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RESEARCH ARTICLE

ANTIFUNGAL ACTIVITY OF SOME PLANTS USED IN YEMENI HERBAL MEDICINE

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Abstract

Capparis cartilaginea Decne.; *Vachellia nilotica* subspecies Indica (Benth) Kyal & Boatwr.; *Fagonia paulayana* J. Wagner & Vierh., are medicinal plants used in traditional Yemen medicine for the treatment a variety of infectious and non-infectious diseases. These plants were selected to evaluate their potential antifungal activity. To determine antifungal activity and phytochemicals in the leaves, and total vegetative extracts of three medicinal plants used in traditional Yemeni medicine for the treatment of various disease like rheumatism, piles fever, skin diseases and snake bite. Plant extracts from three species, namely *Capparis cartilaginea*, *Vachellia nilotica* subsp. Indica, and *Fagonia paulayana*, were prepared using ethanol and water. The extracts were tested for their antifungal activity against *Candida* species isolated from vaginal specimens of women. Phytochemical screening was also performed to identify various constituents in the extracts. The antifungal susceptibility testing was carried out following standard guidelines, and Amphotericin B was used as a reference antifungal agent. The study aimed to evaluate the potential of these plant extracts as natural remedies for *Candida*-related infections. The study evaluated the antimicrobial activity of plant extracts from *Capparis cartilaginea*, *Vachellia nilotica* subsp. Indica, and *Fagonia paulayna* against *Candida* fungal isolates from vaginal specimens. *Vachellia nilotica* subsp. Indica (Ethanol Extract) showed significant inhibitory effects against *Candida* species, while *Capparis cartilaginea* and *Fagonia paulayna* (both Ethanol Extracts) had limited inhibitory activity. Further research is needed to explore the therapeutic potential of *Vachellia nilotica* subsp. Indica as a natural antifungal agent. Extracts of *Vachellia nilotica* subsp. Indica demonstrate notable inhibitory effects against *Candida* species isolated from vaginal samples. This research points to the potential for using extracts of the Vachellia nilotica subsp. Indica plant as a natural remedy for Candida-associated infections.

Keywords: *Capparis cartilaginea*, *Vachellia nilotica* subsp. Indica, *Fagonia paulayna*, *Candida* spp., Ethanol extract and aaqueous extracts, Medicinal plants in traditional Yemen.

Introduction

Plants compounds, continued to play a dominant role in the maintenance of human health since ancient times. According to the World Health Organization plant extracts or their active constituents are used as folk medicine in traditional therapies of 80% of the world drugs are of natural product origin [1].

Yemen high diversity, which reached about 2846 taxa belong to 1079 genera and 179 families, among them 611 endemic species, [2-4]. Jack Florentine said that 54% of the Yemeni medicinal plants have been mentioned in the work on material medical by the world-famous botanist pharmacist Andalusian Ibn Al-Bitar. Florentine also asserts that 36% were not described by any of the classic authorities as a fact confirming the authenticity of Yemeni herbal medicines [5].

Capparis is a name coined by Theophrastus (4th century BC) and endorsed by Dioscorides (1st century AD), it seems to have come into wide use after the spread of the Arab culture in the Middle Ages [6]. It is generally consumed as pickles due to economical and nutritional properties [7]. Capparis plant belongs to the family of Capparaceae and to the genus Capparis with 250 and 400 species, are grown generally in tropical and subtropical regions but some also are in temperate regions in the

Mediterranean including Turkey [8]. Different parts of Capparis plant, have been used for cosmetic, nutritional and treating medicinal purposes. In traditional medicine Capparis species were used to treat some disorders including rheumatic diseases, stomach problems, headache and toothache [9]. *Capparis cartilaginea* Decne. (CC), a scandent shrub, has been identified as a native plant of North Africa, Western Asia, and spanning up to India and the Arabian Peninsula [10].

Fabaceae is the most diverse plant family in the world [11], with a wide distribution of sort, registering 770 genera and 19,500 sort, considered the third largest family of angiosperms in species numbers after Asteraceae and Orchidaceae in the global context [12]. *Vachellia nilotica* sub sp *Indica* (Benth) Kyal & Boatwr., is a moderate sized tree that grows up to 20m, but this is attenuated by site. It has a flattish or umbrella shaped crown and is easily identified by its bright yellow, sweet-scented flower heads, its sweet-smelling gray pods and its paired whitish spines at the base of each leaf. During the hot season the tree is in full leaf and its feathery foliage provides good shade. The two most widely grown for fuel are: Acacia nilotica subsp. Indica (Benth.) Brenan; and Acacia nilotica subsp. Nilotica [13].

