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Antifungal activity of medicinal plants with special reference to antidermatophytic activity: A review

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Abstract
Traditional medicine is useful and without any side effect like the chemical medicine. Various phytoconstituents have been reported to be present in plants which are antidermatophytic. Dermatophytoses are mycoses that affect keratinized tissues in both humans and animals. Development of more effective and less toxic antifungal agents is required for the treatment of dermatophytosis. Plants and their extraction preparations have been used as medicines against infectious diseases. Therefore, nature has provided such a great wealth medicinal plants which are helpful to control a number of serious mycoses, animals in general and in human beings in particular. The present review attempts to furnish a brief overview of antifungal and antidermatophytic properties of medicinal plants.

Keywords: Antidermatophytic, Antifungal, Mycoses, Keratin

1. Introduction
The occurrence of fungal infections is increasing at alarming rates, especially among immunocompromised subjects, such as AIDS patients, transplanted patients, and neonates (Zhang *et al.*, 2009) [1]. Among the pathogens, species of *Candida* are generally associated with these infections, whose incidence is attributed to a variety of factors, either exogenous or endogenous. More than 100 species of *Candida* are known and the frequency of distribution for *Candida spp.* varies in accordance with geographical location (Leite *et al.*, 2014) [2]. Actually, conventional treatments for fungal infections are not fully effective, since the available drugs lead to secondary effects or to development of resistance (Chandrasekar, 2011) [3]. Our aim of the present study was to collect the information about the antidermatophytic activities of plants in India.

Plants are under constant strain of soil borne micro-organisms. Among hundreds of soil-borne microrganisms, fungal pathogens, *Fusarium oxysporum*, *Sclerotium rolfsii* and *Macrophomina phaseolina* are more common which cause diseases in a large number of plant species. Fusarium wilt is the disease of tomatoes (*Lycopersicum esculentum*) caused by *F. oxysporum* sp. *Lycopersici.* It is one of the most destructive diseases because it is responsible for a significant economic loss in tomato yield (Ojha *et al.*, 2012) [4]. In this disease, seedlings become stunted and leaves become yellow with abscission. Eventually the infected plant dies (Jones *et al.*, 1991) [5]. *S. rolfsii* causes serious diseases of a wide variety of plants including field crops, vegetables, fruit and ornamental crops. The fungus infects the lower stem near the soil surface and for some plants, the roots may be infected (Mullen, 2001) [6].

The effective management of plant pathogenic fungi can be successfully done with fungicides but these chemicals have both short term or long term adverse effect on the environment (Bhandari, 2014) [7]. The inappropriate use of fungicides can put the life at risk as they can be carcinogenic (Stranger and Scott, 2005) [8]. It has necessitated an alternative approach to reduce the dependency on the synthetic fungicides. Plant extracts have proved to be complementary control means as they displayed good antimicrobial ability. Their non toxic behaviour and biodegradability have led to a new door of safety (Ibrahim and Al-Ebady, 2014) [9]. Many secondary metabolites which plants produce show antifungal ability, include flavonoids, phenols and phenolic glycosides, unsaturated lactones, sulphur compounds, saponins, cyanogenic glycosides glucosinolates and tannins (Vinale *et al.*, 2014) [10].

The presence of bioactive compounds in different parts of the plant can be exploited against plant pathogenic fungi. The present project has been designed to test antifungal activity of various parts of *N. oleander* viz root, stem bark and leaves, against commercially important

three fungi namely *F. oxysporum* sp. *Lycopersici, M. phaseolina* and *S. rolfsii* using different extracting solvents. Hence for the first time the above mentioned fungi have been exploited by the organic.

Mold fungi growing on wood surfaces cause sapstain and simple sugars and starch present in ray cells and axial cell lumens are consumed by molds (Kerner-Gang and Schneider, 1969; Mansour and Salem, 2015) [11, 12]. Sapstain is a major problem for timber producers as well as pulp and paper manufacturers since fungal colonization and disfigurement of freshly felled material prior to drying can result in significant economic losses. *Alternaria* fungi have black pigment (melanin) that causes distinctly seen dark grey discoloration on wood joints (Domsch *et al*., 2007) [13]. *Alternaria alternata* and other mold fungi isolated from treated wood are recognized as soft-rot fungi and they have been found on painted or preservative-treated wood (Kim *et al*., 2007; Pournou and Bogomolova, 2009; Råberg *et al*., 2009) [14, 15, 16].

