

Antifungal Activity of *Furcraea Foetida* Extract Against *Candida* Species Isolated from Oral Candidiasis Associated with Orthodontic Treatment

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Abstract

The growing resistance of *Candida* species to a wide range of antifungal medications complicates the treatment of oral candidiasis. Our study explored and identified the *in vitro* antifungal properties of *Furcraea foetida* leaf extract against *Candida* spp. Isolated clinically from 50 patients suffering from active recurrent oral candidiasis associated with their orthodontic treatment. Methodology was depending on using agar plate diffusion and internal transcribed spacer (ITS) with PCR genotyping. Genotyping demonstrated 23 isolates of *Candida* spp, showed high frequency of *Candida albicans* isolates (65.2%, 550bp), *Candida parapsilosis* (30.4%, 520bp) and *Candida holmii* (4.3%, 720bp). By employing agar plate diffusion method, the results indicated that the 50% concentration of direct crude extract *Furcraea foetida* demonstrated effective inhibition zones against *Candida* spp. isolates in comparable to 10 mg of fluconazole ($p=0.403$), but against non-albicans isolates, the extract showed smaller inhibition zones ($p<0.001$). These results support *Furcraea foetida* leaf extract as a promising natural antifungal resource for the development of topical or adjunctive therapeutic agents against oral *Candida albicans* infections, demanding further pharmacologic development.

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Citation: Kadhem ZK et al. (2026) Antifungal Activity of *Furcraea Foetida* Extract Against *Candida* Species Isolated from Oral Candidiasis Associated with Orthodontic Treatment. Dentistry 3000. 1:a001
doi:10.5195/d3000.2026.1563
Received: August 2, 2026
Revised: September 9, 2026
Accepted: September 12, 2026
Published: September 30, 2026
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Introduction

Oral candidiasis, primarily caused by *Candida* spp., is a prevalent fungal infection that can be linked to and worsen the condition of orthodontic treatments, especially in immunocompromised individuals [1,2]. Fixed orthodontic treatments including appliances, braces, brackets and elastics, provide a perfect reservoir for candidal and bacterial growth; patients throughout their long orthodontic journey require special oral hygiene care. Oral candidiasis, angular cheilitis and other oral mycosis infections show frequent recurrence during the long-term of orthodontic treatment [3,4]. The rise of resistance to first-line antifungals, such

as fluconazole, poses a considerable clinical challenge, resulting in recurrent infections and extended patient discomfort [5]. Although various synthetic antifungals are accessible, their application may be restricted due to side effects, costs, and potential drug interactions. As a result, medicinal plants, known for their wide array of bioactive compounds and historical safety, present a significant opportunity for the discovery of new antimicrobial agents [6]. *Furcraea foetida*, a member of the Asparagaceae family, is a wild tropical plant utilized in traditional medicine and has been employed in folk remedies; however, its specific antifungal properties, particularly against oral

pathogens, remain scientifically underexplored [7]. Even though *Furcraea foetida* is not native to the plants of Iraq but, it has been introduced and cultivated locally [8]. *Furcraea foetida* has a documented history of use in traditional medicine, particularly in South America and the Caribbean, where its Leaf sap is used for wounds. Previous studies demonstrated further pharmacological uses against dermatophyte fungi that affect human health. The industrial utilization of *Furcraea foetida* as natural medicine in medicated shampoos or in medications for hair treatment supports its antifungal activity [9].

Although chromogenic media serve as a useful initial diagnostic tool, variations in colony coloration may hinder accurate interpretation. It is advisable to exercise diagnostic caution, and confirmatory techniques, including molecular methods, are crucial for dependable identification, particularly for emerging or less frequently encountered *Candida* species [10]. A more dependable diagnostic approach for *Candida* spp. was employed, utilizing the universal barcode region through amplification of the Internal Transcribed Spacer (ITS) region of fungal ribosomal DNA [11].