Zygophyllaceae, the caltrop family, is a group of angiosperm plants frequently restricted to tropical and warm climates. It is widespread in Old and New Worlds especially arid and semi-arid zones. Members of this family are mostly shrubby, but some are herbs and rarely some grow as trees. According to the classification by [14, 15], Zygophyllaceous is a heterogeneous family represented by approximately 27 genera and 285 plant species. The taxonomy within the family has changed over time, since they display a large amount of variability in structural detail [16]. *Fagonia paulayana* Wagner & Vierh: is a genus of wild, flowering plants in the caltrop family, Zygophyllaceous, having about 35 species. Species occurring in the US are commonly referred to as fagonbushes. The distribution of the genus includes parts of Africa, the Mediterranean Basin, the Mid-East, India, and parts of the Americas. Fagonia species have been used ethnobotanically by traditional practitioners under Ayurvedic and other healing regimes for many maladies. Species occur in deserts, dry washes, ditches and on rocky outcrops, including at altitude. Fagonia leaves is a perennial herb of the United States desert southwest. It has opposite leaves, trifoliate with spinescent stipules, a pink corolla and smooth fruits. Under cultivation, F. indica has been found to have a long taproot and to its growth slowing where temperatures dipped below 65 F [17].

The adult human vagina is a complex biota containing a different microorganism. These include archaea, bacteria, protests, fungi, some microscopic plants such as green algae. Bacteria, fungi and parasites are responsible for large number of human and other animal diseases, part of them is life threatening [18].

The genus *Candida* comprises over 200 species, with 15 isolated from infections in humans and animals [19]. Fungi are free-living, eukaryotic organisms that exist as yeasts, and as molds, or a combination of these two dimorphic fungi. *Candida* has emerged as a major group of opportunistic pathogens that cause superficial and invasive infections in humans [20]. Fungal infections caused by *Candida* species is one of the hospitals acquired infections in immunocompetent and immunocompromised patients [21]. Bacteria and yeast form normal flora of our body, which is normally found on the skin, mouth, ears, rectum and vagina. The important etiology of *Candida* spp., nosocomial pathogens include - prolonged use of antimicrobial agents, steroid therapy, malignancy, indwelling catheters, total parenteral nutrition etc. [22]. *Candida* spp., are harmless and are involved in benefiting their host. Some are parasitic in their host, and some are pathogenic, disease causing .*C. albicans* is still the most commonly isolated organism from bloodstream cultures, other *Candida* spp, have emerged as clinically important pathogens in their own right [23].

Antifungal drugs targeting cell-wall (echinocandins) or the ergosterol biosynthesis pathway (azoles) are used as first options to treat infection, but *C. albicans* can develop resistance via the up regulation of azole drugs, the acquisition of mutations affecting the structure or expression of the azole target or the induction of compensatory changes in cell wall in response to echinocandins [20]. The resistance of *Candida* spp., to antifungal drugs is becoming an increasingly difficult problem for treating its infections. The complicated structures of such as capsule and contribute to resistance to antifungals drugs [24].

The objectives of the present study were:

Preliminary phytochemical screening of (*Capparis cartilaginea* Decne.; *Vachellia nilotica* subsp Indica (Benth)Kyal & Boatwr.; *Fagonia paulayana* Wagner & Vierh), to enable further investigate the anti-microbiological activity.

The present study aims:

To evaluate the antifungal activity of an aqueous and ethanol extract of **(***Capparis cartilaginea* Decne.; *Vachellia nilotica* subsp Indica (Benth)Kyal & Boatwr.; *Fagonia paulayana* Wagner & Vierh**)**, against *Candida* isolates from vagina.

Materials and Methods

Study area:

Yemen is located in the southwestern corner of the Arabian Peninsula, including the Socotra archipelago. It borders the Red Sea to the west, the Gulf of Aden to the south, Saudi Arabia to the north, and Oman to the east. Recent population figures estimate over 18 million inhabitants, with concentrations in the Highlands and Red Sea coastal areas. Aden, one of the oldest Arab cities, serves as a significant cultural and economic hub, boasting the most important natural port on the Arabian Sea and the Indian Ocean. Its strategic location between Egypt and India made it famous in ancient trade routes. Aden's capital, Crater, sits atop an extinct volcano and is renowned for its ancient architecture and narrow streets. The plant samples were prepared in the biology laboratories of the Faculty of Education in Aden. As for the isolates and identification of fungi, suspension preparation, and antifungal susceptibility testing, these procedures were carried out in the laboratories of the Drug Control Authority in Aden.

Plants used in the study:

Plants were collected from different locations in Yemen and identified at the Department of Biology, University of Aden, by Professor Abdul Nasser Abdullah Al-Jafari, who works at the Botanical Garden in the Faculty of Education.

Plant material sample:

The raw materials of the medicinal plants were thoroughly washed using flowing tap water and then rinsed several times with distilled water. They were dried in the shade, and the dried masses were finely powdered and placed in small dark plastic bags, properly labelled for use, plants and used parts explain in (**Table 1**).

Preparation of extraction:

The dried and powdered plants were separately extracted with water and ethanol using the Soxhlet method (40 g of raw powder in 400 mL of water or ethanol) for 6-8 hours, followed by filtration. The crude extracts were stored in the refrigerator at 4°C until use.