Pityriasis capitis, commonly known as dandruff, is a most common physiological condition causing desquamation of the skin surface due to the imbalance caused to the stratum corneum. (Turner *et al*., 2012) [17]. Seborrheic dermatitis is yet another condition that is closely related to dandruff, characterized by highly pruritic chronic inflammatory lesions on the head. (Hay, 2011) [18]. These pathologic conditions are considered to be related to three etiologic factors: *Malassezia* yeasts, secretions of the sebaceous glands, and susceptibility to infections in individuals. It has been generally accepted and through the literature inferred by studies, indicating a strong link to said conditions caused by *Malassezia* yeasts, especially *Malassezia furfur* and, established later, its two species forms *Malassezia globosa* and *Malassezia restricta* (DeAngelis *et al*., 2005) [19]. Other conditions associated with this species are pityriasis versicolor, folliculitis, atopic dermatitis, psoriasis, and confluent and reticulate papillomatosis. (Gupta *et al*., 2004) [20]. Treatment strategies include synthetic drug‐based formulations of ketoconazole, zinc pyrithione, selenium sulfide, ciclopirox, etc., which reduce visible symptoms of flaking and restore the normalcy of the skin. (Pierard *et al*., 1997) [21]. In fact, most medicated formulations carry risks of side effects such as dryness of hair/skin, associated cytostasis, and eczema, and also frequent reoccurrence made therapy costlier. So, it is imperative to search for drugs that are safe, cost-effective, and eco-friendly. Thus, there was a call to return to nature and botanical remedies became a part of the green revolution.

1.1 Mycosis

The broad field concerned with study of fungi is called mycology. Mycosis (plural: mycoses) on the other hand is a fungal infection of animals, including humans.(Carla Viegas *et al*., 2015) [22]. Mycoses are common and a variety of environmental and physiological conditions can contribute to the development of fungal diseases. Inhalation of fungal spores or localized colonization of the skin may initiate persistent infections; therefore, mycoses often start in the lungs or on the skin.(Alaa Abdul-Hussein *et al*., 2015) [23]. One of the important class of fungi that has been elevated of its various aspects of research is “Dermatophyte fungi” that are the ringworm fungi (tinea). Dermatophytes may also prefer to live in the soil. Anthropophilic dermatophytes are so well adapted to living on human skin that they provoke minimal inflammatory reaction. Zoophilic or geophilic dermatophytes will often provoke a more vigorous inflammatory reaction when they attempt to invade human skin. Fungal infections in human beings are a major problem in tropical and subtropical countries due to prevailing humidity and temperature regimes. The superficial fungal infection or dermatomycoses is the disease caused by a group of fungi known as dermatophytes. It involves superficial infections of keratinized tissue in human beings. Clinical surveys carried out in India have showed that ringworm is one of the most common dermatomycoses caused by the species of *Epidermophyton floccosum, Microsporum* and *Trichophyton*. Although there are number of synthetic antifungal are available in market but majority of them are fungi static in nature (Roxburg and Borrie, 1973) [24].

Trichophyton is known as a dermatophyte; a part or group of three genera of fungi cause skin disease in people and animals. In many parts of the world *Trichophyton mentagrophytes* is isolated most frequently. *T. mentagrophytes* is typically found in moist, carbon-rich environments. It is characterized by flat suede-like colonies, white to cream colour and with distinctive odour. The colour on the underside of the colonies is usually yellow to reddish brown. The granular colony formed typically has a powdery appearance due to the large amount of microconidia spores formed. The macroconidia are smooth, cigar shaped and thin walled with 4–5 cells separated by parallel cross-walls. In comparison to other fungi, *T. mentagrophytes* grows fairly rapidly. (Brooks *et al*., 2010) [25] *T. tonsurans* is an anthropophilic fungus with a worldwide distribution which causes inflammatory or chronic non-inflammatory finely scaled lesions of skin, nails and scalp. It is a common cause of tinea capitis among the Australian aboriginals and American Negros. (Julius, 1997) [26].

