | [1] [20] |
| Rosaceae | *Sanguisorba Minor* Scop. | Faggass laklab | Roots | Gum infectious | Powder | [21] |
| | *Rosa canina* L. | Nisrîne | Bark Fruit | Gingival bleeding | Decoction (Rinsing, Oral use) | [1] |
| | *Rubus ulmifolius* Schott., | Tût azzarb Serrmû | Leaves | Mouth ulcer | Decoction Crude (Masticatory, Rinsing Oral use) | [2] |
| | *Eriobotryajaponica* (Thunb.) Lindl. | Mzah | Leaves/Bark of the stem | Mouth ulcer | Decoction (Direct application) | [20] |
| Rutaceae | *Ruta montana* L. | Figel | Leaves | Gingivitis | Decoction (Rinsing) | [1] |
| Solanaceae | *Hyoscyamus* sp | Sikran | Seeds | Toothache | Decoction (Gargle) | [1] |
| Thymeleaceae | *Daphne gnidium* L. | Alezz^az | Leaves | Toothache | Decoction (Gargle) | [1] |
| | *Daphne gnidium* L. | Lazzaz | Leaves | Toothache | Decoction | [1] [21] |
| Urticaceae | *Urtica urens* | Hariga | Leaves | Mouth ulcer | Decoction (Rinsing) | [1] [21] |
| Nitrariaceae | *Peganum harmala* L. | Lharmel | Seeds | Gingivitis Toothache Mouth ulcer Herpes Bad breath Stomatitis | Maceration in vinegar Decoction (Gargle) | [1] |
| Lythraceae | *Lawsonia inermis* | Henna | Leaves | Mouth ulcer | Raw (Direct application) | [20] |
| Pinaceae | *Pinus halepensis* L. | Taydâ | Leaf | Antifungal Toothache | Decoction | [8] |
| | *Cedrus atlantica* (Endl.) Manettiex Carrière | Kdran | Resin | Toothache | Raw (Applied externally) | [22] |
| Amaryllidaceae | *Allium sativum* L. | Touma/ Tishert | Bulbs | Gum disease Toothache | Cataplasm (Direct application) | [20] [21] |
| Anacardiaceae | *Pistacia lentiscus* L | Drou | Leaves Barks Root | Toothache Gum | Decoction, Infusion Cataplasm (Mouthwash) | [20] [21] |
| Araliaceae | *Hedera helix* L | Lwwaya | Leaves | Toothache | Infusion, Cataplasm Decoction | [21] |
| Asteraceae | *Anacyclus pyrethrum* (L.) Link | Tiguentest | Wholeplant | Toothaches | Decoction Infusion | [21] |

**Continued**

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|---|---|---|---|---|---|---|
| | *Calendula Arvensis* L. | Jamra | Flowers | Gingivitis | Infusion, Compress (Gargles) | [21] |
| | *Chamaemelum nobile* L. | Baboneje | Flower | Gum | Decoction (Mouthwash) | [20] |
| | *Artemisia herba alba* Asso | Chih | Leaves/ Flower bud | Gum | Decoction (Mouthwash) | [20] |
| | *Bubonium graveolens* (Forssk) Maire | Tafsa | Leaf | Toothache | Powder (Applied externally) | [22] |
| Salicaceae | *Populus nigra* L | Safsaf | Leaves | Gum | Decoction (Mouthwash) | [20] |
| Cupressaceae | *Tetraclinis articulata* (Vahl) Masters | Azougaâ El arâar | Leaves Fruits | Toothache | Cataplasm, Compress, Maceration | [21] |
| | *Thuja occidentalis* L. | Afsa | Leaves | Gum | Decoction (Mouthwash) | [20] |
| Fabaceae | *Retama monosperma (L.) Boiss* | Rtam | Stems Roots Leaves | Gum | Infusion, Decoction | [21] |
| | *Acacia nilotica* L | Sllaha | Fruit | Toothache Gingivitis | Powder (Applied externally, Rinsing) | [22] |
| Myrtaceae | *Eugenia caryophyllata* Thunb | Qronfel | Cloves | Gum | Maceration | [21] |
| Iridaceae | *Crocus sativus* L. | Zaafranhor | Stigma | Gum | Decoction (Mouthwash) | [20] |
| Juglandaceae | *Juglans regia* L. | Souak | Bark of the root | Gum | Raw/Cataplasm(Brushing/Gum) | [20] [22] |
| Burseraceae | *Commiphora africana* (A. Rich.) Engl. | Oum nas | Gum | Toothache | Powder (Applied externally) | [22] |
| Euphorbiaceae | *Euphorbia officinarum* subsp. Echinus (Hook. F. &Coss.) Vindt | Dghmouss | Stem | Toothache | Powder (Applied externally) | [22] |
| Boraginaceae | *Heliotropium curassavicum* L | Lehbalia | Leaf | Toothache | Powder (Appliedexternally) | [22] |
| Anacardiaceae | *Rhus albida* schousboe | Zewaya | Bark | Toothache | Decoction | [22] |

