LETTERS IN BIOMATHEMATICS
An International Journal

RESEARCH ARTICLE

OPEN ACCESS

Comparative In-Vitro Evaluation of Propolis against Clinical *Trichophyton* Isolates: Epidemiological Distribution and Antifungal Susceptibility Analysis

Mariam Muwafaq Jasim Albadry[1*], Abeer Fawzi Murad[1], Mohammad Al Hattab[1]

[1] University of Babylon-College of Science for Women-Department of Biology, Iraq

ABSTRACT

Background: Dermatophytosis is a widespread superficial fungal infection primarily caused by *Trichophyton* species and is a significant public health issue, especially in the developing world. The development of decreased susceptibility to certain antifungal drugs has spurred the exploration of natural sources of alternative therapies. Objective: The aim of the study was to examine the epidemiology of dermatophytosis and to compare the antifungal effects of propolis against clinical strains of *Trichophyton* against standard anti-fungal medications. Methods: 100 clinical samples were taken from patients suspected of dermatophytosis. Sixty-eight (68) samples (68%) were positive for dermatophytes, and 50 isolates were morphologically identified as *Trichophyton* species by Sabouraud Dextrose Agar culture, macroscopic colony characteristics, and microscopic observation. Results: The most frequent clinical manifestation was that of *Tinea corporis* (45%), *Tinea capitis* (21.7%). Among the people in rural areas and those aged 1-24 years, there was more infection. Concentration-dependent antifungal activity on *Trichophyton* isolates was demonstrated by Propolis, and increasing concentrations of the antifungal increased the degree of inhibition. Out of conventional antifungals, terbinafine was found to have high inhibitory properties, whereas itraconazole in powder form possessed weak or no inhibitory effect under the conditions of the experiment. These results favor propolis as a bioactive natural product. Conclusion: Propolis showed encouraging anti-fungal in vitro effects and could present a prospective natural alternative or complement of dermatophytosis treatment.

ARTICLE HISTORY

Received October 13, 2026

Accepted November 17, 2026

KEYWORDS

Dermatophytosis,
Trichophyton spp.,
Propolis,
Antifungal Activity,
Terbinafine,
Tinea Corporis,
In Vitro Study

1. Introduction

Dermatophytosis is a common skin fungal infection in most regions of the world, which infects keratinized surfaces like nails, skin, and hair. It is most commonly caused by dermatophytes of the genera *Trichophyton*, Microsporum and Epidermophyton, with *Trichophyton* as the most commonly implicated in human infection (Achterman & White, 2012). These infections are common in the developed countries and developing countries and are impacted by a variety of factors such as climatic conditions, hygiene, socioeconomic status, immune capacity of the host and exposure to infected humans or animals. Over the last few years, a growing level of concern has been raised over the decreased susceptibility and therapeutic failure with certain traditional antifungal agents, especially *Trichophyton* species, prompting the need to maintain the use of surveillance and different treatment plans (Monod, 2019).

In our current study, 68% of the clinical samples sampled yielded dermatophytes, and it means that the burden of infection among the clinical samples studied was relatively high. The greatest prevalence was in those aged 1-24 years which might be attributed to increased physical contact, sharing of personal items, school-related infection and lack of awareness of preventive hygiene. The rate of infection was also found to be higher among the rural inhabitants and may be attributed to exposure to more animals, overpopulation, and inability to access medical services. The results confirm that dermatophytosis does not lose its connection with behavioral and environmental factors with age.

Though a number of antifungal agents exist to treat dermatophytosis, they may exhibit different efficacies based on the infecting pathogen, formulation used, and their resistance in the area. Besides, the success of conventional therapy might be restricted by a longer course of treatment, recurrence, side effects, the development of resistant strains (Apalla et al., 2019). Because of these reasons, the interest in natural products as a potential source of new antifungal agents has

CONTACT Mariam Muwafaq Jasim Albadry: Scw275.mariem.mufaq@student.uobabylon.edu.iq

been growing. Most importantly, propolis has been of particular interest since it is a biologically acting bee product with a high concentration of flavonoids, phenolic acids, and other compounds that are known to possess antimicrobial, antioxidant, and antifungal properties (Sforcin & Bankova, 2011; Silva-Carvalho et al., 2015).