Consequently, the aim of this study was to assess the *in vitro* antifungal activity of *Furcraea foetida* leaf extract against *Candida* spp. That was clinically isolated from oral candida infections associated with fixed orthodontic treatment, with the application of both genotypic and phenotypic identification approaches. The hypothesis of our study was that the leaf extract of *Furcraea foetida* would produce an *in vitro* antifungal activity against *Candida* spp. clinical isolates in comparison to fluconazole.

Material and Methods

Patients were randomly recruited from private dental clinics in Baghdad province, Iraq. Patients age range were (18-30 years old). The study was ethically approved by the scientific committee of College of Dentistry at Mustansiriyah University (2025/MUOPOP13). Inclusion criteria included: subjects undergoing fixed metal orthodontic treatment for a duration of more than 6 months, suffering from recurring oral candidiasis; at the time of clinical evaluation, the patients showed signs and symptoms including oral candidiasis with erythema, burning sensation, taste changes and angular cheilitis. The subjects were medically free and generally healthy. Exclusion criteria included: Patients who were immunocompromised or had diagnosed with autoimmune diseases or patients who had taken any medications in the previous month which may interrupt the oral normal flora. The study was carried out from November 2025 to February 2026. Fifty patients clinically fit the inclusion criteria and were diagnosed with oral candidiasis.

Sterile oral swabs were collected from all the participants. The examiner sampling by rub the upper and lower vestibular mucosa and again on the multiple fixed brackets around areas for each patient.

Mature leaves of *Furcraea foetida* were washed with distilled water, cut, macerated, and mixed with 20ml of sterile distilled water using a sterile plastic plate. The extract was filtered through double-layer medical gauze to remove plant material residues. Then filtered again using filter paper, then the filtered

extract Placed in glass screw- capped cup. The extract was evaporated at 40°C in an oven until it became thick in consistency, then autoclaved to avoid microbial contamination. To prepare 50% concentrations of thick extract, 5 gm was weighted, dissolved in 10 ml of sterile distilled water, and stored in a dark glass container at a temperature of 5°C in the refrigerator until use [12].

The plant material was taxonomically authenticated by Dr. Abd al-Ridha Akbar Alwan, a lecturer in the Department of Ecology at the College of Science, University of Basra. A voucher specimen was deposited in the departmental Babylon herbarium for future reference.

Swabs were cultured on Sabouraud Dextrose Agar (SDA) by streaking method and incubated for 24-48 hours at 30°C. Isolation and identification of 50 pure clinical isolates of *Candida* spp. were obtained. The isolates were cultured on Sabouraud Dextrose Agar (SDA), then the pure colonies of *Candida* spp were preliminarily identified by CHROMagar medium and confirmed by specific polymerase chain reaction (PCR) [13,14]. Out of the 50 isolates, 23 isolates represented from the CHROMagar phenotyping were selected for PCR genotyping and then for the antifungal tests.

DNA extraction was conducted from a pure *Candida* colony cultivated on culture media on CHROMagar and SDA, utilizing the Favrogen extraction kit (Thailand.com). The phenotypic identification of fungi under interested was confirmed by simple PCR by universal primer pair ITS5/ITS4, targeted ITS region (ITS1, 5.8S rRNA gene, and ITS2) was amplified using Primers: ITS5 (GGAAGTAAAGTCGTAACAAGG) and ITS4 (TCCTCCGCTTATTGATATGC).

One microliter of DNA (20µg/ml) from each of 23 isolates was mixed with a PCR mixture (final reaction volume 25µL) consisted of 12µL of 20x Master Mix (Promega.com), 2µL of primers (10 pmol each), and complete volume with distilled water. PCR conditions: pre-denaturation 94°C for 3min, 30 cycles of denaturation at 94°C for 30 sec. annealing temperature 56°C for 30 sec and, extension at 72°C for 45 sec. and final extension was 72°C for 5 min. Gel electrophoresis was performed on 1% agarose gel with TBE buffer, 45vol. for 60 min. This method is particularly beneficial for studying *Candida* in oral cavity due to it precisely identification method [11]. The determination of each *Candida* spp amplicon sizes depended on Fujita and Hashimoto methodology [15].