Candida albicans is the most common fungal human pathogen and is found naturally in human digestive and reproductive organs; as it prefers moist area. (Kim and Francoeur, 2011) [27]. It causes disease called candidiasis. Oral candidiasis (thrush) is the most common oral infection, which is characterized by extensive white pseudo membrane consisting of desquamated epithelial cell, fibrin and fungal hyphae. It is most often seen in patients with diabetes, AIDS and those using steroid aerosol inhalers (Akpan and Morgan, 2002) [28].

The anti-dermatophytic activity of chitosan/COS has received relatively little attention. (Sajomsang *et al*., 2012) [29] described *in vitro* antifungal effects of five quaternized chitosan samples against *T. rubrum, T. mentagrophytes* and *M*. gypseum. The clinical anti-dermatophytic efficacy of chitosan/COS remains unknown. We prepared a COS sample by enzymolysis and assessed its anti-fungal activity against T. rubrum both in vitro and *in vivo* (usinga guinea pig model). Antifungal susceptibility was tested by two methods: broth microdilution and agar diffusion. Morphological changes of fungal cells were evaluated by transmission electron microscopy. Clinical efficacy was evaluated based on skin lesions core and histopathological examination. Our findings provide new insights into anti-dermatophytic effects of COS and potential development of COS as a therapeutic agent against tinea diseases.

1.2 Dermatophytes

Dermatophytes are generally referred as the group of fungus that mostly causes skin disease in animals and humans. (Carla Viegas *et al*., 2015) [22] *Microsporum*, *Epidermophyton* and

Trichophyton are the three genera of this group. There are about 40 species in these three genera. Dermatophytes obtain nutrients from keratinized material. (Midgley *et al.*, 1994) [30] The organisms colonize the keratin tissues causing inflammation as the host responds to metabolic by-products. Colonies of dematophytes are usually restricted to the nonliving cornified layer of the epidermis because of their inability to penetrate viable tissue of an immunocompetent host. Invasion does elicit a host response ranging from mild to severe. Acid proteinases, elastase, keratinases and other proteinases reportedly act as virulence factors. The development of cell-mediated immunity correlated with delayed hypersensitivity and an inflammatory response is associated with clinical cure, whereas the lack of or a defective cell-mediated immunity predisposes the host to chronic or recurrent dermatophyte infection.

There are various types of dermatophyte infections including Tinea pedis, Tinea cruris, Tinea corpora, Tinea faciei, Tinea capitis, Tinea capitis, Tinea manuum etc. Tinea pedis or athlete's foot affects not solely athletes. It affects men more than women; it can be seen initially affecting the webs between the toes, before spreading to the sole of the foot in a "moccasin" pattern. Tinea cruris or jock itch the feet are also involved. The true is that the feet get infected first from contact with the ground. The fungus spores are carried to the groin from scratching, from putting on underclothing or pants. Frequently extend from the groin to the perianal skin and gluteal cleft. Tinea corpora or ringworm of the body appears, red, scaly, patches with well-defined, raised edges; central clearing and itchy. Tinea faciei or facial ringworm can be misdiagnosed for other conditions like psoriasis, discoid lupus, etc. It is aggravated by treatment with topical steroid or immunosuppressive creams. (Tim and Cameron, 2006) [31] Tinea capitis or blackdot ringworm infected hair shafts are broken off just at the base, leaving a black dot just under the surface of the skin. Tinea capitis cannot be treated topically, and must be treated systemically with antifungals. (Devinder, 2015) [32] Tinea capitis or scalp ringworm is the most common cause of *Trichophyton tonsumans* in children, and is the main cause of endothrix (inside hair) infections. *Trichophyton rubrum* is also a very common cause of favus, a form of tinea capitis in which crusts are seen on the scalp. Tinea manuum or ringworm of the hands is mostly cases of tinea manuum, only one hand is involved. Subsequently both feet are involved concurrently, thus the saying "one hand, two feet". (Samanta**,** 2015) [33] The simultaneous presence of more than one type of dermatophyte infection is common (eg, tinea pedis and tinea cruris or tinea pedis and tinea unguium). Performance of a full skin examination including the skin, hair, and nails aids in the detection of additional sites of infection. Occasionally, patients develop a dermatophytid reaction, a secondary dermatitic reaction at a distant site that may reflect an immunologic reaction to the infection.