Several potential mechanisms have been proposed to explain the antifungal activity of propolis and this includes causing a break in fungal cell membrane integrity, ergosterol biosynthesis and causing oxidative stress on fungal cells (Zulhendri et al., 2021). This and other properties imply that propolis could be an effective alternative or complementary antifungal treatment (Wagh, 2013). Thus, this work was designed not only to assess the antifungal efficacy of propolis with respect to clinical isolates of *Trichophyton* against the selected antifungal drugs but also to compare the activities of propolis and the chosen antifungal drugs. Since the isolates were characterized by culture and morphological techniques alone, the experiment speaks of morphologically characterized *Trichophyton* isolates, as opposed to the molecularly characterized strains.

2. Materials and Methods

2.1 Study Design

The current work was carried out as an experimental in vitro comparative study in order to examine the prevalence of dermatophytosis in clinically suspective cases and the antifungal effect of *Trichophyton* isolates against conventional antifungal agents and propolis (Siddig et al., 2023). It was a work dedicated to the laboratory isolation and identification of dermatophytes in clinical samples and subsequent testing of antifungal sensitivity based on the physical form of the antifungal substance under test with various methods. The objective of the study was to compare the inhibitory properties between commercial available antifungal drugs and propolis as a natural product that could have therapeutic use (Wang et al., 2021).

2.2 Sample Collection

Ten clinical samples were tested on 100 suspected individuals and wanted to tell you all about that. The selection of samples varied by the clinical manifestation, and skin, scalp, or other keratinized tissues with superficial fungal infection were sampled (Lepera et al., 2025). All samples were failed under suitable conditions in the laboratory in order to isolate dermatophytes. Following culture and analysis, 68 samples (68% of the total sampled) grew positive in the presence of dermatophytes, suggesting that the prevalence of fungal infection was relatively high among the sampled cases. Among the positive cultures, 50 isolates were determined as those of the genus *Trichophyton* and these isolates were chosen to be evaluated further using mycological methods and antifungal susceptibility testing (Singh et al., 2025).

2.3 Isolation and Identification of Fungi

The clinical specimens collected were cultured on Sabouraud Dextrose Agar (SDA), which is a traditional media that is widely used in the isolation of fungi especially dermatophytes. The media inoculated was left to grow and develop fungal characteristics under appropriate laboratory conditions. Incubated fungal isolates were then scrutinized with diagnostic traits (Giuliani et al., 2025).

The isolates were identified by traditional morphological methods only. This consisted of macroscopic and microscopic studies. The related macroscopic analysis checked the outward image, the textural outlook, the color, the growth rate, and the pigmentation on the backside and the front side of the medium in which the culture was maintained. These markers of colonies play critical initial roles in differentiating genera and species of dermatophytes (Pérez-Rodríguez et al., 2023). During the microscopic analysis, fungal components were identified to discover forms that include hyphae, microconidia, macroconidia, and other common reproductive components that aids genus- and species-level identification (Bhosale et al., 2022). Using these cultural and microscopic results, 50 isolates were considered to be *Trichophyton* spp. It is worth mentioning that there was no use of molecular techniques such as polymerase chain reaction (PCR) in this study and so the identification was based purely on morphological factors (Steixner et al., 2025).

2.4 Selection of Isolates for Experimental Study

Among the *Trichophyton* isolates identified, the isolates recovered best on morphological grounds were especially *Trichophyton mentagrophytes* and *Trichophyton* rubrum. The comparative antifungal studies utilized these isolates since they were the primary dermatophyte species tested in the experiment.

2.5 Antifungal Testing Approach

Depending on the type of the antifungal material being tested, antifungal susceptibility testing was conducted with

various methods. This has been adopted to make sure that the most suitable laboratory method is used to test each agent. The disk diffusion method was used to test tablet-form antifungal drugs, the agar well diffusion method was used to test powdered antifungal drugs and the poisoned medium technique was used to test propolis (Lovesley et al., 2022). The effect of each of the agents under investigation was inhibitory and was established by monitoring fungal growth slowdown or the difference in the inhibition zone surrounding the article under test after incubation.

2.6 Ethical and Laboratory Considerations

Laboratory procedures were conducted under normal aseptic conditions to prevent contamination of the specimen during handling, culture and testing. The trial was based on standard mycological procedures based on fungus isolation and identification. Since only in vitro laboratory exploration was performed, the results indicate antifungal activity in the controlled experimental conditions and should be viewed in that context.

2.7 Antifungal Susceptibility Testing

Antifungal susceptibility tests were conducted in three methods depending on the physical form of the antifungal agent being tested. This was done to make sure that each substance was tested using the best possible laboratory method. Action of the tested agents against *Trichophyton* isolates was determined by measuring the area of inhibition or reduction of fungal growth following the test.