Asso, *Bubonium graveolens* (Forssk) Maire, *Thuja occidentalis* L. *Acacia nilotica* L, *Crocus sativus* L, *Juglans regia* L. [20] are used to heal gingivitis and gum diseases.

Many species have been used in different regions of Morocco to treat mouth ulcers and stomatitis: *Thymus saturejoides* [18], *Origanum vulgare* L S. [20], *Thymus willdenowii* Boiss, *Origanum compactum* Benth, *Laurus nobilis*, *Olea*

*europaea* L. *Rubus ulmifolius* Schott., *Peganum harmala* L [1], *Urtica urens [21]*, *Ocimum basilicum* L., *Cinnamomum zeylanicum*, *Eriobotrya japonic*a (Thunb.) Lindl., *Lawsonia inermis* S. [20].

According to our review report, the preparation methods used by the Moroccan population were infusion, maceration, decoction, fumigation, cataplasm, and powder. Regarding the mode of use, it can be either by mastication, inhalation, brushing, gargling, or direct application.

### 3.2. Moroccan Plants with Anticandidal Activity

Several studies have demonstrated the existence of antifungal activity in several plant species belonging to different families [23]. Research studies that explored the anticandidal activity of essential oils (EO) and plant extracts obtained from different regions of Morocco are listed in **Table 2**. Antifungal activity against *Candida albicans* was assessed by the disc diffusion method, minimum inhibitory concentration (MIC), and minimum fungicidal concentration (MFC) values.

In all reported studies, inhibition zone diameter (IZD) was assessed including the disc diameter of 6 mm determined by the agar disc-diffusion method at a concentration of 10 ul of oil/disc except Abdelghani Aboukhalaf *et al.* [24] who used 20 ul of oil/disc, and Jeldi *et al.* 2 ul of oil/disc [25]. MIC represents the lowest essential oil/plant extracts concentration that completely inhibits the growth of Candida albicans. It was determined using macro/microdilution methods in mg/ml. MFC corresponds to the lowest concentration at which the incubated microorganism was completely killed [26].

The most cited plant family in the present work was Lamiaceae. Other families that were also mentioned are Mytraceae, Geraniaceae, Apocynaceae, Cictaceae, Asteraceae, Amaranthaceae, Rutaceae, Cannabaceae Ranunculaceae, Euphorbiaceae, Papaveraceae, Apiaceae, Fagaceae, Lauraceae.

When the inhibition zone diameter is 8 mm or more, the crude extracts have good antimicrobial activity. It is moderate if IZD is 6 - 7 mm; low if it is 4 - 5 mm; very low if it is 2 - 3 mm, or without antimicrobial activity [24]. Regarding essential oils, they are considered active if the IZD is greater than or equal to 15 mm [6]. In this review, the values for IZD of plants extract vary between 6 and 13 mm and those for essential oil from 7 to 85 mm.

The antimicrobial activity of plants extracts is considered significant when MIC ≤ 0.1 mg/mL, moderate when 0.1 ≤ MIC ≤ 0.5 mg/ml, low when 0.5 ≤ MIC ≤ 0.1 mg/ml, and inactive when the value of MIC is higher than 1 mg/ml [27]. In this review, the lowest value of MIC of plants extracts was that found by Benoutman *et al.* (MIC: 0.63 mg/ml. Acetonic extract of *Thymus capitatus*). However, a higher concentration of crude methanol extract of *Cistus monspeliensis* was needed to inhibit the growth of Candida albicans (MIC: 200 mg/ml).