1.3 Treatment

Topical or systemic antifungal drugs with anti-dermatophyte activity are effective therapies. Most superficial cutaneous dermatophyte infections can be managed with topical therapy with agents such as azoles, allylamines, butenafine, ciclopirox, and tolnaftate. Nystatin, an effective treatment for *Candida* infections, is not effective for dermatophytes. Oral treatment with agents such as terbinafine, itraconazole, fluconazole, and griseofulvin is used for extensive or refractory cutaneous infections and infections extending into follicles or the dermis (e.g, Majocchi's granuloma) or involving nails. Patients should not be treated with oral ketoconazole because of risk for severe liver injury, adrenal insufficiency, and drug interactions.

Although they can be effective and may accelerate resolution of the clinical manifestations of superficial dermatophyte infections (El-Gohary *et al*., 2014) [34], use of combination antifungal and corticosteroid products that include medium- or high-potency corticosteroids (eg, clotrimazole 1% /betamethasone dipropionate 0.05%) is discouraged because corticosteroid therapy is not necessary for achieving cure and use of a topical corticosteroid introduces risk for topical corticosteroid-induced skin atrophy. Treatment failures have also been reported (Alston *et al*., 2003; Greenberg *et al*., 2002; Rosen and Elewski, 1995) [35, 36, 37]. On the other hand immunosuppression may increase risk for dermatophyte infection and may contribute to the development of extensive or persistent disease. The possibility of an underlying immune disorder should be considered in patients with particularly severe or treatment-refractory disease.

Treatment is recommended to alleviate symptoms (pruritus), reduce risk for secondary bacterial infection, and limit spread of the infection to other body sites or other individuals. Topical antifungal therapy is the treatment of choice for most patients. Systemic antifungal agents are primarily reserved for patients who fail topical therapy. Topical drugs effective for tinea pedis include azoles, allylamines, butenafine, ciclopirox, tolnaftate, and amorolfine. Amorolfine is not available in the United States. A meta-analysis of randomized trials published prior to February 2005 supports efficacy of topical therapy, finding strong evidence of superiority of topical antifungal agents (azoles, allylamines, ciclopirox, tolnaftate, butenafine, and undecanoate) over placebo (Crawford and Hollis, 2007) [38]. Allylamines may be slightly more effective than azoles; a meta-analysis of data from 11 trials that compared topical allylamines to topical azoles found slightly higher cure rates with allylamines (risk ratio of treatment failure 0.63, 95% CI 0.42-0.94). Topical antifungal treatment is generally applied once or twice daily and continued for four weeks. Shorter treatment courses may be effective; high cure rates have been obtained with terbinafine 1% cream applied to interdigital tinea pedis for one week (Korting *et al*., 2001) [39].

Patients requiring oral antifungal therapy are usually treated with terbinafine, itraconazole, or fluconazole. Griseofulvin can also treat tinea pedis, but may be less effective than other oral antifungals and requires a longer duration of therapy (Gupta and Cooper, 2008) [40]. In a systematic review, terbinafine was found more effective than griseofulvin, while the efficacy of terbinafine and itraconazole were similar (Bell-Syer *et al*., 2012) [41]. Typical adult doses for griseofulvin for tinea pedis are: 1000 mg per day of griseofulvin microsize for four to eight weeks or 660 or 750 mg per day of griseofulvin ultramicrosize for four to eight weeks (Gupta and Cooper, 2008) [40]. Dosing for children is weight-based with durations of treatment similar to adults.

Patients with hyperkeratotic tinea pedis can benefit from combining antifungal treatment with a topical keratolytic, such as salicylic acid. Burow's (1% aluminum acetate or 5% aluminum subacetate) wet dressings, applied for 20 minutes two to three times per day, or placing gauze or cotton between toes may be helpful as an adjunctive measure for patients with vesiculation or maceration. Interventions that may help to reduce recurrences include use of desiccating foot powders, treatment of shoes with antifungal powder, and avoidance of

occlusive footwear.