Antifungal drugs in tablet form, such as fluconazole, ketoconazole and itraconazole, were administered using the disk diffusion technique. The agar was inoculated with the fungal isolates and the antifungal disks put on the agar surface. The antifungal activity was determined by measuring the diameter of inhibition zone surrounding each disk after incubation (Berkow et al., 2020).

Agar well diffusion technique has been used in powdered antifungal products, terbinafine and itraconazole powder. Serial dilution of Stock 1 (10^-1) and Stock 2 (10^-2) was prepared in distilled water. The ready solutions were placed into prepared wells created in the inoculated agar, and the zone of inhibition was measured after two hours (Hossain, 2024).

The poisoned medium method was used to assess the antifungal properties of propolis at different concentrations (8% 6% 4% 2), and a control (0%). The concentration was originally set at 10%, and the range was set after fungal growth was detected at 2% (Siopi et al., 2024).

2.8 Preparation of Propolis Extract

Propolis was acquired in a nearby apiary in Al-Hilla city and was named by a botanist at Al-Qasim Green University, College of Agriculture. To prepare the extract, 11.5g of propolis was individually soaked in 240 ml of 99% ethanol and 240 ml of distilled water. The mixtures were allowed to stand in room temperature after 48 hours in order to extract the active constituents. Then samples were filtered with sterile gauze and followed by sterile filter paper No. 1 to exclude the impurities and solid particles. Drying of the filtrates in an oven at 40 C produced the extracts. Emulsions The RPMI 1640 medium was then used to prepare the final stock solutions to be used in antifungal tests.

2.9 Measurement of Antifungal Inhibition

Antifungal was evaluated by quantification of the zone of inhibition forming against the fungal isolates tested. A 2fold horizontal and vertical measure of an inhibition zone was taken on each plate to enhance precision. The average size of the inhibition zone was obtained from the following formula:

2.9.1 Mean inhibition zone = (Horizontal + Vertical) / 2

Where the same treatment was applied to more than one plate, the final outcome was reported as the mean size of the final plate.

3. Results

3.1 Overall Isolation Rate

One hundred clinical samples were available to collect patients with clinical suspicion of dermatophytosis. Subculture culture on Sabouraud Dextrose Agar and morphology after culture indicated that 68 cases (68%) had positive growth on dermatophytes, whereas 32 cases (32%) had no growth. Of the positive cultures 50 morphologically identified as part of the genus *Trichophyton* were used in antifungal susceptibility testing. These results suggest that a significant fraction of superficial fungal infections in the cases investigated comprised of dermatophytes.

Table 1: Culture Results of Collected Clinical Samples

Result	No. of Samples	Percentage (%)
Positive for Dermatophytes	68	68.0
Negative	32	32.0
Total	100	100

3.2 Demographic Distribution of Positive Cases

Demographic information of the 68 positive cases was compared by gender, age group, residence, animal contact history, and diabetes status. There was a marginal male predominance with 39 cases (57.4%) involved in males and 29 cases (42.6%), in females.

Table 2: Gender Distribution of Positive Cases

Gender	No. of Cases	Percentage (%)
Male	39	57.4
Female	29	42.6
Total	68	100

The analysis of ages indicated that the age-group of 1-24 years was the most common, representing 34 cases of dermatophytosis (50.0%). This was then followed by the 21- 40 years group that had 24 cases (29.4%), the 41- 60 years group that had 10 cases (14.7%), and the patients aged above 60 years, which had 4 cases (5.9%).

Table 3: Age Distribution of Positive Cases

Age Group (Years)	No. of Cases	Percentage (%)
1-24	34	50.0
21-40	24	29.4
41-60	10	14.7
>60	4	5.9
Total	72	100

Infection was more prevalent in rural residents (42 cases; or 61.8%) as opposed to urban residents (26 cases; or 38.2%) according to the place of residence criteria.

Table 4: Distribution According to Residence

Residence	No. of Cases	Percentage (%)
Rural	42	61.8
Urban	26	38.2
Total	68	100

In terms of risk factors, 37 patients (54.4%) had a history of animal contact, and 31 patients (45.6%) did not. Regarding diabetes mellitus, 15 critical cases (22.1) were diabetic and 53 critical cases (77.9) were not diabetic.