To genotype *Candida* isolates of interest while maintaining statistical robustness, 50 isolates were stratified into distinct phenotypic cohorts based on their CHROMagar reaction profiles. A proportional stratified random sampling method was employed, selecting 23 isolates that accurately reflect the distribution of these

clinically relevant PCR typing. This ensures that every major phenotypic category of interest is represented in the genotyping phase, preventing bias toward any single subpopulation.

The *in-vitro* assessment of antifungal activity of *Furcraea foetida* against *Candida* spp isolated from clinical specimens, with fungal identification that described before. The methodology of the agar well diffusion has been used to assess the antifungal efficacy of extract [16]. A suspension of *Candida* spores with a volume of 50µl, holding around 10⁵ spores/ml, with the using of sterile spreader was evenly spread on plates of Sabouraud dextrose agar. Wells with a diameter of 5 millimeters were created on the agar plates using a sterile cork borer and filled with 100µl of the previously prepared leaf extract. Disc of 10 mg of fluconazole was used as standard antifungal. These discs were then placed on the plates inoculated with *Candida* spp. Plates were incubated in an upright position at a temperature of 30°C for duration of 24-48 hours. After incubation, the diameter of the inhibition zone (in mm) was measured. The core principle of this test is a semi-quantitative screening that relies on comparing the zone of inhibition diameters produced by each substance.

Experiments were conducted in triplicates, and their means and standard deviations (SD) were calculated. IBM SPSS V24.0 was used for data analysis. An independent sample Welch's t-test was used to compare means between groups. A p-value ≤ 0.05 was considered statistically significant.

Results

All colonies of *Candida* spp. displayed a white-creamy color on Sabouraud dextrose agar (SDA) and were therefore subjected to preliminary identification method using a CHROMagar. Among the 50 *Candida* isolates obtained, 35 were identified as *Candida albicans* based on chromogenic reaction. The remaining 15 non-*albicans* isolates gave variable colors, some showed apple green color, while the remaining isolates exhibited a pale to white color; some were pre-identified as *Candida parapsilosis* (Figure 1).

The results indicated that CHROMagar played a significant role in differentiating *Candida* spp into two categories: *Candida albicans* and non-*albicans* species. CHROMagar test did not reveal a distinct boundary between these yeasts based merely on their color on CHROMagar [13].

The amplification results of ITS1-5.8S-ITS2 and the surrounding primer pairs ITS5/ITS4 demonstrated variability in the amplicon sizes across 23 isolates of *Candida* spp., *Candida albicans* isolates exhibited sizes of 550 bp, *Candida parapsilosis* isolates showed sizes of 520 bp, while

Candida holmii isolates showed a size of 720 bp (Figure 2). Genotyping of the 23 isolates of *Candida* spp. showed that 65.2% were *Candida albicans* isolates (15/23), 30.4% *Candida parapsilosis* (7/23) and 4.3% *Candida holmii* (1/23). In the present study, we evaluated the antifungal efficacy of *Furcraea foetida* extract using the agar diffuse plate technique. Table 1 shows the mean of inhibition zones and they were: for Fluconazole was (32.67±11.02 mm) against *Candida albicans*, while against non-*albicans* was (40±5 mm), for plant extract was (30±5 mm) against *Candida albicans*, while against non-*albicans* was (31±3.6 mm). An Independent Welch's t-test was used to compared means which demonstrated a non-significant difference at (p=0.403) between fluconazole and *Furcraea foetida* in *Candida albicans* isolates, and a statistically significant difference (p<0.001) in non-*Candida albicans* isolates. Fluconazole showed fluctuation in inhibition zones, with *Candida albicans* isolates showed high sensitivity (40 mm inhibition zone), also the fluconazole mean of inhibition zones shown high standard deviation 11.02 with *Candida albicans* while 5 with non *albicans* as shown in Table 1 and Figure 3 A-B.