In some cases systemic treatment is an alternative for patients with extensive skin involvement and patients who fail topical therapy. Terbinafine and itraconazole are common treatments. Griseofulvin and fluconazole can also be effective, but may require longer courses of therapy. Randomized trials support the efficacy of systemic therapy (Bourlond *et al.*, 1989; Cole and Stricklin., 1989; Panagiotidou *et al.*, 1992; Faergemann *et al.*, 1997) [42-45].

Dermatophytes are fungi that can cause infections of the skin, hair, and nails due to their ability to utilize keratin. The organisms colonize the keratin tissues and inflammation is caused by host response to metabolic by-products. The dermatophytes are included in three fungal genera *viz,* i). *Epidermophyton:* This genus consists of 2 species, one of which is a pathogen ii). *Microsporum*: There are 19 described species but only 9 are involved in human or animal infections. iii). Trichophyton: There are 22 species, most causing infections in humans or animals (Indira, G. 2014) [46].

In the past few decades, a worldwide increase in the incidence of fungal infections has been observed as well as a rise in the resistance of some fungal species to different fungicidals used in medicinal practice. Fungi are one of the most neglected pathogens, as demonstrated by the fact that the amphotericin B, a polyene antibiotic discovered 1956, is still used as a "gold standard" for antifungal therapy. The last two decades have witnessed a dramatic rise in the incidence of life threatening systemic fungal infections (Abad *et al.*, 2007) [47].

Unlike the search for antibiotics, which took root from the discovery of penicillin late 1930s, the search for antiviral agents began in the 1950s but had a breakthrough in 1964. Early success in this direction included the use of methisazone for the prophylaxis of small pox and the use of idoxuridine for the treatment of herpes keratitis (Kinchington *et al.*, 1995) [48].

Two major obstacles to the development and use of effective antiviral chemotherapy are the close relationship that exists between the multiplying virus and the host cell, and that viral diseases can only be diagnosed and recognized after it is too late for effective treatment. In the first case, an effective antiviral agent must prevent completion of the viral growth cycle in the infected cell without being toxic to the surrounding normal cells (Desselberger, 1995) [49]. One encouraging development is the discovery that some virus specific enzymes are elaborated during multiplication of the virus particles and this may be a point of attack by a specific inhibitor. However, recognition of the disease state too late for effective treatment would render that antiviral agent useless even if they were available.

Until early recognition of the disease state is provided, most antiviral chemotherapeutic agents will have their value as prophylactic agents. The reason for the apparent lack of progress in antiviral chemotherapy as compared with the field of anti-bacterials has been a problem of selectivity (Kinchington *et al.*, 1995) [48]. Any antiviral agent must selectively kill the pathogenic organism in the presence of other living cells. Sufficient biochemical differences exist between the metabolism of prokaryotic bacterial cells and mammalian cells to enable selectivity to be achieved, hence the early development of antibacterial agents, which were safe for human use. Viruses on the other hand, despite their apparent simplicity present a bigger problem. This is because during their replicative cycle, they become physically and functionally incorporated into the host cells and it is therefore difficult to distinguish unique biochemical features suitable for selective attack.

Some viruses also persist in a latent infection, in which case, antiviral drugs are less likely to be effective. However increased understanding of the molecular events of virus infections has meant that the search for antiviral drugs against specific targets can be conducted on a more rational basis (Abonyi, 2009) [50].

Early cultures also recognized the value of plant materials in medicine. Plant extract has been used traditionally to treat a number of infectious diseases including those caused by bacteria, fungi, protozoa and viruses (Soylu *et al.*, 2005) [51]. In the recent years, researches on medicinal plants have attracted a lot of attention globally. Large body of evidence has accumulated to demonstrate the promising potential of medicinal plants used in various traditional, complementary and alternate systems of treatment of human diseases. Plants are rich in a wide variety of secondary metabolites such as tannins, terpenoids, alkaloids, flavonoids, etc, which have been found in vitro to have antimicrobial properties (Yoshida *et al.*, 2005) [52].