The EO isolated from *Mentha suaveolens* exhibited the highest activity against *Candida albicans* (MIC: 0.00069 mg/ml) reported by Oumzil *et al.* (2002) [28]. 20.00 mg/ml of *Laurus nobilis* EO was needed to inhibit Candida albicans

**Table 2.** Moroccan plants with antifungal activity against *Candida albicans*.

| Family | Species (Local name) | IZD mm | MIC (mg/ml) | MFC (mg/ml) | References |
|---|---|---|---|---|---|
| Lamiaceae | *Thymus broussonetii* | 38.5 ± 0.70 EO | 0.25 EO | – | [30] |
| | *T. broussonetii* | 50.00 ± 1.00 W<br>49.67 ± 1.15 C<br>EO | 0.45 W;<br>0.46 C<br>EO | 0.45 W<br>0.46 C<br>EO | [34] |
| | *T. broussonetii* | 50.00 ± 1.00 EO | 0.45 EO | 0.45 EO | [36] |
| | *Thymus maroccanus* | 44.5 ± 0.35 EO | 0.25 EO | – | [36] |
| | *T. maroccanus* | 52.33 ± 1.15 EO | 0.46 EO | 0.46 EO | [36] |
| | *T. maroccanus* | 52.3 ± 1.2 W<br>41.3 ± 0.6 CWtF<br>41.0 ± 1.0 CWF<br>EO | 0.16 W<br>0.14 CWtF<br>0.03 CWF<br>EO | 0.16 W<br>0.14 CWtF<br>0.03 CWF<br>EO | [33] |
| | *T. maroccanus* | 52.33 ± 1.15 W<br>51.00 ± 1.00 C<br>EO | 0.46 W; 0.48 C<br>EO | 0.46 W; 0.48 C<br>EO | [34] |
| | *T. maroccanus* | 31 ± 0.1<br>EO | – | – | [37] |
| | *Thymus saturejoides* (Tazouknit) | 42.00 ± 1.00 W<br>41.33 ± 0.76 C<br>EO | 0.89 W; 0.90 C<br>EO | 0.89 W; 0.90 C<br>EO | [34] |
| | *T. saturejoides* | 42.00 ± 1.00 EO | 0.89 EO | 0.89 EO | [36] |
| | *T.saturejoides* | _ | 0.0059 EO | | [38] |
| | *T. saturejoides* (Tazouknit) | 53 EO | 0.9062 EO | 0.9062 EO | [39] |
| | *T. saturejoides* | – | 2.5 EO | 5 EO | [40] |
| | *Thymus vulgaris* (Ziitra) | – | 0.6 EO | 0.6 EO | [40] |
| | *Thymus zygis* subsp. Gracilis/Timahdite | – | 0.15 EO | 0.3 EO | [40] |
| | *Thymus zygis* subsp. Gracilis/Ain Aghbal | – | 1.2 EO | 1.2 EO | [40] |
| | *Thymus zygis* subsp. Gracilis/Tigrigra | – | 0.6 EO | 1.2 EO | [40] |
| | *Thymus zygis* subsp. Gracilis/Bensmim | – | 0.3 EO | 0.3 EO | [40] |
| | *Thymus serpyllum* | 17.33 ± 1.15 EO | 3.52 EO | 3.52 EO | [36] |
| | *Thymus willdenowii* | 32 WP;<br>39 L<br>32S<br>27 I<br>EO | 0.0069WP<br>0.0138 L<br>0.0069 S<br>0.0138 I<br>EO | – | [31] |
| | *Thymus ciliatus* | 48.00 ± 1.32 EO | 0.43 EO | 0.43 EO | [36] |

