Original Article | Iran J Med Microbiol. 2023; 17(6): 680-686

10.30699/ijmm.17.6.680

Iranian Journal of Medical Microbiology | ISSN:2345-4342

Detection of Biologically Active Compounds in *Eriobotrya japonica* L. Seeds Extract and Determination of Their Effectiveness Against Dermatophytes

Shahad Basheer Bahedh*, Dina Yousif Mohammed

Department of Biology, College of Science, Mustansiriyah University, Baghdad, Iraq

ABSTRACT

Background and Aim: Effective dermatophytosis treatment necessitates antibiotics, which can harm the body's health. This systematic review study aims to evaluate the susceptibility profile of dermatophytes to plant extracts, and to address this critical gap in understanding resistance and treatment of dermatophytes.

Materials and Methods: *Eriobotrya japonica* seeds were collected, ground, and extracted, and then GC-MS analysis was performed to detect secondary compounds. Then, treatments of the plant extract (Ethanol) were made at a concentration (300, 150 and 75 mg/mL) with a control treatment (-) and a control treatment (+) containing a medicinal antifungal (Nystatin), treating it against dermatophytes and indicating the rate of inhibition for each isolate of dermatophytes (*Trichophyton rubrum*, *Trichophyton mentographytes, Microsporum canis, Trichophyton verrucosum, Trichophyton quinckeanum, Epidermophyton, Trichophyton simii, Trichophyton interdigitale,* and *Fusarium*).

Results: The seed extract significantly inhibited dermatophyte growth at 300 mg/mL concentration, with percentage inhibition growth ranging from 100% to 96.56%, compared to concentrations at 150 and 75 mg/mL, with percentage inhibition growth ranging from 97.27% to 86.66% and from 93.66% to 79.84%, respectively. The results of GC-MS analysis indicated that the ethanol seeds extract of loquat has a lot of active chemical compounds, including twenty-five phytoconstituent compounds that are distinguished in the extract of seeds with *E. japonica* L. In addition, the high area percentages revealed in each extract were Propylene glycol monooleate 5.03%, D-Mannitol or DL-Glucitol 5.67%, Beta-sitosterol 5.70%, n-hexadecanoic acid 14.53% and 9,12-Octadecadienoic acid (Z, Z)- 22.85%.

Conclusion: Based on our results, the ethanolic extract of the loquat plant was effective in inhibiting the growth of most dermatophytes to a significant extent, but the *Fusarium genus* was less sensitive. This is useful in choosing plant extracts in treating dermatophytes, which confirms their importance and their containment of beneficial active compounds.

Keywords: Antifungal, Dermatophytes, *Eriobotrya japonica*, Ethanol Extract, Seeds

Received: 2023/09/19; **Accepted**: 2024/01/15; **Published Online:** 2024/01/29

Corresponding Information: **Shahad Basheer Bahedh**, *Department of Biology, College of Science, Mustansiriyah University, Baghdad, Iraq* Email: shahadbasheer92@gmail.com

Use a device to scan and read the article online

Basheer Bahedh S, Yousif Mohammed D. Detection of Biologically Active Compounds in *Eriobotrya japonica* L. Seeds Extract and Determination of Their Effectiveness Against Dermatophytes. Iran J Med Microbiol. 2023;17(6):680-6.

Download citation: BibTeX | RIS | EndNote | Medlars | ProCite | Reference Manager | RefWorks

Send citation to: Mendeley Zotero RefWorks

1. Introduction

Dermatophytosis, a disorder predominantly caused by various species of dermatophytes residing in the epidermal layer of the skin, poses a significant risk of transmission between individuals and from animals to humans. Across All species of mammals, including humans, susceptibility to dermatophytosis extends to the skin, hair, and nails **(1)**. Among the nine genera identified, Trichophyton, Microsporum, and Epidermophyton stand out as the most common culprits in human infections.