Medicinal plant products have been used as folk remedies for different kinds of ailments including viral diseases (Field and Biron, 1994) [53]. There is a need to search for new compounds for treatment of viral infections since there is an increasing resistance to antiviral drugs. Traditional plant extracts having anti-infective properties, have been screened for their antiviral activity (Chiang *et al.*, 2003) [54].

Also, several antiviral compounds have been tried as therapeutic use in earlier decades (Kinchington *et al.*, 1995) [48]. Nucleoside derivative drugs such as acyclovir (AVC), gancyclovir (GCV) and pencyclovir have been widely approved drugs for the treatment of HSV infections. However, wide spread use of these drugs has shown resistance especially inimmunocom promised and bone marrow transplant recipients. (Vanden *et al.*, 19986; Vijayan *et al.*, 2004) [55, 56]. In order to circumvent the problem of viral resistance, development of new antiviral products with different mechanism of action is crucial. The activity of the Indian medicinal plant extract, Swertiachirata agains therpes simplex virus type-1 (HSV-1) using multiple approaches.

Previously, EHP (1-(2-ethyl,6-heptyl)phenol) compound which extract from *Cuminum cyminum* (cumin) seeds by benzene solvent had possessed antifungal activity in an in vitro study against ten pathogenic fungal isolates (Mekawey *et al.*, 2008) [57]. Also, high activities were recorded against and seven cell lines of tumor (Mekawey *et al.*, 2009) [58]. The present study was designed to evaluate the antiviral and antidermatophyte activity of EHP (1-(2-ethyl,6-heptyl) phenol) compound, the antifungal drugs activities at the same concentrations and organic solvent are compared. The percentage of inhibition and MIC are also recorded.

2. Antifungal activity

Leaves of *Catharanthus roseus* showed antifungal activity against *Microsporum gypseum, Trichophyton simii* and *Malbranchea gypsea* or *Chrysosporium tropicum* and *C tropicum* (Singh and Singh, 1997) [59]. *In vitro* antifungal activity was investigated by using different organic solvent of lemon, nerium, olive oil and basil against *Microsporum canis, Microsporum gypseum, Trichophyton mentagrophytes, T. verrucosum* and *Epidermatophyton floccosum* (Bokhari, 2009) [60]. Plants of *Allium sativum, Cymbopogen martinii* and *Catharanthus roseus* were screened for their antimycotic

activity by using disc diffusion method. Water extract methanol, free flavonoids and bound flavonoids of various plants were tested against *Trichophyton rubrum, T.mentagrophytes* and *Microsporum gypseum*. Free flavonoid and bound flavonoid extracts showed maximum inhibitory effect against pathogenic fungal species (Bhadauria and Kumar, 2011) [61].

Antifungal activity of *Ramunculeus sceleratus* and *Pongamia pinnata (P. pinnata)* was tested for anti-ringworm activity of five strains *Trichophyton rubrum, T. mentagophytes, T. tonsourons, Microsporum gypseum* and *Microsporum fulvum* (Sharma *et al*., 2012) [62]. Leaves of *Calotropis spp*. were evaluated against *Trichophyton rubrum, T. tonsurans, T. mentagrophytes, Epidermatophyton floccosum* and *Asperigillus flavus* which showed antimycosis activity (Halua and Vidyasagar, 2012) [63]. *In vitro* antifungal activity of *Azadirachta indica L., Cassia tora* L. and *Lawsonia inermis L.* against three human pathogenic fungi, *Trichophyton rubrum, Trichophyton mentagrophytes* and *Epidermophyton floccosum* (Mohanty *et al*., 2012) [64]. *In vitro* antifungal activity of different synthetic, herbal shampoos and natural products were tested against clinical isolated species like *Malassezia, Trichophyton* and *Asperigillus* spp. Synthetic shampoos showed excellent inhibitory activity against *Trichophyton, Malassezia* spp. *Aspergillus flavus* and *Asperigillus niger* (Rao *et al*., 2013) [65].

Though there are advanced antifungal therapies, most problems remain to be solved for most antifungal drugs available in the market like Amphotericin B, Fluconazole, Ketoconazole, Miconazole etc. Most of them inducing resistance development in pathogens. This leads to therapeutic failures, and some of them have adverse side effects. Thus discovery of new compounds is required to combat fungal infections (Ravindra *et al*., 2008; Prakash and Ragavan, 2008) [66, 67].