**Continued**

| | | | | | |
|---|---|---|---|---|---|
| | *Thymus pallidus* | – | 0.0214 EO | – | [38] |
| | *T. pallidus* (Ajellabi) | 37.67 ± 0.58 EO | 0.90 EO | 0.90 EO | [36] |
| | *T. pallidus* | 85 EO | 0.7837 EO | 0.7837 EO | [39] |
| | *Thymus leptobotrys* (Azoukni) | 50.00 ± 0.57 EO | 0.23 EO | 0.46 EO | [36] |
| | *T. leptobotrys* | 85 EO | 0.33 EO | 0.33 EO | [39] |
| | *T. leptobotrys* | 50.0 ± 0.6 W<br>41.0 ± 1.0 CWtF<br>43.0 ± 1.0 CWF<br>EO | 0.13 W<br>0.14CWtF<br>0.05 CWF<br>EO | 0.26W<br>0.14CWtF<br>0.05 CWF<br>EO | [33] |
| | *T. leptobotrys* | – | 0.0022 EO | – | [38] |
| | *T. leptobotrys* | 27.00 ± 1.00 EO | 1.25 EO | 1.25 EO | [29] |
| | *Thymus capitatus* | – | 0.0025 EO<br>0.63 AE<br>2.5 ME | 0.00375 EO<br>2.08 ± 0.54 AE<br>3.75 ± 1.37 ME | [41] |
| | *Mentha * piperita* | – | 0.0057<br>EO | – | [38] |
| | *Mentha pulegium* (Fliou) | – | 0.016 EO | – | [38] |
| | *Mentha spicata* | – | 0.0093 EO | – | [38] |
| | *Mentha suaveolens* (Timija) | – | EO-Pul 0.00069 | – | [28] |
| | *Mentha rotundifolia* | 32 EO | 0.63 EO | – | [6] |
| | *Rosmarinus officinalis* L. (Azir) | | 0.0228 EO | | [38] |
| | *Origanum compactum* (Za'tar) | 36.0 ± 1.7 EO | 0.216 EO | 0.288 EO | [25] |
| | *Origanum compactum* | 34.0 ± 1.7 EO | 0.216 EO | 0.288 EO | [25] |
| | *Majorana hortensis* (Merdedouche) | 35 EO | 0.63 EO | 0.63 EO | [6] |
| | *Vitex Angus-castus* L. (Anguerf) | 50 EO | 0.53 EO | 1.06 EO | [5] |
| | *Salvia officinalis* (Salmia) | 15 EO | 0.63 EO | – | [6] |
| | *Lavandula stoechas* (Halhal) | 8 EO | 1.25 EO | – | [6] |
| | *Lavandula angustifolia* (Khzamafassiya) | 30 EO | 0.63 EO | 12.5 EO | [6] |
| Geraniaceae | *Pelargonium graveolens* | – | 0.0045 EO | – | [38] |
| | *Pelargonium graveolens* | 45 EO | 1.25 EO | – | [6] |
| | *Pelargonium graveolens* | 13.60 ± 0.17 ME | 0.47 ME | – | [27] |
| | | 9.42 ± 0.37 DCM | 1.87 DCM | – | |
| | | 7.53 ± 0.32 HX | 3.75 HX | – | |
| *Rutaceae* | *Citrus limon* | – | 0.0855 EO | – | [38] |

**Continued**

| | | | | | |
|---|---|---|---|---|---|
| Cistaceae | *Cistus villosus* | – | 6.25 Crude ME<br>50 ETAC<br>3.125 B | – | [32] |
| | *Cistus monspeliensis* (Tuzzalabéda) | – | 200 Crude ME<br>100 ETAC<br>50 B | – | [32] |
| Cannabaceae | *Cannabis sativa* L. (Lkif) | 12.0 ± 0.7 EO | 9.5 EO | – | [17] |
| Apocynaceae | *Caralluma europaea* (Guss.) (Daghmous, Zakkum, Tikiwt) | 14.50 ± 0.35 EO | 3.75 EO | 7.5 EO | [42] |
| | *Periploca laevigata Aiton* (elhallaba) | 12.50 ± 0.35 EO | 0.937<br>EO | 1.875 EO | [16] |
| Ranunculaceae | *Nigella sativa* (Black cumin, Habbatul baraka, alhabbaassaouda,sanouje) | – | 0.008 EO | – | [14] |
| Amaranthaceae | *Chenopodium mural* L. (Berremram) | NI EO | – | – | [24] |
| | *Dysphania ambrosioides* (L.) Mosyakin & Clemants (Mkhinza) | 15 EO | 0.075 EO | – | [15] |
| Myrtaceae | *Myrtuscommunis* (Rihàn) | 22 EO | 5 EO | – | [6] |
| | *Syzygium aromaticum* (Qronfel) | 14.00 ± 1.00 EO | 5 EO | 5.00 EO | [29] |
| | *Psidiumguajava* (Guava) | 16 ± 1.73 EO | | | [43] |
| Asteraceae | *Scolymushispanicus* L. (El guernina) | NI | – | – | [24] |
| | *Senecioanteuphorbium* (Achbartou) | 22.00 ± 0.17 CA (CCMM L61)<br>27.00 ± 1.00 CA (CCMM L4) EO | 1.024 CA (CCMM L61)<br>2.048 CA (CCMM L4) EO | 4.096 CA (CCMM L61)<br>4.096 CA (CCMM L4) EO | [12] |
| | *Dittrichia viscosa* L. (Trehla or Magramane) | 7 ± 0.05 EtOH<br>10.6 ± 0.03 AE | 0.93 EtOH<br>0.87 AE | 1.75 EtOH<br>1.75 ACE | [10] |
| Euphorbiaceae | *Mercurialis annua* L. (Horrigalmalssa) | NI Crude extracts | – | – | [24] |
| Papaveraceae | *Papaver rhoeas* L. (Belaaman) | 6 ± 0.3<br>Crude extracts | – | – | [24] |
| Apiaceae | *Foeniculum vulgare* Mill (Besbas beldi) | 8 ± 0.15<br>Crude extracts | – | – | [24] |
| Fagaceae | *Quercus suber* (fernan) | – | 12.5 ME (Bark) | – | [44] |
| Lauraceae | *Laurus nobilis* | 7.00 EO | 20.00 EO | 20.00 EO | [29] |