The urgency for innovative therapeutic approaches arises from the challenges of resistance and adverse effects associated with conventional topical and systemic antifungal medications used in dermatophyte infections **(2)**. Medicinal plants emerge as promising reservoirs for discovering novel

antimicrobial agents, historically renowned for their antifungal efficacy against superficial skin infections (3). One such botanical candidate is *Eriobotrya japonica*, commonly known as the subtropical loquat tree, originating from China and Japan. Renowned for its evergreen foliage, captivating blossoms, and nutritionally rich fruits, it has found commercial cultivation in various nations, including Iraq, primarily as an ornamental tree (4).

Beyond its aesthetic appeal and nutritional value, *E. japonica* possesses a rich medicinal history, with documented applications in alleviating Inflammation, diabetes, cancer, chronic bronchitis, and coughs (5). Of notable significance are loquat seeds, pivotal in the plant's propagation and boasting diverse industrial and traditional medicinal applications (6, 7). Extracts derived from these seeds exhibit anti-inflammatory properties, as evidenced by a reduction in immunoglobulin E production in rats exposed to dinitrofluorobenzene (8). Such bioactivity is attributed to the abundant presence of phenolics, triterpenes, carotenoids, flavonoids, and vitamins across different parts of the plant (9).

Studies have underscored the significant antimicrobial and antioxidant potential of ethanolic extracts from loquat peel and seeds due to the presence of many active compounds like phenols, tannins, alkaloids, etc. which have shown a significant antimicrobial activity (10). Against this backdrop, our study elucidates the importance of bioactive components, delineating the effects of an ethanolic extract from *E. japonica* seeds on dermatophytes, thereby advancing our understanding of its therapeutic potential in combating dermatophytosis.

2. Materials and Methods

2.1 Collection and Preparation of Plant

The *E. japonica* seeds were sourced from local markets in Baghdad. Upon acquisition, the fruits underwent incision, facilitating the separation of seeds from their outer coating. Meticulously, the seeds were sifted, rinsed, and subjected to a three-week drying period under shade at room temperature, with regular rotation to ensure uniform drying. Subsequently, they underwent grinding to a fine powder using a grinder. Following established protocols (11), hot ethanolic extracts were meticulously prepared to utilize 100 g of the dried powder obtained from the Soxhlet apparatus, which was carefully packed into a thimble. The resulting extracts were aliquoted into serial tubes and stored at 4°C until further use, ensuring preservation of their bioactive constituents.

2.2 Phytochemical Screening by Gas chromatography-mass spectrometry (GC-MS) Analysis

A total of 5 µL of ethanol extract derived from loquat seeds underwent GC-MS analysis conducted by Agilent Technologies (SHIMADZU Japan) employing a high-temperature column for effective separation. Helium gas served as the carrier gas at a flow rate of 1.0 mL/min, with a split ratio of 1:10, adhering to a meticulously designed temperature program. Both injector and detector temperatures were maintained at 280°C, while the initial column temperature was set at 70°C. A sample volume of 5 µL was injected into the column and subjected to analysis utilizing split (1:10) mode.

Following 2 minutes, the oven temperature underwent incremental elevation to 110°C at a ramp rate of 5°C/min, with a subsequent hold time of 9 minutes. Subsequently, the oven temperature was further increased to 280°C at a ramp rate of 7.5°C/min, with an additional hold time of 9 minutes. Identification of compounds was facilitated by comparing their mass spectra with authentic standards (12), ensuring rigorous characterization of the constituents present in the loquat seed extract.

2.3 Collection of Specimens

Specimens gathered for the investigation of dermatophytic diseases were sourced from individuals afflicted with various manifestations of Tinea across different age groups. Collection methods included skin scraping, hair fragments, and nail clippings. The fungal laboratory at the College of Science, University of Baghdad, oversaw the sample collection. These samples were extracted from patients previously diagnosed with dermatophytes and subsequently cultured on low-pH growth media, ensuring a comprehensive representation of the fungal pathogens under investigation.