Preparation of alcoholic and aqueous extracts of studied plants:

The extracts were prepared following the method mentioned in [25], which involved placing 40 grams of dried and powdered leaves in a Soxhlet apparatus in paper thimbles using 400 mL of 70% ethanol to prepare the alcoholic extract. The apparatus was heated for 6-8 hours, and the alcoholic extract was obtained. Then, 400 mL of water solvent was placed in the apparatus for 24 hours to extract the aqueous extract. It was extracted using a rotary evaporator for 10 minutes at a speed of 3500 rpm, followed by filtration using Whatman-No-1 filter paper (England) and left to dry in a Petri dish. It was then placed in a Vaciotem-T oven (under pressure) for acetone and alcoholic and aqueous extracts. The process was repeated several times to obtain the plant extracts, which were collected and stored in the refrigerator at 4°C until use.

Aqueous extraction:

The selected plant material was extracted by boiling method. For this method, the plant materials were ground to a coarse powder or very small pieces. Approximately 40 grams of raw powder or plant pieces were placed in a round-bottomed flask containing 400 mL of distilled water. The mixture was heated for three hours at the boiling point using a heating mantle. The mixture was filtered, and the solvent was removed from the filtrate using a rotary evaporator, and the extracted material free from the solvent was weighed and placed in an amber bottle in the refrigerator for later use [26].

Physicochemical analysis

The physicochemical parameters like loss on drying, total ash, acid insoluble ash, water-soluble ash, sulphated ash and extractive values were determined as per WHO guidelines [27]. The solvents used were petroleum ether (PE), toluene (TO), ethyl acetate (EA), methanol (ME) and water (AQ). The details of the procedure followed is as described earlier by [28].

Table 1: Local Medicinal Plants and Their Used Parts.

Family	Scientific Name	Parts used	Local Name
CAPPARACEAE	*Capparis cartilaginea* Decne.	Leaves	كبار
FABACEAE Sup Family: CAESALPINIODEAE	*Vachellia nilotica* subsp. Indica (Benth) Kyal. & Boatwr.	Leaves	القرض
ZYGOPHYLLACEAE (CREOSOTE-BUSH or CLTROPS)	*Fagonia paulayana* Wagner & Vierh. Mg synonym.	Total vegetative	الاكسير،حل الشوك

Phytochemical screening

The Capparidaceae, Fabaceae and Zygophyllaceae family contains so many active constituents such as alcohol, alkaloids, amino acids, amyrin, anthocyanins, betulin, carbohydrates, flavonoids, glycosides, saponins, steroids, sterol and terpenes were reported in various researches. The various phyto-constituents are separated from the Capparidaceae, Fabaceae and Zygophyllaceae family reviewed here. Detection of alkaloids, Detection of tannins, Detection of saponins, Detection of steroids, Detection of triterpenoids, Detection of cardiac glycosides and Detection of flavonoids were identified using characteristic color changes using standard procedures described by [29, 30] as given below.

Ethical considerations:

Approval was obtained from the Department Chair and the College of Education Dean, along with official approval from the Approval Committee at the College of Medicine, to proceed with the research and fulfill its requirements, limited to conducting the study in public hospitals only.

Isolates and identification of Fungi

Vaginal swabs were taken from women with proven clinical diagnosis of vaginal yeast infection after clinical examination by Gynecologists in Aden City (Friendship Teaching Hospital, Aden province, Yemen., German Aden Hospital, Al-Shifa hospital in Aden, Shafiqa Alkhatib clinic in Aden, Sina Meridian clinic in Aden, Hanan Medical Center in Aden, Al-Madina Medical Center in Aden). This study involved a total of 31 women with abnormal vaginal discharge, who were clinically suspected cases of *Candida vaginitis* (CV). The study was conducted over a period of one year and included women in the age group of 14-49 years who had a history of vaginal discharge and were clinically suspected of having CV. The following samples were collected from each patient, three vaginal swabs and one sample from ten healthy women were taken as control. Three vaginal swabs were taken and immediately sent to the microbiology laboratory (Drug control authority in Aden) for processing, by microscopy, culture on media and using biochemical tests. *Candida* vaginitis were identified by Sabouraud dextrose agar culture medium with 50.0 mg of chloramphenicol and 5.0 mg gentamicin/ 1000ml of des. H_2O) was used for the isolation of *Candida* spp., with germ tube test, production chlamydoconidia on Corn meal agar (Hi media, India) and specific colors of colonies on CHROMagar *Candida* (CHROMagar *Candida*, Hi media, India [31]. Material finely sent to Assiut University, Mycological Center, Faculty of Science to confirm the diagnosis of these samples.

Suspension preparing

Each isolate was inoculated onto test tubes contained 10ml SDB and incubated at 37°C for 18h with shaking. Each tube centrifuged for 30min and the sediment was washed by PBS for 30min. Supernatant was removed and sediment was re-suspended in distilled water (sterile). A suspension with turbidity according to the McFarland standard #2 of yeast cells was prepared in distilled water [32].