Table 5: Animal Contact Among Positive Cases

Animal Contact	No. of Cases	Percentage (%)
Yes	37	54.4
No	31	45.6
Total	68	100

Table 6: Diabetes Status Among Positive Cases

Diabetes status	No. of Cases	Percentage (%)
Diabetic	15	22.1
Non-diabetic	53	77.9
Total	68	100

3.3 Clinical Types of Dermatophytosis

The clinical manifestations were categorized by the place of infection. The most common clinical pattern was tinea corporis with 31 (45.6) cases and tinea capitis with 15 (22.1) cases. There were 22 cases (32.3%) of other clinical forms.

Table 7: Clinical types of Dermatophytosis

Clinical type	No. of Cases	Percentage (%)
Tinea corporis	31	45.6
Tinea capitis	15	22.1
Other forms	22	32.3
Total	68	100

These results show infection of glabrous skin as the most frequent clinical manifestation of the study population and then scalp infection.

3.4 Species Distribution

Of the 50 morphologically characterized *Trichophyton* isolates subjected to the experimental study, 26 of the total isolates (56.5%) were determined as *Trichophyton mentagrophytes* and 24 of the total isolates (43.5%) as *Trichophyton* interdigitale.

Table 8: Species Distribution of *Trichophyton* Isolates

Species	No. of Isolates	Percentage (%)
T. mentagrophytes	26	56.5
T. rubrum	24	43.5
Total	50	100

3.5 Antifungal Activity of Propolis

Propolis antifungal activity was tested by the use of the poisoned medium technique on 8%, 6%, 4% and 2% of propolis, together with an untreated control. The findings indicated a definite concentration based repelling impact of both *T. mentagrofytes* and *T. rubrum*. The most effective concentration 8% had the most inhabitation and the lowest concentration 2% had the lowest activity that was measurable (Armengol et al., 2021). There was no inhibition observed in the control group.

In the case of *T. mentagrovytes*, the average size of the inhibition zone measured at 2% and 8% rose to 6.4 mm and 18.6 mm, respectively. In the case of *T. rubrum* the inhibition value varied between 5.8 mm at 2% and 17.9 mm at 8%. Overall, T. mentagrophytes were a little more vulnerable to propolis than *T. rubrum* at all tested concentrations (Veiga et al., 2018).

Table 9: Antifungal Activity of Propolis Against *Trichophyton* Species (mean inhibition zone, mm)

Propolis Concentration	*T. mentagrophytes*	*T. rubrum*
8%	18.6	17.9
6%	15.2	14.7
4%	11.1	10.3
2%	6.4	5.8
Control (0%)	0.0	0.0

3.6 Antifungal Activity of Powdered Drugs

Antifungal activity of powdered terbinafine and itraconazole on agar well diffusion was assessed using 10 -1 and 10 -2 stock concentrations of the agar as the diffusion medium. Terbinafine was the most effective inhibitor against the two species tested. *T. mentefera T. menteferiestisi*. The terbinafine Stock 1 (10^-1) gave the highest level of activity with mean inhibition zones of 24.3 mm (*T. mentagrotes*) and 23.6 mm (*T. rubrum*). Minor poorer but still good activity was presented by terbinafine Stock 2 (10^-2).

Conversely, itraconazole powder had low or no activity. At Stock 1 (10^-1) *T. mentagrovytes* and *T. rubrum* produced a series of 7.2 mm and 6.4 mm inhibition zones respectively. No inhibition of either species was detectable at Stock 2 (10^-2).

Table 10: Antifungal Activity of Powdered Drugs Against *Trichophyton* Species (Mean Inhibition Zone, mm)

Stock Concentration	*T. mentagrophytes*	*T. rubrum*
Terbinafine Stock 1 (10^-1)	24.3	23.6
Terbinafine Stock 2 (10^-2)	24.8	19.9
Itraconazole Stock 1 (10^-1)	7.2	6.4
Itraconazole Stock 2 (10^-2)	0.0	0.0

These results show the strong effectiveness of terbinafine compared to itraconazole powder in the conditions under

study.

3.7 Antifungal Activity of Tablet Drugs

Fluconazole, ketoconazole and itraconazole tablets were tested against the two *Trichophyton* species using the disk diffusion method. Of the tablet drugs tested, ketoconazole gave the largest inhibition zones, with the means of 19.1 mm against *T. mentagrotes* and 17.8 mm against *T. rubrum* at the same time. Itraconazole was moderately active, with an inhibition zone of 13.2 mm and 12.6 mm, respectively. The weakest activity was observed with fluconazole with inhibition zones of 9.4 mm with *T. mentagrofytes* and 8.7 mm with *T. rubrum*.