2.4 Determination of *Eriobotrya japonica* Seeds Extract on Dermatophytes

The ethanolic seed extract underwent preparation by dissolution in a DMSO solution to yield three distinct dilution sets (300, 150, and 75 mg/mL), each combined with 200 mL of Sabouraud dextrose agar (SDA). The amalgamation of extracts and SDA was meticulously stirred before being poured into sterile Petri dishes, where it solidified under controlled conditions.

Segments measuring 10 mm, derived from mycelial proliferation in mold cultures cultivated over 14 days, were delicately positioned at the center of each plate. Following inoculation, the plates underwent incubation at a temperature of 28°C for a duration ranging from 7 to 14 days. Subsequent assessment involved measuring. The diameters of fungal colonies using a

ruler and comparing them against control samples to determine the antifungal activity of each concentration, as indicated by growth inhibition **(13).**

2.5 Statistical Analysis

The collected data underwent a one-way analysis of variance (ANOVA) test to enable comparison among groups representing control-negative, control-positive, Nystatin, and Ethanol at concentrations of 300, 150, and 75 mg/mL. Significance levels were determined based on the P-values obtained, with values less than 0.05 being considered statistically significant.

3. Results

This study was conducted to emulate the effects of crude alcoholic extract of the medical plant *E. japonica*. The results of the GC/MS analysis identified and focused on the detection of numerous active compounds found in the ethanolic extracts of seeds *E. japonica*, their retention indexes and percentage composition are summarized in Table 1 and are illustrated in Figure (1). Our findings reveal the presence of 25 peaks in the ethanolic extracts.

The effect of the ethanolic seed extract of *E. japonica* on the nine types of dermatophytes is shown in Table (2). This table presents the different concentrations of the ethanolic extract of loquat seeds with a positive control (nystatin) and a negative control (naturally grown). The effect of the ethanolic seed extract is calculated by measuring the diameter of the fungal growth. The analysis reveals that at the concentrations of 300, 150, and 75 mg/mL of the ethanolic seed extract, there is a highly significant difference between all tested groups and the negative control. Additionally, there is a significant difference between the 150 and 75 mg/mL concentrations of ethanol and the positive control, but there is no significant difference between the positive control and the 300 mg/mL concentration of ethanol.

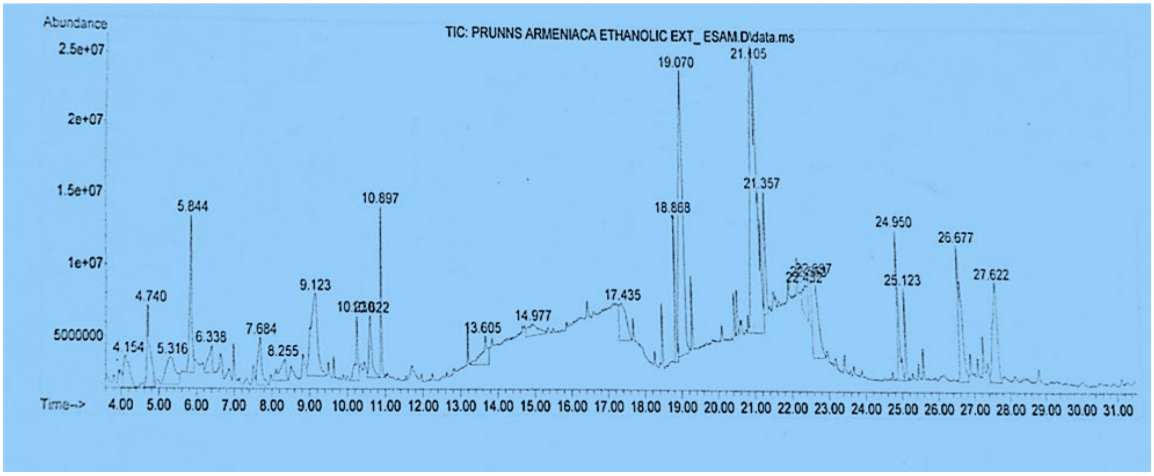

Figure 1. GC-MASS analysis chromatogram of *E. japonica* ethanolic seeds extract.