Antifungal susceptibility testing

Antifungal susceptibility testing methods were used according to the guidelines of the Clinical and Laboratory Standards Institute (CLSI) for in vitro antifungal susceptibility testing. A broth microdilution assay was conducted to determine the minimum inhibitory concentration (MIC) values of the aqueous and ethanol extracts of *Capparis cartilaginea* Decne, *Vachellia nilotica* subsp. Indica (Benth) Kyal & Boatwr, and *Fagonia paulayana* Wagner & Vierh, following the CLSI M27-A3 guidelines for yeasts [33]. Additionally, a broth microdilution assay was performed for Amphotericin B as a reference antifungal agent.

Results and Discussion:

Valachia nilotica subsp Indica, and *Capparis cartilaginea* and *Fagonia pulayna*, a plant found in Yemen, is used in traditional Yemeni medicine to treat various ailments [34, 35, 36, 37, 38]. However, there is little scientific research on this plant. Specifically, no formal pharmacogenetic studies have been conducted to characterize the plant's physical and chemical properties. Pharmacognosy involves studying the physical and chemical properties of plant drugs to establish their identity, purity and quality standards. Biological evaluation of the plant's therapeutic effects and chemical constituents is also limited. This suggests that, these plant extracts may contain compounds with inhibitory activity against the fungus isolates. These findings suggest the potential use of these plant extracts in future research for combating fungal infections or for developing plant-based medical or pharmaceutical products. However, further studies are needed to determine the complete details of their effectiveness and safety for use.

Extractive values obtained from plant using different solvents were recorded in **(Table 2)**, *Valachia nilotica* subsp Indica, and *Capparis cartilaginea* indicate the amount of soluble material that can be extracted from the plant materials. The results show that *Valachia nilotica* subsp Indica has the highest extractive value with ethanol (25.78 %) and *Fagonia pulayna* has the highest extractive value with water (15.98%). *Capparis cartilaginea* has the lowest extractive values with both ethanol and water (14.13% and 11.38%, respectively).

Extract of each solvent was weighed; the extractive value in terms of percentage extract was calculated as follow:

$$The\ extractive\ value\ \% = \frac{weight\ of\ the\ extract\ yield}{wieght\ of\ the\ air-dried\ drug} \times 100$$

Genetic diversity and variations in plant species and structures are significant factors affecting the extractive values. The content of soluble materials may vary from one plant to another based on various environmental and genetic factors [39].

The timing of plant collection and climate conditions can influence the natural chemical composition within the plant [40]. This could be a reason for variations in results between different studies.

The growth location of plants can impact their chemical constituents. For instance, plants growing in dry environments may have higher concentrations of extractable materials compared to those in humid environments. [41].

The physiochemical characteristics (**Table 3**) showed that, **the moisture content** analysis indicates the amount of water present in the medicinal plant samples. A higher moisture content usually means the plant has more water-soluble phytochemicals. Fagonia paulayna having the highest moisture content of 9.5% suggests it is richest in water-soluble bioactive compounds.

Ash content represents the total mineral and metal composition of the plants after burning off organic matter. The higher ash content of 12.95% in *Fagonia paulayna* implies it likely contains more diverse minerals like calcium, potassium, iron etc compared to *Vachellia nilotica* and *Capparis cartilaginea*.

Acidity and alkalinity greatly impact the solubility and stability of medicinal plant constituents. The aqueous extracts of *Fagonia paulayna* being more acidic with lower pH values indicates its compounds are more soluble and stable in acidic medium versus alkaline. This has implications for extraction and preparation of traditional remedies.

The variations in these physicochemical parameters among the three medicinal plants studied highlights that although similar, their biochemical composition and properties differ. These factors can impact their medicinal potency, safety and efficacy profiles.

Further in-depth phytochemical analysis of the specific bioactive compounds, as well as biological assays, are required to better characterize and compare the medicinal values of these traditionally used desert plants.

Phytochemical analysis

The results of the primary phytochemical analysis of plant extracts reveal the presence of a diverse range of chemical compounds in each of the three plants: *Vachellia nilotica subsp. Indica (Benth)*, *Capparis cartilaginea*, and *Fagonia pulayna*. **(Table 4)**.

All three plants contain alkaloids, saponins, tannins, resins, and carbohydrates. These chemical compounds are known to have various biological activities and may contribute to the medicinal properties of these plants [42, 43].

Additionally, some specific compounds are present only in certain plants. Phenolic compounds, flavonoids, and terpenes have been identified in some of these plants. These compounds are often associated with antioxidant, anti-inflammatory, and other health-promoting properties [44, 45].