IZD: Inhibition zone diameter. MIC: Minimum inhibitory concentration. MFC: Minimum fungicidal concentration, W: wild; C: cultivated, CWtF: Cultivated without Fertilizer; CWF: Cultivated with Fertilizer; WP: Whole Plant; L: Leaves; S: Stems, I: Inflorescences, EO: Essential oil; AE: Acetonic extract; EtOH: ethanolic extract; ME: Methanolic extract; EO-Pul: Essential oil rich in pulegone, DCM: Dichloromethane, HX: Hexane. ETAC: ethyl acetate; B: Butanol; NI: No inhibition; CA: Candida albicans.

growth [29].

These findings suggest that EO and plant extract can be considered as a potential source of natural antimicrobials. Therefore, their utilization in addition to antifungal drugs for the treatment of some candidiasis due to C. albicans is possible. It may constitute a promising strategy to overcome the intense use of antifungal drugs and reduce the minimum effective dose, thus minimizing their toxic side effects and the treatment cost [30].

The effectiveness of essential oils is influenced by the plant's origin and the parts used in their preparation [10]. Essential oil of *Thymus willdenowii* stems (MIC = 0.0069 mg/ml) was more active than that of leaves (MIC = 0.0138 mg/ml) and inflorescences (MIC = 0.0138 mg/ml) [31].

The type of organic extract (Hexane, methanol, dichloromethane, ethanol, ethyl acetate, butanol, acetonic/extract) also affects the antifungal activity as shown by the studies of S. El Aanachi *et al.*, H. Bouamama *et al.* and I. Mssillou *et al.* [10] [27] [32].

The activity of essential oils and plant extracts also depends on whether the plants are wild or cultivated with or without fertilizersn [33] [34].

In this review, Thymus is one of the most cited genera. 21 species represent the genus Thymus (Lamiacae) in Morocco. IMC values vary from 0.0022 mg/ml to 0.9 mg/ml. This variation may depend on the chemical composition of thyme essential oils, which in turn depends on several factors such as species, genetic heritage, origin, environmental influences, and growth stage [35].

### 3.3. Moroccan Plants with Antifungal Activities

In recent years, several studies have been devoted to the study of plant extracts to develop new antifungal compounds that can be used in medical fields to treat various infections and in agricultural fields to control post-harvest diseases of fruits and vegetables.

A promising antifungal activity for several plants used in Morocco against many fungal species involved in plant or human diseases has been evidenced. According to studies, this activity exists whether it was in essential oils, plant extracts, or powders. These plants are listed in **Table 3**.

These results may provide support for further studies to evaluate the antifungal action of Moroccan plants against Candida albicans. The effectiveness of phytotherapy is well-proven. It is currently one of the main health care in Morocco. However, numerous studies show that medicinal plants can be carcinogenic, teratogenic, or even endanger life conditions. The toxicity of a plant is related to several factors, including the type and quantity of chemical compounds present in the plants, the quantity consumed, the exposure time, the part used (Seeds, leaves, oil, bark, stem, root), the climate and the soil, body chemistry, genetic and the preparation method used (Extraction: Solvent types, essential oils). Guidelines must be established to protect medicinal and aromatic plants and to regulate their local use by the population [56] [57].