Table 1. The major compounds that are found in various parts of hot ethanolic seeds extract of *E. japonica*. by using GC-mass.

Peak #	RT(min)	Area%	Name	Molecular Formula
1	4.154	2.136	Hexanal	$C_6H_{12}O$
2	4.740	2.944	Benzaldehyde	C_7H_6O
3	5.316	2.838	1,2,3-Thiadiazole	$C_2H_2N_2S$
4	5.844	3.715	benzyl alcohol	C_7H_8O
5	6.338	1.185	Hydrouracil	$C_4H_6N_2O_2$
6	7.684	2.079	4H-Pyran-4-one	$C_5H_4O_2$
7	8.255	1.538	Benzoic acid	$C_7H_6O_2$
8	9.123	6.291	5-Hydroxymethylfurfural	$C_6H_6O_3$
9	10.230	1.627	Isosorbide	$C_6H_{10}O_4$

Peak #	RT(min)	Area%	Name	Molecular Formula
10	10.622	1.961	dl-Erythro-1-phenyl-1,2-propanediol	$C_9H_{12}O_2$
11	10.897	2.041	Eugenol	$C_{10}H_{12}O_2$
12	13.605	1.827	beta-D-glucopyranose	$C_6H_{14}O_7$
13	14.977	1.397	Sorbitol	$C_6H_{14}O_6$
14	17.435	3.067	Polygalitol	$C_6H_{12}O_5$
15	18.868	2.015	Dibutyl phthalate	$C_{16}H_{22}O_4$
16	19.070	14.538	n-Hexadecanoic acid	$C_{16}H_{32}O_2$
17	21.105	22.854	9,12-Octadecadienoic acid (Z, Z)-	$C_{18}H_{32}O_2$
18	21.357	2.410	1,5-Anhydroglucitol	$C_6H_{12}O_5$
19	22.432	1.788	D-Mannitol	$C_6H_{14}O_6$
20	22.553	1.395	DL-Glucitol	$C_6H_{14}O_6$
21	22.697	5.675	D-Mannitol	$C_6H_{14}O_6$
22	24.950	2.785	DL-Glucitol	$C_{12}H_{23}ClO$
23	25.123	1.162	Dodecanoyl chloride	$C_8H_6O_4$
24	26.677	5.032	Phthalic acid	$C_{21}H_{40}O_3$
25	27.622	5.703	Propylene glycol monooleate	$C_{29}H_{50}O$

Table 2. The percentage of the *E. japonica* plant's ethanolic seed extract inhibits growth at varying concentrations against dermatophytes.

	Study Groups					
Genus	**Negative Control - (growth %)**	**Positive Control + (Nystatin 2%)**	**Ethanol 300***	**Ethanol 150***	**Ethanol 75***	**P-value**
	Mean±SD	**Mean±SD**	**Mean±SD**	**Mean±SD**	**Mean±SD**	
T. verrucosum	82 ± 4.32	100 ± 0.00	100 ± 0.00	97.03±2.64	93.66±4.52	*0.09 NS
T. quinckeanum	75.67 ± 1.95	100 ± 0.00	*A 100 ± 0.00	B 96.53±2.23	C 89.83±2.25	0.05
Epidermophyton	63.00 ± 1.63	100 ± 0.00	100 ± 0.00	95.71±3.27	93.56±4.71	*0.086 NS
T. simii	87.33 ± 2.05	100 ± 0.00	100 ± 0.00	96.97±2.30	90.81±1.15	*0.06 NS
Fusarium	87.67 ± 2.05	100 ± 0.00	A 96.56 ± 0.99	B 86.66±1.60	C 79.84±1.11	0.05
T. interdigitale	84.33 ± 3.68	100 ± 0.00	A 100 ± 0.00	B 96.10±1.29	C 88.10±1.32	0.05
T. mentagrophytes	77.33 ± 2.05	100 ± 0.00	100 ± 0.00	96.61±3.10	93.14±4.92	* 0.09 NS
M. canis	62.67 ± 2.52	100 ± 0.00	100 ± 0.00	96.09±4.19	92.47±6.83	*0.091 NS
T. rubrum	87.00 ± 2.65	100 ± 0.00	100 ± 0.00	97.27±2.93	91.22±2.09	*0.07 NS
P value	*0.07 NS	*0.09 NS	* 0.06 NS	*0.08 NS	*0.091 NS	