Table 2: Extractive values of study plants

	Scientific name	Parts used with amount	Extractive value ethanol	Extractive value water
1	*Fagonia pulayna*	Total Vegetative (40g)	10.075%	15.975%
2	*Valachia nilotica subsp* Indica	Leaves (40g)	25.7825%	18.275%
3	*Capparis cartilaginea*	Leaves (40g)	14.125%	11.375%

Table 3: Physiochemical analysis of *Fagonia paulayana*, *Valachia nilotica* subsp Indica and *Capparis cartilaginea*

Scientific name	Parts used	Moisture (%w/w)	Ash (%w/w)	PH ethanol	pH water
Fagonia paulayana	Total vegetative	9.5	12.95	4.80	5.95
***Valachia nilotica* subsp Indica**	Leaves	3	12.93	5.18	6.21
Capparis cartilaginea	Leaves	8.5	10.24	4.10	4.33

The presence of diverse chemical compounds, including active compounds like alkaloids, tannins, and resins, suggests that these plants may indeed have medicinal properties and potential health benefits [46, 47]. Alkaloids, for instance, are known to have diverse pharmacological activities, including analgesic and antimicrobial effects. Tannins possess antioxidant properties and may contribute to the plant's ability to combat oxidative stress [48, 49].

However, the results are labelled as preliminary, indicating that further research is necessary to fully understand the effects and health benefits of these compounds. The identified chemical compounds are only a starting point, and their specific interactions and effects on human health require further investigation.

To determine the precise medicinal properties and health benefits of these plants, more in-depth studies are needed. These subsequent studies might involve bioassays, animal experiments, and clinical trials to assess the safety and efficacy of the identified compounds. Additionally, researchers might explore possible synergistic effects among the different compounds present in each plant, as these interactions could influence their overall pharmacological potential.

We think the phytochemical analysis provide valuable insights into the chemical constituents of the studied plants and suggest their potential medicinal value. However, further research is crucial to unlock their full therapeutic potential and establish their safety and efficacy for human use.

Several studies indicate that many *Capparis* species have the antifungal activities against several fungal pathogens [50, 51,52].

Table 5. Showed the results obtained from the analysis of fungal clinical isolates show that the analysis of fungal clinical isolates shed light on the distribution and prevalence of different *Candida* species among the isolates examined. The data shows that *Candida albicans* is the most frequent isolate, accounting for 54.5% of the total isolates. This finding is consistent with previous studies [53], as *Candida albicans* is widely recognized as the most common fungal pathogen in human infections. It is a known opportunistic pathogen and is frequently associated with various types of candidiasis, including vaginal yeast infections. High Frequency of *C. parapsilosis* and *C. glabrata* indicate that, the second most frequently isolated species, with each accounting for 12% of the total isolates. This finding is noteworthy because both *C. parapsilosis* and *C. glabrata* have been associated with increased resistance to antifungal agents [54]. Prevalence of *C. tropicalis* and *C. krusei* each accounted for 9% of the isolates. These species are also known to cause opportunistic fungal infections in humans. While their prevalence is lower than that of *C. albicans*, their presence in clinical isolates highlights their importance in the context of fungal infections. *C. dubliniensis* was the least isolated species, comprising only 3% of the total isolates. This species is closely related to *C. albicans* [55], and shares many characteristics with it. Although less common, its identification is still valuable for understanding the epidemiology of candidiasis.

Table 4: Preliminary phytochemical analysis of the plant extracts.

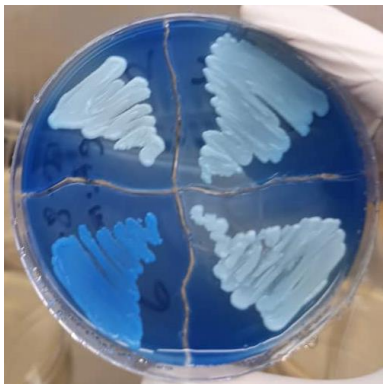
Plant:	*Vachellia nilotica subsp. Indica (Benth)*		*Capparis cartilaginea Decne.*		*Fagonia paulayna*	
Specific reagent:	**Ethanol**	**Aqueous**	**Ethanol**	**Aqueous**	**Ethanol**	**Aqueous**
Alkaloids	+	+	+	-	-	-
Saponins	+	+	-	+	+	+
Flavonoids and Flavonols	-	-	+	+	+	+
Tannins	+	+	+	+	+	+
Resins	+	+	+	+	+	+
Furanocoumarins	-	+	+	+	+	+
Terpenoids	+	+	+	+	+	-
Amino Acids and Primary and Secondary Amines	-	-	+	+	+	+
Carbohydrate	+	+	+	+	+	+
Triterpenes and Steroids	-	-	-	-	+-	+-
Phenolics	-	+	+	+	+	+
Glycosides	+	-	-	-	-	-
Flavanoids	-	+	+	+	+	+

Overall, these results emphasize the significance of accurate species identification in clinical fungal isolates. Knowing the specific fungal species causing infections is crucial for effective management and treatment. Different *Candida* species may exhibit varying susceptibilities to antifungal drugs, making species identification essential for selecting appropriate treatment strategies. Additionally, the presence of species with increased antifungal resistance, like *C. parapsilosis* and *C. glabrata*, necessitates constant surveillance and prudent use of antifungal agents to combat the development of resistance.