Discussion

The present study evaluated extracts of *Furcraea foetida* for its *in vitro* antifungal activity, revealing that its natural compounds from *Furcraea foetida* represent a substantial source of materials that could offer sustainable antifungal therapies against human pathogens. Our study findings reported a considerable antifungal property with consistent and robust bioactivity of *Furcraea foetida* crude extract against *Candida albicans*, with no significant differences were demonstrated statistically in the inhibition zone of the *Furcraea foetida* crude extract in comparison to fluconazole (P = 0.403). The extract of the observed plant in our study possibly showed antifungal properties due to its rich and bioactive constituents, include bio-compounds as sulfur, phenolics, phytochemicals, flavonoids, coumarins. These metabolites can deliver oxidative stress on the cell membrane of the fungus which in turn disrupt the synthesis of ergosterol and affect the integrity of the cell [17,18].

Our findings align with numerous studies investigated the antimicrobial activity of various plants extracts and among these medicinal plants, *Furcraea foetida* reported to be utilized for the stabilization of silver nanoparticles AgNPs for the delivery of stable and strong anti-candida activity [19-21]. Furthermore, in the disc diffusion results, our study demonstrates antifungal properties of *Furcraea foetida* against oral candidiasis, which

corroborates the findings of several authors regarding the fact that many of new medicinal plant are derived from the significant active metabolites of plants. Extensive study globally is focused on the isolation and production of therapeutic active metabolites from plants for antifungal purposes [22-24].

The present study also found resistance to antifungal medication and the emerging of the *Candida parapsilosis*, which has increasingly been documented as pathogenic, commensal and an opportunistic organism which associated invasive diseases such as candidemia, peritonitis and endocarditis [21,25]. The comparable effectiveness to Fluconazole is encouraging, suggesting that components of *Furcraea foetida* may function through a different or complementary mechanism, potentially bypassing existing resistance pathways. This result is crucial in light of the increasing Fluconazole resistance among oral *Candida* isolates [5]. We demonstrated that the crude extract from *Furcraea foetida* leaves exhibited good *in vitro* natural antifungal activity against oral *Candida* spp. isolates. This suggests that *Furcraea foetida* represents a promising, may cost-effective, natural, and environmentally friendly candidate for natural therapy against candidiasis. Nevertheless, additional experiments are necessary to assess the antifungal activity. Furthermore, *in vivo* studies are essential to confirm any potential toxic effects of the extract on mammals.

Our study limitations included the *in vitro* study design, the specific clinical inclusion criteria used, Pure Culture Requirement. For accurate direct sequencing, it is generally necessary to begin with a single colony. Mixed cultures will produce unreadable chromatograms.

Conclusion

The leaf extract of *Furcraea foetida* demonstrated considerable *in vitro* antifungal activity against *Candida* spp. clinically isolated from oral candidiasis infection, with efficacy comparable to fluconazole against *Candida albicans*. These findings position *Furcraea foetida* as a natural antifungal resource, which warrants further pharmacological development and clinical investigation.

Author Contributions

Z.K.K. conceived and designed the study, performed laboratory work, analyzed the data, and drafted the manuscript.

S.M.A.S. contributed to patient recruitment, sample collection, and manuscript revision.

S.S.N. contributed to microbiological analysis, interpretation of results, and critical revision of the manuscript.

All authors read and approved the final manuscript.

Funding

The authors received no specific funding for this work.

Conflict of Interest

The authors declare no conflict of interest.

Ethical Approval

This study was approved by the Scientific Committee of the College of Dentistry.