* The ethanol concentration is provided as mg/mL.
* P value =between tested groups ($P \leq 0.05$ were considered significantly different).
* (A, B, and C) LSD represented the levels of significant, highly significant start from the letter (A) and decreasing with the last one.
* NS: Non-significant

4. Discussion

The seeds extract containing at least 5 peaks with a percentage area of more than 5% were Propylene glycol monooleate 5.03%, D-Mannitol or DL-Glucitol 5.67%, Beta-sitosterol 5.70%, n-Hexadecanoic acid 14.53% and 9,12-Octadecadienoic acid (Z, Z)- 22.85% (Figure 1). The ethanolic seeds extract of *E. japonica* has been found to exhibit a range of active compounds, with 9,12-Octadecadienoic acid (Z, Z)- (22.854%) emerging as the most prominent. Conversely, Phthalic acid was noted to have the lowest value (1.162%). The active compound 9,12-octadecadienoic acid (Z, Z)- was the most predominant, which is in agreement with the reports of **[14]** and **[15]** on tamarind leaves and seeds. Moreover, 9,12-octadecadienoic acid (Z, Z)- has been shown to possess a range of pharmacological potentials, including antioxidant, anti-inflammatory, hepatoprotective, antibacterial, and antifungal properties **[16, 17]**. The ethanolic extract of seeds contains a diverse range of secondary metabolites that have been observed to exhibit numerous pharmacological properties, including antifungal activity, such as Hexanal **(18)**, Benzaldehyde **(19)**, benzyl alcohol **(20)**, 4H-Pyran-4-one **(21)**, Benzoic acid **(22)**, Eugenol **(23)**, Sorbitol **(24)**, Dibutyl phthalate **(25)**, Dodecanoyl chloride **(26)**, and Phthalic acid **(27)**.

The results showed that using ethanol as an extraction solvent resulted in the seed extract (Table 1). This is because bioactive compounds with high polarity are more soluble in highly polar solvents like ethanol, enabling ethanol to extract non-glyceride constituents such as phosphatides, sterols, tocopherols, and pigments. These results are consistent with earlier research, which demonstrated that polar solvents yielded more extracts than non-polar solvents **(28)**. Additionally, bio-solvents like ethanol and water pose lower hazards due to their reduced toxicity. Ethanol is frequently utilized as a polar solvent during extraction processes and is also regarded as a bio-renewable substance, as it can be easily acquired at a low cost. Both equipment and solvent types have been shown to significantly impact the quality of extracts **(29)**. Polar solvents such as ethanol exhibit the capacity to extract bioactive constituents, including phenols, alkaloids, glycosides, flavonoids, and tannins. Notably, the total quantity of phytochemical compounds extracted is intrinsically linked to the polarity of solvents employed. Specifically, an increase in the polarity of solvents directly corresponds to a higher concentration of extracted compounds **(30)**. However, these findings are still in the early stages, and future experimental and clinical studies are subsequently needed in this kind of GC-MS investigation. It represents an initial step towards recognizing the dynamic standards in this medicinal field for further detailed study.

As Scheibler et al. indicated **(31)**, Nystatin is the most extensively recommended antifungal medication for treating superficial infections. This study employs nystatin to compare medicinal antifungal drugs for the skin and seed extracts by studying the efficiency and side effects of these plants and drugs. For this purpose, a 2% concentration of nystatin was used with the nine types of dermatophytes: *Trichophyton rubrum*, *Trichophyton mentographytes*, *Microsporum canis*, *Trichophyton verrucosum*, *Trichophyton quinckeanum*, Epidermophyton, *Trichophyton simii*, *Trichophyton interdigitale*, and Fusarium fungi. The results showed that loquat plant seed extracts significantly inhibited all nine types of dermatophytes.