Table 3. Moroccan plants with antifungal activities.

| Family | Species | Forme | References |
|---|---|---|---|
| Rosaceae | *Rubus ulmifolius* Schott | Powder | [45] |
| Amaranthaceae | *Hammada scoparia* | Powder | [45] |
| Cistaceae | *Halimium antiatlanticum* | Powder | [45] |
| | *Halimium umbellatum* | Powder | [45] |
| | *Cistus Creticus* | EO | [46] |
| Anacardiaceae | *Pistacia atlantica* | Powder | [45] |
| Fabaceae | *Ceratoniasiliqua* | Powder | [45] |
| Cupressaceae | *Cupressus atlantica* | EO | [11] |
| Cupressaceae | *Juniperus phoenicea* (Ar'ar) | EO | [47] |
| Cyperaceae | *Cyperus longus* | EO | |
| Lamiaceae | *Mentha viridis* (Naanaa) | EO | [19] |
| | *Thymus bleicherianus* | EO | [35] |
| | *Origanum compactum* | EO | [23] |
| | *Thymus glandulosus* | EO | [23] |
| | *Lavandula dentata* | Organic extract | [23] |
| | *Origanum vulgare* | Organic extract | [23] |
| Pinaceae | *Pinus halepensis* Mill | Extracts and EO | [48] |
| Gentianceae | *Centaurium erythraea* Rafn (Korsatlhaya) | Extracts and EO | [49] |
| Zingiberaceae | *Zingiber officinale* extracts roscoe | Ethyl acetate extracts<br>Ethanol extracts<br>Water extracts | [50] |
| Rutaceae | *Citrus limonum* | EO | [23] |
| Asteraceae | *Anvillea radiata* | Organic extract | [23] |
| | *Silybum marianum* (L.) Gaertn | Decoction | [51] |
| | *Ighermia pinifolia* | Powder | [45] |
| | *Inula viscosa* | Powder | [45] |
| | *Artemisia absinthium* L. *(Chiba)* | Decoction | [8] |
| | *Anthemis tenuisecta* | EO | [52] |
| | *Artemisia campestris* L. | Extracts and EO | [53] |
| Myrtaceae | *Eucalypltu scitriodora* L. (kelitto) | Powder | [8] |
| | *Eucalyptus globulus* L. (Kalitouse) | Organic extract | [23] |
| Lauraceae | *Cinnamomum zeylanicum* | EO | [23] |
| Apiaceae | *Cuminum cyminum* L. (Kammun) | Cooking | [8] |
| Amarillydaceae | *Allium sativum* L. (Touma) | Cooking | [8] |
| | *Allium cepa* L. (Bsal) | Maceration | [8] |

**Continued**

| | | | |
|---|---|---|---|
| Apocynaceae | *Nerium oleander* L. (Dafla) | Infusion | [8] |
| Salicaceae | *Salix alba* L. (Ud el-mâ) | Decoction | [8] |
| Vitaceae | *Vitis vinifera* L. (La'anb) | Powder | [8] |
| Arecaceae | *Phoenix dactylifera* L. (Tamr) | Extract | [54] |
| Urticaceae | *Urtica dioica* L. (Hourriga, al quarâs) | Powder, Infusions Decoction | [55] |

## 4. Conclusion

The research of new active principles extracted from medicinal and aromatic plants is nowadays a priority for many countries to face the increasing resistance of the human body against drugs. In this article, a review of existing knowledge on the antifungal activity of different plants of Moroccan origin was carried out. First, plants used by the Moroccan population for oral diseases were cited. Then, studies that discussed the anti-candidal activity of essential oils and extracts from Moroccan plants were reported. This review represents the unique comprehensive overview of Moroccan plants active against Candida albicans. Finally, the plants presenting an antifungal action against fungal species involved in plant or human diseases were listed. The anticandidal activity has been proven for several Moroccan plants, and this review will supply a baseline to identify this activity for other Moroccan plants. Further investigation should be undertaken in the future to study the toxicity of essential oils and plant extracts and to determine the optimal concentrations for clinical use. This article will provide supporting data and perspectives for future research studies on the antifungal activities of Moroccan plants.

## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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