References

1. Sanz-Orrio-Soler I, Arias de Luxán S, Sheth CC. Oral colonization by *Candida* species in orthodontic patients before, during and after treatment with fixed appliances: A prospective controlled trial. *Journal of Clinical and Experimental Dentistry*. 2020;12(11):e1071-e1077. doi: 10.4317/jced.57565.
2. Mulimani P, Popowics T. Effect of orthodontic appliances on the oral environment and microbiome. *Frontiers in Dental Medicine*. 2022;3:924835.
3. Brusca MI, Chara O, Sterin-Borda L, Rosa AC. Influence of different orthodontic brackets on adherence of microorganisms *in vitro*. *Angle Orthodontist*. 2007;77:331–336.
4. Hamodat HF, Hamdoon S, Al-Adool RJ. Prevalence of *Candida* Species in Patients with Fixed Orthodontic Appliance. *Mustansiria Dental Journal*. 2025;21(1):40-50. <https://doi.org/10.32828/mdj.v21i1.1165>
5. Van Rhijn N, White PL. Antifungal treatment strategies and their impact on resistance development in clinical settings. *Journal of Antimicrobial Chemotherapy*. 2025;80(12):3208-3226.
6. Abdallah EM, Alhatlani BY, de Paula Menezes R, Martins CHG. Back to Nature: Medicinal Plants as Promising Sources for Antibacterial Drugs in the Post-Antibiotic Era. *Plants*. 2023;12(17):3077.
7. Verloove F, Smith GF. An update on *Agave* and *Furcraea* (Agavaceae; Asparagaceae sensu lato) escaped and naturalized in Madeira. *Bradleya*. 2024;42:186-196.
8. Guest E. Flora of Iraq. Ministry of Agriculture of the Republic of Iraq, Baghdad 1966;458 pp.
9. Imran ZK, Ali Hasan KM, Kadhim WA, Mutaleb WH. A novel antidermatophytic activity of *Furcraea foetida* leaf extract against *Microrosporum canis*. *Biochemical and Cellular Archives*. 2018;18(Suppl 1):1065-1068.
10. Bloch A, Bogiel T, Prazyńska M, Gospodarek-Komkowska E. Usefulness of Chromogenic Media in the Identification of *Candida* spp. Yeasts Compared to Mass Spectrometry. *Methods and Protocols*. 2025;8:98.
11. Magalhães J, Correia MJ, Silva RM, Esteves AC, Alves A, Duarte AS. Molecular Techniques and Target Selection for the Identification of

Candida spp. in Oral Samples. Applied Sciences. 2022;12:9204.

12. Parekh J, Jadeja D, Chanda S. Efficacy of aqueous and methanol extracts of some medicinal plants for potential antibacterial activity. Turkish Journal of Biology. 2005;29(4):203-10.

13. Nadeem SG, Hakim ST, Kazmi SU. Use of CHROMagar *Candida* for the presumptive identification of *Candida* species directly from clinical specimens in resource-limited settings. Libyan Journal of Medicine. 2010; 5:2144

14. Ejaz H, Mushtaq M, Khan S, Azim N, Hussain A, Kakar K, Khan MZ, Hafeez A, Moezullah S. Investigation of multi-drug resistant *Candida auris* using species-specific molecular markers in immunocompromised patients from a tertiary care hospital in Quetta, Pakistan. PLOS ONE. 2025;20(4): e0319485. <https://doi.org/10.1371/journal.pone.0319485>.

15. Fujita S, Hashimoto T. DNA fingerprinting patterns of *Candida* species using HinfI endonuclease. International Journal of Systemic and Evolutionary Microbiology. 2000;50(3):1381-1389.

16. Govindappa NS, Poojashri MN. Antimicrobial, antioxidant and in vitro anti-inflammatory activity of ethanol extract and active phytochemical screening of *Wedelia trilobata* (L.)

Hitchc. Journal of Pharmacognosy and Phytotherapy. 2011;3(3):43-51.