In the past, few decades, the incidence of dermatophytosis has risen dramatically. The humid weather, over population and poor hygienic conditions are ideally suited for the growth of dermatophytes and these factors are more important in a tropical country like India. Among the infectious diseases, diseases caused by fungal infections account for a larger proportion of health problems in humans particularly among women and children (Simaljakova and Skutilova, 1995) [68]. A number of studies have been carried out reporting garlic as an antifungal agent (Amer *et al*., 1980; Bronwyn *et al*., 1991) [69, 70]. Turmeric oil was found to inhibit dermatophytes *in vivo* (Apisariyakul *et al*., 1995) [71]. Ibrahim studied the inhibitory activity against dermatophytes using ethanol extracts of *Cassia alata* leaves (Ibrahim and Osman, 1995) [72].

The ethanol extract of the whole plant of *Lawsonia inermis* showed antifungal activity against *Trichophyton mentagrophytes, Candida albicans, Candida neoformans, Aspergillus niger* and *Microsporum canis* (Bhakuni *et al*., 1971) [73]. The essential oil of *Ocimum* spp. has been reported to have antimicrobial and antidermatophytic properties (Janseen *et al*., 1989) [74]. *Psoralea corylifolia* seed essential oil showed moderate antifungal activity (Sharma and Singh, 1979) [75].

Since antimycotic activity of plants remain largely unexplored, interest has grown in studying antifungal activity from plant sources. Anti-candidal activities of 20 household South Indian medicinal plants and/or plant products have been reported using 30 *Candida albicans* isolates obtained from vaginal samples of patients with candidiasis (Vaijayanthimala *et al*., 2000) [76].

Acetone extracts of five medicinal plants viz., *Catunaregum spinosa, Psoralea corylifolia, Woodfordia fructicosa, Solanum virginianum* and *Syzygium cumini* were effective against the standard fungal culture of *Fusarium oxysporum* and *Alternaria alternata* (Kharat *et al*., 2005) [77].

Most of the extracts were devoid of antifungal, except the aqueous extract of leaves of *Indigofera suffruticosa* obtained by infusion. The MIC value of dermatophyte strains were 2500 mg ml against *Trichophyton rubrum* and *Microsporum canis*. The medicinal plant extracts of *Curcuma longa, Acalypha indica* and *Anona sqamosa* were tested by Cold percolation method against dermatophytic isolates (Anand *et al*., 2007) [78]. *Curcuma lounga* showed antifungal effect against *Trichophyton rubrum* and *Microsporum gypseum.* These two organisms were found to be resistant towards *Acalypha indica* and *Anona sqamosa*. The other dermatophytes were resistant to all medicinal plants tested.

Various pathogenic fungi *(Aspergillus fumigatus, Candida albicans, Epidermophyton floccosum, Microsporum canis* and *Trichophyton rubrum* were tested for effectiveness of ozanized olive oil (oleozone) by using agar dilution method. Among the species tested, *Microsporum canis* and *Trichophyton rubrum* showed maximum susceptibility (Neveen and Geweely, 2006) [79]. Leaves of *Cassia obvata* were extracted with different solvents and tested against pathogenic fungus species viz., *Asperigillus flavus, A. niger, Microsporum gypseum, Trichopyton tonsourons* and *Trichophyton rubrum.* As compared to other solvents, the aqueous extract showed maximum inhibitory effect against the dermatophytes (Pirzada *et al*., 2007) [80].

Different parts of plants were tested for antifungal activity from Jaipur district Rajasthan by food poisoning technique. Highest antifungal activity was showed by leaves of *Azadirachita indica* and *Datura metal* seed against *Trichophyton rubrum* (Kumar *et al*., 2012) [81]. Sharma *et al*. (2012) [82] tested antifungal activity of chloroform, methanol and water extracts of *Ranunculatus sceleratus* and *Pongamia pinnata in vitro* for anti-ringworm activity against five strains *Trichophyton rubrum,T. mentagrophytes, T.tonsourons, Microsporum gypseum* and *Microsporum fulvum* inagar well diffusion. The minimum inhibitory concentrations of the extracts were determined by broth macro dilution method.