The effect of the ethanolic seed extract of *Eriobotrya japonica* on the nine types of dermatophytes is shown in Table (2). This table presents the different concentrations of the ethanolic extract of loquat seeds with a positive control (nystatin) and a negative control (naturally grown). The effect of the ethanolic seed extract is calculated by measuring the diameter of the fungal growth. The analysis reveals that at the concentrations of 300, 150, and 75 mg/mL of the ethanolic seed extract, there is a highly significant difference between all tested groups and the negative control. Additionally, there is a significant difference between the 150 and 75 mg/mL concentrations of ethanol and the positive control, but there is no significant difference between the positive control and the 300 mg/mL concentration of ethanol.

There was a significant difference in the amount of growth inhibition between 150 and 75 mg/mL of ethanol as well as between the positive and negative controls. However, the percentage of growth inhibition was not statistically significant between ethanol concentration of 300 mg/mL and the positive control group. This indicates that using a concentration of 300 mg/mL of the ethanolic extract leads to effectiveness similar to that of the antifungal agent against pathogenic fungi (Nystatin) in most cases.

Increasing the concentration of the ethanolic seed extracts enhanced the efficiency of inhibition, likely attributed to an escalation in the concentration of active compounds within them. Statistical analysis revealed significant differences at the 0.05 level in inhibiting the growth of dermatophytes used in this study. When utilizing ethanol extraction of seeds at 300 mg/mL concentration, it demonstrated extreme efficiency in inhibiting the growth of dermatophytes, with a growth inhibition percentage of 100% observed

in almost all dermatophytes examined in this study, except for Fusarium, which exhibited a growth inhibition percentage of 96.56%. At ethanol concentrations of 150 and 75 mg/mL, the percentage of growth inhibition was lower compared to the positive and negative controls, likely due to the diversity and complexity of the natural mixtures of bioactive compounds in crude plant extracts. It is rather challenging to comprehensively analyze and characterize all compounds present in the extract and elucidate their structures in a single study due to the phytochemical results revealing different components of plant extracts with different solvents based on the polarity of each solvent **(32)**.

5. Conclusion

Our results suggest that loquat plant extracts hold promise as environmentally friendly antifungal agents against dermatophytes. Moreover, they encompass a spectrum of phytochemicals exhibiting enhanced biological activity, thereby presenting potential as medications with minimal risk of fungal resistance development and reduced environmental hazards. The present study underscores the superior impact of loquat seed ethanolic extract on inhibiting dermatophyte growth compared to the antifungal nystatin. However, further research is warranted to delve into these effects, especially amidst the ongoing quest for more economical and safer alternatives to prescription drugs.

Acknowledgment

We're highly thankful to the of College of Science, Mustansiriyah University and University of Baghdad to providing us the facilities and also opportunity to achieve our research.

Conflict of Interest

The authors declare no conflict of interest.

Funding

This research received no specific grant from any funding agency in the public.