In conclusion, the study provides valuable information about the distribution and prevalence of *Candida* species in clinical isolates. These findings can guide clinicians in the management of fungal infections and help in developing targeted treatment approaches based on the identified species and their susceptibility patterns to antifungal agents.

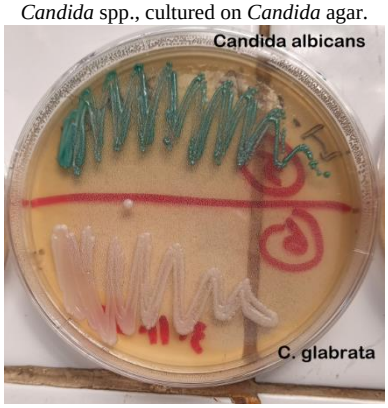
Table 5: List of fungal clinical isolates and their frequency in percentage.

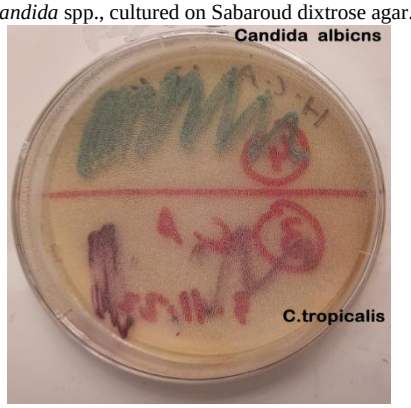
Fungi	No. of isolates(n=32)	% Frequency
C. albicans	18/32	54.5 %
C. tropicalis	3/32	9%
C. glabrata	4/32	12%
C. krusei	3/32	9%
C. dubliniensis	1/32	3%
C. parapsilosis	4/32	12%



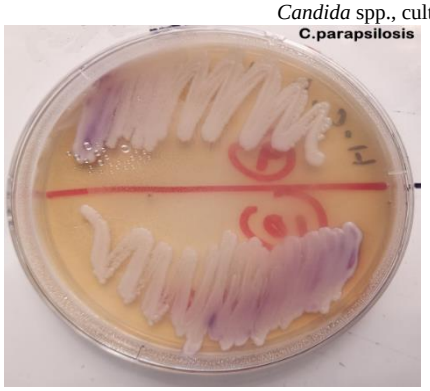
Candida spp., cultured on *Candida* agar.

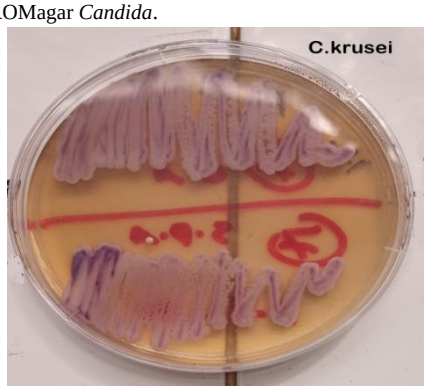
Candida spp., cultured on Sabaroud dixtrose agar.





Candida spp., cultured on CHROMagar *Candida*.





Candida spp., cultured on *Candida* CHROMagar.

Fig. 1a, b, c, d, e, f. High vaginal swab streaked on; **a)** *Candida* agar. **b)** on Sabouraud dextrose agar and **;c; d; e and f)** on *Candida* CHROMagar where upper half showed *C. albicans*; *C. glabrata*; *C. tropicalis*; *C. parapsilosis* and *C. krusei*, see Morphology and color of *Candida* on *Candida* CHROM agar.

Table 6: Antimicrobial resistance profiles of Plants Extract against fungal isolates from vaginal specimen of women in Aden, Yemen.

Test of organisms	Plants Extract	Ethanol Extract					Water Extract				
		Zone of inhabitation in (mm)					Zone of inhabitation in (mm)				
		8mg/ml	16mg/ml	24mg/ml	32mg/ml	40mg/ml	8mg/ml	16mg/ml	24mg/ml	32mg/ml	40mg/ml
C. albicans	*Vachellia nilotica* subsp. Indica	13	14	14	16	17	-	-	-	-	-
	Capparis cartilaginea	11	12	12	12	12	-	-	-	-	-
	Fagonia paulayna	12	12	12	12	12	-	-	-	-	-
C. tropicalis	*Vachellia nilotica* subsp. Indica	15	17	18	20	22	-	-	-	-	-
	Capparis cartilaginea	-	-	-	-	-	-	-	-	-	-
	Fagonia paulayna	-	-	-	-	-	-	-	-	-	-
C. glabrate	*Vachellia nilotica* subsp. Indica	19	21	23	26	27	14	17	19	19	21
	Capparis cartilaginea	14	14	14	14	14	-	-	-	-	-
	Fagonia paulayna	12	12	12	12	13	-	-	-	-	-
C. krusei	*Vachellia nilotica* subsp. Indica	21	22	24	27	27	-	-	-	-	-
	Capparis cartilaginea	-	-	-	-	-	-	-	-	-	-
	Fagonia paulayna	-	-	-	-	-	-	-	-	-	-
C. parapsilosis	*Vachellia nilotica* subsp. Indica	21	23	23	23	23	13	14	17	18	19
	Capparis cartilaginea	13	15	16	17	17	-	-	-	-	-
	Fagonia paulayna	12	13	15	15	15	-	-	-	-	-