3. Antidermatophytic activity

Leaves of *Eucalyptus rostrata* show antidermatophytic activity against four *Trichophyton mentagrophytes, Epidermophyton floccosum,Microsporum gypseum* and *M. canis* (Singh *et al*., 1988) [83]. Leaves of Neem also showed the antidermatophytic activity against 88 clinical isolates of dermatophytes (Venugopal and Venugopal, 1994) [84]. Leaf extract of *Pistia scleratus* showed antidermatophytic activity against *Trichophyton rubrum, Trichophyton mentagrophytes, Microsporum gypseum, Microsporum nanum,* and *Epidermatophytes floccosum* (Kumar and Shyamsundes, 2005) [85]. Hydro-alcohlic extract of *Eucalyptus camaldulensis* was tested against dermatophytes by using *in vitro* dilution technique (Moghimipour *et al*., 2009) [86].

Drynaria quercifolia used by tribals in Maharastra was tested for antidermatophytic activity against *Trichophyton mentagrophytes, Microsporum canis, M. gypseum, T. rubrum* and *Epidermophyton floccosum* by using agar dilution and disc diffusion method. The ethanol extracts isolated by thin layer chromatography was found to be possess

antidermatophytic activity with clear zone due to presence of triterpenes and coumarins (antifungal compounds) (Nejad and Deokule, 2009) [87]. Root extracts of *Solanum dulcamara* were found to possess anti-dermatophytic activity against *Trichophyton rubrum, T. mentagrophytes,* and *Microsporum gypseum.* Best activity of root extract was found against *Microsporum gypseum* with inhibition zone of *Trichophyton mentagrophytes* was found to be larger than Ketoconazole (Kumar and Bhadauria, 2009) [88]. *Curcuma* species were screened for antidermatophytic activity of *Trichophyton rubrum* and *Microsporum canis* by broth dilution method (Shukla *et al.*, 2011) [89]. *Mentha piperita* leaves were tested *in vitro* against two species of *Trichophyton* and *Microsporum canis*. Ethanolic extract of leaves of *Mentha piperita* exhibited the strongest activity against *Trichophyton rubrum* and *Microsporum canis* (Avinash *et al.*, 2012) [90].

Calotropis procera leaves extracts were tested against three different genera of dermatophytes *viz, Microsporum, Trichophyton,* and *Epidermatophyton* by dilution agar method. The ethonolic extract of *Calotropis procera* leaves was found to be inhibited all the species of dermatophytes (Goyal *et al.*, 2013) [91]. Various extracts of Neem *(Azadirachta indica)* leaves possess antidermatophytic activity against dermatophytes isolated from patients with dermatophytosis (Radhika and Michael, 2013) [92]. India is rich in medicinal plants with antidermatophytic activity.

Soils from different habitats of Madras city were studied by Sundaram and Subramaniam (1986) [93]. The isolated fungi include *Trichophyton rubrum, T. terrestre, Microsporum gypseum, Phialophora* sp., *Aspergillus* sp. and *Chrysosporium* sp. etc. The highest percentage occurrence was found in soils of garbage tanks. The discovery of geophilic keratinophilic fungi from soil, opened a new era of screening various habitats for their occurrence Vanbreuseghems (1952) [94]. The *M. gypseum* was isolated in 1955 by Cesar *et al.*, [95] using hair baiting technique from Atlanta, Georgia.

Leaf extract of *Cassia occidentalis, Cassia tora, Lawsonia intermis* and *Xanthium inermi* in different solvents were tested against *Trichophyton tonsourns, mentagrophytes, T. rubrum, Microsporum gypsum, Epidermatophyton floccosum.* Among other solvent ethylacetate was found to be best solvent which showed maximum inhibitory effect against dermatophytes (Sagar and Vidyasagar, 2013) [96].

4. Conclusion

The ultimate conclusion of this study supports the traditional medicine use of different plant extracts in treating different infections caused by pathogenic fungi in India either by using a single or combined extracts. It also suggests that great attention should be paid to medicinal plants which are found to have plenty of pharmacological properties that could be sufficiently better when considering a natural food and feed additives to improve human and animal health.

5. References

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