References

1. AL-Khikani FH. Dermatophytosis a worldwide contiguous fungal infection: Growing challenge and few solutions. Biomed Biotechnol Res J. 2020; 4(2):117-22. [DOI:10.4103/bbrj.bbrj_1_20]
2. Al-Janabi AA. Dermatophytosis: Causes, clinical features, signs and treatment. J Symptoms Signs. 2014;3(3):200-3.
3. Mei A, Ricciardo B, Raby E, Kumarasinghe SP. Plant-based therapies for dermatophyte infections. Tasman Med J. 2022;4(3):21-37.
4. Al-Ghazali NA, Hameed ZL, Abu-Duka AB. First Report of Aspergillus Leaf Spot on Loquat (Eriobotrya japonica) Caused by Aspergillus fumigatus in Iraq. In IOP Conference Series: Earth and Environmental Science. IOP Publishing. 2023; 1158(4):042030. [DOI:10.1088/1755-1315/1158/4/042030]
5. Jian T, Chen J, Ding X, Lv H, Li J, Wu Y, et al. Flavonoids isolated from loquat (Eriobotrya japonica) leaves inhibit oxidative stress and inflammation induced by cigarette smoke in COPD mice: the role of TRPV1 signaling pathways. Food Funct. 2020;11(4):3516-26. [DOI:10.1039/C9FO02921D] [PMID]
6. Henmi A, Shoji M, Nomura M, Inoue T. Fatty acid composition and applications of Eriobotrya japonica seed oil. J Oleo Sci. 2019;68(7):599-606. [DOI:10.5650/jos.ess18178] [PMID]
7. Inoue M, Hayashi S, Craker L. Culture, history, and applications of medicinal and aromatic plants in Japan. In Aromatic and Medicinal Plants-Back to Nature. Intechopen Publishing. 2017:95-110. [DOI:10.5772/66505]
8. Cornejal N, Pollack E, Kaur R, Persaud A, Plagianos M, Juliani HR, et al. Antimicrobial and Antioxidant Properties of Theobroma cacao, Bourreria huanita, Eriobotrya japonica, and Elettaria cardamomum-Traditional Plants Used in Central America. J Med Act Plants. 2023;12(1):1-17.
9. Liu Y, Zhang W, Xu C, Li X. Biological activities of extracts from loquat (Eriobotrya japonica Lindl.): a review. Int J Mol Sci. 2016;17(12):1983. [DOI:10.3390/ijms17121983] [PMID] [PMCID]
10. Rashed KN, Butnariu M. Isolation and antimicrobial and antioxidant evaluation of bio-active compounds from Eriobotrya japonica stems. Adv Pharm Bull. 2014;4(1):75-81.
11. Abubakar AR, Haque M. Preparation of medicinal plants: Basic extraction and fractionation procedures for experimental purposes. J Pharm Bioallied Sci. 2020;12(1):1-10. [DOI:10.4103/jpbs.JPBS_175_19] [PMID] [PMCID]
12. Eswaran R, Anandan A, Doss A, Sangeetha G, Anand SP. Analysis of chemical composition of Cissus quadrangularis linn by GC-MS. Asian J Pharm Clin Res. 2012;5(Supple 2):139-40.

13. Wang SY, Wu CL, Chu FH, Chien SC, Kuo YH, Shyur LF, et al. Chemical composition and antifungal activity of essential oil isolated from Chamaecyparis formosensis Matsum. wood. Holzforschung. 2005;59(3):295-9. [DOI:10.1515/HF.2005.049]

14. Abdu B. Comparative study of antimicrobial potentials of seed oils of jatropha curcas and Tamarindus indica. Int J Sci Res Sci Eng Technol. 2019;6(5):29-36.

15. Mehdi MA, Alawi AH, Thabet AZ, Alarabi F, Omar GM, Pradhan V. Analysis of bioactive chemical compounds of leaves extracts from Tamarindus indica using FT-IR and GC-MS spectroscopy. Asian J Res Biochem. 2021;8(1):22-34. [DOI:10.9734/ajrb/2021/v8i130171]

16. Fagbemi KO, Aina DA, Olajuyigbe OO. Soxhlet extraction versus hydrodistillation using the clevenger apparatus: A comparative study on the extraction of a volatile compound from Tamarindus indica seeds. Sci World J. 2021;2021:1-8. [DOI:10.1155/2021/5961586] [PMID] [PMCID]

17. Khidir A, Abdel Karim M. Constituents and Antimicrobial Activity of Oil from Withania somnifera Grown in Sudan. J Faculty Sci Technol. 2022;9(2):117-24.