The results of the antimicrobial resistance profiles of plant extracts against fungal isolates from vaginal specimens of women in Aden, Yemen, showed that, *Vachellia nilotica* subsp. Indica (Ethanol Extract) showed inhibitory activity with zone sizes ranging from 13 to 17 mm at different concentrations in *Candida albicans*. *Capparis cartilaginea* and *Fagonia paulayna* (both Ethanol Extracts) exhibited inhibitory activity with a constant zone size of 12 mm at all tested concentrations (**Table 6**). This suggests that these plant extracts may contain compounds with inhibitory activity against the fungus *Candida albicans*. These findings suggest the potential use of these plant extracts in future research for combating fungal infections or for developing plant-based medical or pharmaceutical products. However, further studies are needed to determine the complete details of their effectiveness and safety for use. No inhibitory activity was observed with Water Extracts of any of the three plants against *C, albicans*.

Vachellia nilotica subsp. Indica (Ethanol Extract) demonstrated inhibitory activity with zone sizes ranging from 15 to 22 mm at different concentrations against *Candida tropicalis*. *Capparis cartilaginea* and *Fagonia paulayna* (both Ethanol Extracts) showed no inhibitory activity against *Candida tropicalis*. No inhibitory activity was observed with Water Extracts of any of the three plants.

Vachellia nilotica subsp. Indica (Ethanol Extract) exhibited inhibitory activity with zone sizes ranging from 19 to 27 mm at different concentrations against *Candida glabrata*. Additionally, Water Extracts showed inhibitory activity with zone sizes ranging from 14 to 21 mm at different concentrations. *Capparis cartilaginea* (Ethanol Extract) showed inhibitory activity against *Candida glabrata*, with a constant zone size of 14 mm at all tested concentrations. However, no inhibitory activity was observed with Water Extracts. *Fagonia paulayna* (Ethanol Extract) showed inhibitory activity with zone sizes ranging from 12 to 13 mm at different concentrations. No inhibitory activity was observed with Water Extracts against *Candida glabrata*.

Vachellia nilotica subsp. Indica (Ethanol Extract) showed inhibitory activity against *Candida krusei*, with zone sizes ranging from 21 to 27 mm at different concentrations. *Capparis cartilaginea* and *Fagonia paulayna* (both Ethanol Extracts) showed no inhibitory activity against *Candida krusei*. No inhibitory activity was observed with Water Extracts of any of the three plants against *Candida krusei*.

Vachellia nilotica subsp. Indica (Ethanol Extract) exhibited inhibitory activity against *Candida parapsilosis*, with zone sizes ranging from 21 to 23 mm at different concentrations. Additionally, Water Extracts showed inhibitory activity with zone sizes ranging from 13 to 19 mm at different concentrations against *Candida parapsilosis* .*Capparis cartilaginea* and *Fagonia paulayna* (both Ethanol Extracts) showed no inhibitory activity against *Candida parapsilosis*.

The results indicate that, *Vachellia nilotica* subsp. Indica (Ethanol Extract) generally exhibited inhibitory activity against the tested *Candida* species which is partially in line with [56]**,** while *Capparis cartilaginea* and *Fagonia paulayna* (both Ethanol Extracts) showed limited or no inhibitory activity. Water Extracts, in most cases, did not show significant inhibitory effects against the tested fungal isolates. However, it is essential to note that further research and testing are necessary to determine the potential of these plant extracts as effective antifungal agents.

To analyze the effectiveness of plant extracts in ethanol and water against fungal isolates from vaginal specimens of women in Aden, Yemen. We had five types of Specific fungal isolates, namely *Candida albicans*, *Candida tropicalis*, *Candida glabrata*, *Candida krusei*, and *Candida parapsilosis*. We evaluated the effectiveness of extracts from three types of plants, namely *Vachellia nilotica* subsp. Indica, *Capparis cartilaginea*, and *Fagonia paulayna*, against the isolated fungi. We used different concentrations of the extracts (8mg/ml, 16mg/ml, 24mg/ml, 32mg/ml, and 40mg/ml) and measured the zone of inhibition, which is the circular area around the extract disk where no fungal growth occurs.