Table 11: Antifungal activity of tablet drugs by disk diffusion (mean inhibition zone, mm)

Drug	*T. mentagrophytes*	*T. rubrum*
Fluconazole	9.4	8.7
Ketoconazole	19.1	17.8
Itraconazole	13.2	12.6

Results suggest that in the 2 tested species, ketoconazole was the most active antifungal in tablet form and lowest inhibitory effect was observed in fluconazole.

3.8 Comparative Summary of Antifungal Effects

Comparison with all the tested agents revealed that terbinafine exhibited the best overall overall antifungal activity of the conventional drugs used, when used in the powder form. The tablet drugs were most effective with ketoconazole. Propolis exhibited an antimicrobial effect showing a concentration-dependent inhibitory effect that showed potential immunocylobacterical activity. Propofolis activity was lower than the terbinafine activity, but still significant and reliable between the two Trichophytals (Koç & Silici, 2008). Itraconazole powder have the least performance and at low concentration, could not prevent fungal growth.

On the whole, the information indicates that T. mentagrophytes was a bit more vulnerable than *T. rubrum* to the majority of the tested agents. The results also indicate the possible use of propolis as a natural antifungal agent in concentrations dependent on the effects on dermatophytes (Shao et al., 2025).

4. Discussion

4.1 Epidemiological Interpretation

In the current study, dermatophytosis was frequently observed in the analyzed cases and dermatophyte growth was observed in 68% cases of clinical samples. This result justifies persistence of superficial fungal infections as a health issue of interest to the population, particularly in places where there is crowding, inadequate hygiene facilities and contact with animal species. Dermatophytosis is one of the most common fungi in the world, and *Trichophyton* species has been reported as the most prevalent causative agents in human disease. The *Trichophyton* preponderance of the current study is thus compatible with known epidemiology of dermatophyte infections.

The increased rate of infection in rural inhabitants could be attributed to all of these joint causes. Rural communities can be in closer contact with animals that can be carriers and reservoirs of dermatophytes. Moreover, the environmental exposures, co-residency, and procrastinating treatment seeking as well as personal hygiene practices might contribute to transmission. These are often mentioned as causative factors of dermatophytosis epidemiology, especially in developing areas where zoonotic and anthropophilic transmission may co-exist. The possibility that environmental and zoonotic exposure was also a significant factor in transmission is also supported by the presence of the measured association with animal contact in your study.

The most common presentation was a clinical manifestation of tinea corporis, and then tinea capitus. The trend could be indicative of local behavior and environment. Tinea corporis has been commonly attributed to direct person to person transmission - via skin-to-skin contact, shared clothing or towels, and exposure to animals, whereas tinea capitis is particularly prevalent in children due to their scalp fragility and close contact. The fact that these two types were predominant as clinical manifestations implies that the primary anatomical locations in your study population were the body skin and your scalp.

4.2 Age Distribution Explanation

The age group 1-24 years is the most infected group which can be explained by both biological and behavioural factors. Children and adolescents tend to experience close physical contact with others in schools and homes, to share combs, clothing, bedding, and sports equipment; and to engage in inconsistent hygiene behaviors. These contribute to the

proliferation of dermatophytes, mainly in densely populated areas. Specifically, tinea capitus is known to occur more commonly among children since the conditions favoring dermatophyte growth are more common among children before puberty than in the adult scalp.

Your age pattern might also be relating to the maturity of immune, habits of exposure and the transmission of the family. Younger people are more likely to experience more intense networks of contacts and to fail to recognize the initial symptoms of the disease or find immediate treatment. Young people are also more likely to come into contact with domestic animals in rural areas. All these reasons contribute to why the first three age groups had the highest seasonal disease burden in the current research.

4.3 Antifungal Susceptibility and Resistance Mechanisms

The antifungal activity of the traditional antifungal agents was varied. Terbinafine exhibited high inhibitor effect and itraconazole in powder form exhibited weak or no effect under conditions tested and the tablet drugs showed varying levels of inhibitor effect. This variation is in line with the increasing awareness that dermatophytes have inherent variability and potentially vary depending on species, formulation, conditions of exposure and local resistance patterns.

The decreased susceptibility or antifungal resistance of dermatophytes may be explained by a series of mechanisms. Among major mechanisms, a change in the target enzyme or pathway of the drug is considered. In the case of terbinafine the development of resistance has been linked predominantly to mutation in the gene encoding squalene epoxidase which diminishes drug binding and makes organisms resistant. In the case of azole antifungals, decreased activity can be caused by modification of the ergosterol biosynthesis pathway, such as altered expression, or mutation of sterol production enzymes. The other significant process is the increased expression of efflux pumps, which act by actively eliminating the antifungal drug out of the fungal cell and causes the drug to build up in the cell. Moreover, biofilm formation, adaptation to metabolism and the stress-response mechanisms might also play a role in persistence and worse response to treatment.