17. Amalraj A, Gopi S. Biological activities and medicinal properties of Asafoetida: A review. Journal of Traditional and Complementary Medicine. 2016;7(3):347-359. <https://doi.org/10.1016/j.jtcme.2016.11.004>

18. Iyer MS, Sheshanna SH, Rao RN, Puttegowda D, Ramu R. Antibiofilm and antimicrobial potential of *Trigonella foenum-graecum* and *Ferula asafoetida* essential oils against oral pathogens: Synergistic effects and in silico insights. The Microbe. 2026; 10,100667, <https://doi.org/10.1016/j.jmi-crob.2026.100667>.

19. Devendra BN, Srinivas N, Talluri VSSL, Latha PS. Antimicrobial activity of *Moringa oleifera* Lam., leaf extract, against selected bacterial and fungal strains. International Journal of Pharma and Bio Sciences. 2011;2(3):13-18.

20. Devi GS, Priya V, Abiramasundari P, Jeyanthi PG. Antibacterial activity of the leaves, bark, seed and flesh of *Moringa oleifera*. International Journal of Pharmaceutical Sciences and Research. 2011;2(8): 2045-2049.

21. Sitrarasi R, Nallal VUM, Razia M, Chung WJ, Shim J, Chandrasekaran M, Dwiningsih Y, Rasheed RA, Alkahtani J, Elshikh MS, Ovi D. Inhibition of multi-drug resistant microbial pathogens using an eco-friendly root extract of

Furcraea foetida mediated silver nanoparticles. Journal of King Saud University-Science. 2022;34(2), p.101794.

22. Oksman-Caldentey KM, Barz WH. Plant Biotechnology and Transgenic Plants. 1st edn. CRC Press, Boca Raton, 2002;780 pp.

23. Amenu D, Desalegn R, Nugusa A, Tafesse T. Evaluation of antifungal activity of plant extracts against plant pathogen associated with sweet orange (*Citrus sinensis* L.), in Jimma, Western Ethiopia. Discover Applied Sciences. 2024;6:357. <https://doi.org/10.1007/s42452-024-06054-2>

24. Maj W, Pertile G, Rózsalska S, Skic K, Frac M. Comprehensive antifungal investigation of natural plant extracts against *Neosartorya* spp. (*Aspergillus* spp.) of agriculturally significant microbiological contaminants and shaping their metabolic profile. Scientific Reports. 2024;14:8399. <https://doi.org/10.1038/s41598-024-58791-4>

1. 25. Guinea J, Escribano P, Cadeau M, Lombardi L, Morio F. Emerging antifungal resistance in *Candida parapsilosis*: the end of the innocence. npj Antimicrobial Resistance. 2025; 3:99. <https://doi.org/10.1038/s44259-025-00173-5>

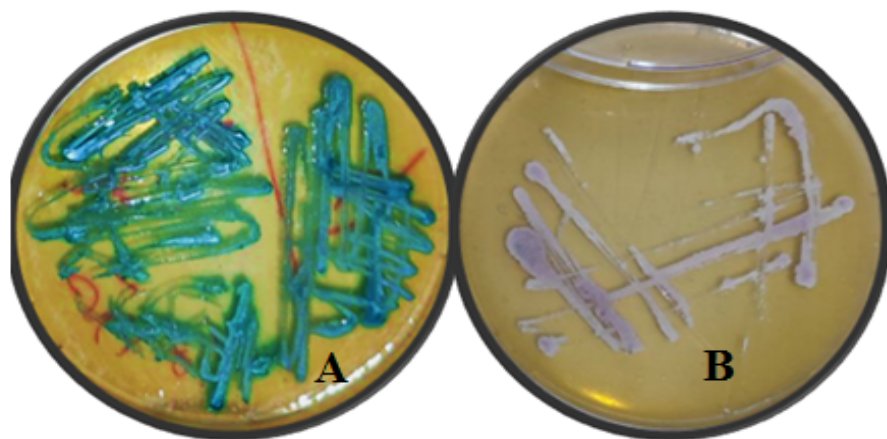


Figure 1. *Candida* spp chromogenic reaction on CHROMagar medium A. *Candida albicans*, B. *Candida parapsilosis*.