Results of efficacy for *Candida albicans*, *Vachellia nilotica* subsp. Indica (Ethanol Extract) showed inhibitory effects with zone sizes ranging from 13 to 17 mm at different concentrations, while *Capparis cartilaginea* and *Fagonia paulayna* (both Ethanol Extracts) were ineffective. Water Extracts showed no efficacy against this fungus. Regarding *Candida tropicalis*, *Vachellia nilotica* subsp. Indica (Ethanol Extract) exhibited inhibitory effects with zone sizes ranging from 15 to 22 mm, while *Capparis cartilaginea* and *Fagonia paulayna* (both Ethanol Extracts) were ineffective. Water Extracts also showed no efficacy against this fungus. *For Candida glabrata*, *Vachellia nilotica* subsp. Indica (Ethanol Extract) showed inhibitory effects with zone sizes ranging from 19 to 27 mm at different concentrations. Water Extracts also demonstrated efficacy with zone sizes ranging from 14 to 21 mm. *Capparis cartilaginea* (Ethanol Extract) showed efficacy with a constant zone size of 14 mm, but *Fagonia paulayna* (Ethanol Extract) was ineffective. For *Candida krusei* and *Candida parapsilosis*, none of the plant extracts showed efficacy against these fungal isolates.

Conclusions

In conclusion, ethanol extracts of *Vachellia nilotica* subsp. Indica have displayed promising inhibitory effects against specific *Candida* species, warranting further investigation for potential therapeutic applications. This study has unveiled encouraging insights into the efficacy of plant extracts in combating fungal infections, paving the way for the enhancement of natural remedies and the provision of safer alternatives to chemical medications. Plant-derived compounds hold significant promise as effective alternatives for patients, underscoring the necessity to intensify research into medicinal plants, cultivate secure and efficient treatments, and bolster both industrial and natural approaches to advance public health.

In light of these findings, it can be inferred that *Vachellia nilotica* subsp. Indica extracts exhibit inhibitory effects against certain isolated fungi. However, it is noteworthy that the effectiveness of these extracts varies among different fungal strains, with some demonstrating greater resistance. Further investigations are imperative to elucidate the mechanisms of action of these extracts and to conduct more comprehensive testing before considering them as potential remedies for fungal infections.

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مقالة بحثية

النشاط المضاد للفطريات لبعض النباتات المستخدمة في الطب العشبي اليمني

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المُلخّص

استُخدمت نباتات طبية تشمل *Capparis cartilaginea* Decne؛ *Vachellia nilotica* subsp. Indica (Benth) Kyal & Boatwr.؛ و Fagonia *paulayana* J. Wagner & Vierh. في الطب التقليدي اليمني لعلاج مجموعة متنوعة من الأمراض المعدية وغير المعدية. تم اختيار هذه النباتات لتقييم إمكانية نشاطها المضاد للفطريات. الهدف من الدراسة هو تقدير نشاطها المضاد للفطريات والمركبات النباتية في الأوراق والمستخلصات النباتية الكلية للثلاثة النباتات الطبية المستخدمة في الطب التقليدي اليمني لعلاج مجموعة متنوعة من الأمراض مثل الروماتيزم والبواسير والحمى وأمراض الجلد ولدغات الثعابين. تم تحضير المستخلصات النباتية من ثلاثة أنواع نباتية، وهي *Capparis cartilaginea* و *Vachellia nilotica* subsp. Indica و *Fagonia paulayana*، باستخدام الإيثانول والماء. تم اختبار هذه المستخلصات من حيث نشاطها المضاد للفطريات ضد أنواع *Candida* تم عزلها من عينات مهبلية للنساء. تم أيضًا إجراء فحص المركبات النباتية لتحديد المكونات المختلفة في هذه المستخلصات. تم إجراء اختبارات الحساسية المضادة للفطريات وفقًا للإرشادات القياسية، وتم استخدام أمفوتريسين ب كمرجع للمضادات الفطرية. الهدف من الدراسة هو تقييم إمكانية استخدام هذه الاستخراجات النباتية كعلاجات طبيعية للعدوى الكانديدا.قام الباحثين بتقييم النشاط المضاد للفطريات للمستخلصات النباتية من *Capparis cartilaginea* و Vachellia *nilotica* subsp. Indica و Fagonia *paulayana* ضد الفطريات *Candida* المعزولة من عينات مهبلية. أظهرت المستخلصات *Vachellia nilotica* subsp. Indica (الإيثانول) تأثيرات مثبطة ملحوظة ضد أنواع الكانديدا، بينما كان لديها تأثير محدود للمستخلصات *Capparis cartilaginea* و Fagonia *paulayana* (كلاهما بالإيثانول). يجب إجراء بحوث إضافية لاستكشاف الإمكانيات العلاجية لاستخدام *Vachellia nilotica* subsp. Indica كعامل مضاد للفطريات الطبيعي. المستخلص النباتي *Vachellia nilotica* subsp. Indica أظهر تأثيرات مثبطة ملحوظة ضد أنواع الكانديدا المعزولة من عينات المهبل. تشير هذه الدراسة إلى إمكانية استخدام المستخلص النباتي *Vachellia nilotica* subsp. Indica كوسيلة طبيعية لمكافحة العدوى الكانديدا.

الكلمات المفتاحية: *Capparis cartilaginea*؛ *Vachellia nilotica* subsp. Indica، *Fagonia paulayna*، *Candida* spp.، مستخلص الإيثانول ومستخلص الماء، النباتات الطبية في الطب التقليدي اليمني.

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