The fact that certain antifungal preparations perform poorly in your study does not automatically indicate that these preparations are actually clinically resistant to it but does indicate less in vitro susceptibility when the preparations are tested in the conditions used. This is significant because failure of treatment in dermatophytosis may be due to a combination of microbial resistance, inadequate drug penetration, inadequate compliance, reinfection, or a lack of proper treatment the length of time. Hence the in vitro results must be viewed as markers of antifungal activity instead of the sole cause of treatment effect.

4.4 Antifungal Mechanism of Propolis

One key observation of the current research was that propolis had a concentration-dependent antifungal effect on *Trichophyton mentagrophytes* and *Trichophyton* rubrum. The effect of propolis was inhibitory and depended on the concentration of propolis, which confirms the idea that propolis consists of antifungal biologically active constituents based on which the effect on dermatophytes is observed. This finding is in line with other literature that reveals that propolis has an antimicrobial and antifungal activity due to the abundance of chemical compounds such as flavonoids, phenolic acids, terpenoids, and aromatic compounds.

The antifungal effect of propolis could be attributed to several mechanisms. Firstly, flavonoids and other phenolic compounds may cause damage to fungal cell membranes, causing them to become permeable and resulting in the leakage of vital intracellular parts. Second, propolis could disrupt the synthesis of ergosterol, causing defects in the membrane integrity and the functioning of the fungal cells in a conceptually similar way with some traditional antifungals. Third, propolis can induce oxidative stress in fungal cells by affecting reactive oxygen species production or eliminating antioxidant responses, consequently damaging proteins, lipids and nucleic acids. All these measures can suppress the growth of fungi and the growth of colonies.

The dependence on concentration in the activity of your results contributes to the biological plausibility of such mechanisms. Increased levels of propolis probably result in increased exposure to active compounds causing more severe interference in fungal growth. In your model study, propolis was not found to be any stronger than terbinafine; however, that it has been shown to have a quantifiable effect indicates it can be of use as a substitute natural antifungal agent. This is especially topical in the light of growing interest in the potential of drug resistance and necessity of alternative or supplementary treatment.

4.5 Interpretation of the Overall Findings

Combined, the findings indicate that the epidemiological conditions in your study group contributed to the development of dermatophytosis, with young age and rural environment being the most recognizable ones, and that *Trichophyton* species were the main pathogens among the tested isolates. The antifungal assays also suggested that the

antifungal drugs commonly used are not equally effective in the laboratory setting and that there is significant in vitro inhibitory performance of propolis. These results reinforce the assumption that natural products could offer valuable clues to future antifungal development, especially where high levels of resistance to current agents are suspected.

Concurrently the current results can be explained within the framework of the study design. Morphological identification was undertaken without molecular validation and the antifungal tests were conducted in vitro. Thus, the findings should be regarded as initial yet encouraging indicators of the antifungal properties of propolis against clinical isolates of *Trichophyton*.

5. Conclusion

Dermatophytosis is still a frequent superficial infection by fungi and is especially common in young people and in rural regions. The most prevalent species of pathogens found in the current study were *Trichophyton* species. Results of the antifungal susceptibility tests revealed some variability among the traditional antifungal agents with some antifungal agents exhibiting more activity than others. Propolis showed a demonstrable in vitro antifungal effect on *Trichophyton* isolates tested and the effect was enhanced by concentration. The results indicate that propolis as a natural product has potential as an alternative or complement to controlling dermatophytosis, but additional standardization and validation are necessary.

6. Recommendations

To derive more accurate and comparable data on the susceptibility, future research needs to establish the lowest dose of propolis to inhibit growth of the bacteria using standardized broth microdilution tests. Memory The chemical composition of a test propolis is also to be determined using GC-MS or any other comparable analysis method, since the biological properties of propolis are affected greatly on its chemical profile and geographical origin. Furthermore, it would also be worthwhile to explore the potential for the synergistic effect of propolis with terbinafine as combination treatment could improve the effectiveness of antifungal agents and potentially decrease the required dosage of traditional agents. Last, in vivo tests must be conducted to determine safety, efficacy, tissue penetration, and therapeutic potential in a clinical setting.

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