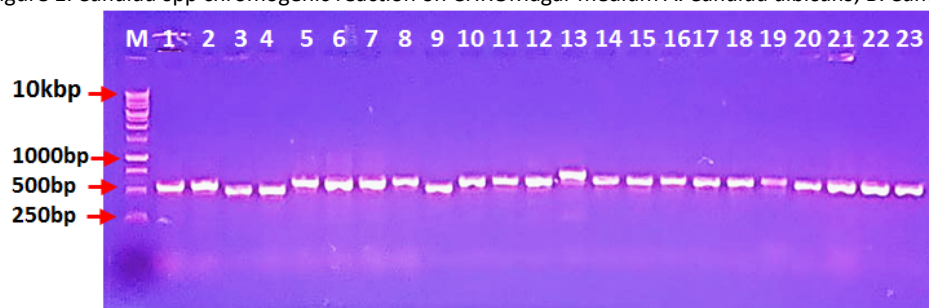


Figure 2. Profile of gel electrophoresis PCR products of *Candida* spp. wells:1-2, 5-8, 10-12, 14-19: 550 bp (*Candida albicans*). Wells 3-4, 9, 20-23: 520 bp (*Candida parapsilosis*). Well 13: 720 bp (*Candida holmii*).

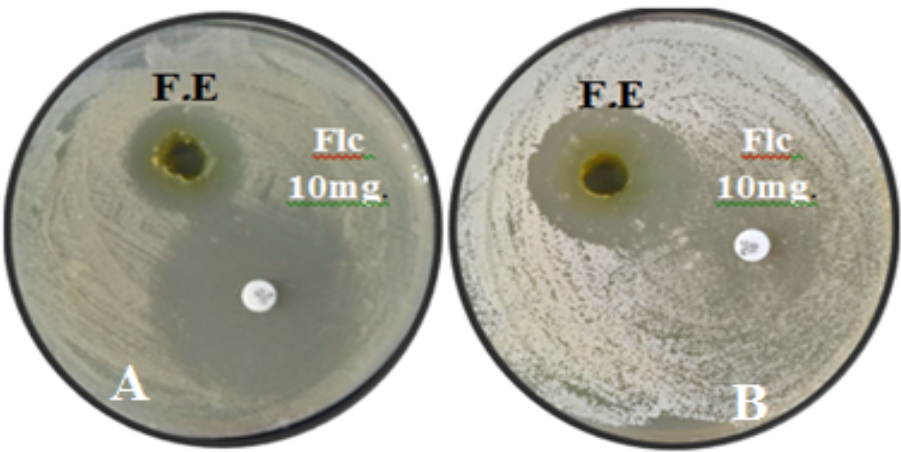


Figure 3. Antifungal activity of *Furcraea foetida* leaf extract against two *Candida albicans* isolates on SDA, based on diameter of inhibition zone under incubation for 24 hours at 30°C; F.E = *Furcraea foetida* extract, fluconazole 10 mg. A. *Candida albicans* sensitive to fluconazole, B. *Candida albicans* resistance to fluconazole in glass.

Table 1. Mean of Inhibition zones of *Candida albicans* and non-*Candida Albicans* isolates under *Furcraea foetida* crude extract compared with fluconazole.

Antifungal agent	<i>Candida albicans</i> (N=15) Mean ± SD (mm)	Non- <i>Candida albicans</i> (N=15) Mean ± SD (mm)
Fluconazole 10mg	32.67 ± 11.02	40 ± 5
<i>Furcraea foetida</i> crude extract	30 ± 5	31 ± 3.6
<i>p-value</i>	0.403	<0.001

Test=Independent Welch’s t-test.SD=Standard Deviation.