18. Cui K, He L, Cui G, Zhang T, Chen Y, Zhang T, et al. Biological activity of trans-2-hexenal against the storage insect pest Tribolium castaneum (Coleoptera: Tenebrionidae) and mycotoxigenic storage fungi. J Econ Entomol. 2021;114(2):979-87. [DOI:10.1093/jee/toab001] [PMID]

19. Neto LJ, Ramos AG, Freitas TS, Barbosa CR, de Sousa Júnior DL, Siyadatpanah A, et al. Evaluation of benzaldehyde as an antibiotic modulator and its toxic effect against Drosophila melanogaster. Molecules. 2021;26(18):5570. [PMID] [PMCID] [DOI:10.3390/molecules26185570]

20. Ogala JB, Hassan Y, Samaila A, Bindawa MI, TOK TT. Synthesis, antifungal activity and in silico ADMET studies of benzyl alcohol derivatives. İstanbul J Pharm. 2022;52(1):47-53. [DOI:10.26650/IstanbulJPharm.2022.958484]

21. Mahdavi SM, Habibi A, Dolati H, Shahcheragh SM, Sardari S, Azerang P. Synthesis and antimicrobial evaluation of 4H-pyrans and schiff bases fused 4H-pyran derivatives as inhibitors of Mycobacterium bovis (BCG). Iran J Pharm Res. 2018;17(4):1229-39.

22. Joye, IJ. Acids and Bases in Food. Editor(s): Laurence Melton, Fereidoon Shahidi, Peter Varelis, Encyclopedia of Food Chemistry. Academic Press. 2019:1-9. [PMID] [DOI:10.1016/B978-0-08-100596-5.21582-5]

23. Abdou A, Elmakssoudi A, El Amrani A, JamalEddine J, Dakir M. Recent advances in chemical reactivity and biological activities of eugenol derivatives. Med Chem Res. 2021;30:1011-30. [DOI:10.1007/s00044-021-02712-x]

24. Kim J, Kim YY, Chang JY, Kho HS. Candidacidal activity of xylitol and sorbitol. J Oral Med Pain. 2016;41(4):155-60. [DOI:10.14476/jomp.2016.41.4.155]

25. Shobi T, Viswanathan M. Antibacterial activity of di-butyl phthalate isolated from Begonia malabarica. J Appl Biol Biotechnol. 2018;5(2):97-100. [DOI:10.15406/jabb.2018.05.00123]

26. Lima R, Fernandes C, Pinto MM. Molecular modifications, biological activities, and applications of chitosan and derivatives: A recent update. Chirality. 2022;34(9):1166-90. [DOI:10.1002/chir.23477] [PMID]

27. Huang L, Zhu X, Zhou S, Cheng Z, Shi K, Zhang C, et al. Phthalic acid esters: Natural sources and biological activities. Toxins. 2021;13(7):495. [DOI:10.3390/toxins13070495] [PMID] [PMCID]

28. Sbihi HM, Nehdi IA, Mokbli S, Romdhani-Younes M, Al-Resayes SI. Hexane and ethanol extracted seed oils and leaf essential compositions from two castor plant (Ricinus communis L.) varieties. Ind Crops Prod. 2018;122:174-81. [DOI:10.1016/j.indcrop.2018.05.072]

29. Castejón N, Luna P, Señoráns FJ. Alternative oil extraction methods from Echium plantagineum L. seeds using advanced techniques and green solvents. Food Chem. 2018;244:75-82. [DOI:10.1016/j.foodchem.2017.10.014] [PMID]

30. Adham D, Taufiqurrahman I, Helmi ZN. Flavonoid level analysis of Binjai leaf extract (Mangifera caesia) in ethanol, methanol, and n-hexane solvents. 2019;4(1):46-9.

31. Scheibler E, Garcia MC, Medina da Silva R, Figueiredo MA, Salum FG, Cherubini K. Use of nystatin and chlorhexidine in oral medicine: Properties, indications and pitfalls with focus on geriatric patients. Gerodontology. 2017;34(3):291-8. [DOI:10.1111/ger.12278] [PMID]

32. Muraih JK, Arean AG, Abdulabass HT. Phytochemical and antibacterial activity of Capparis spinosa roots extracts against some pathogenic bacteria. Ann Trop Med Public Health. 2020;23(S10):SP231010. [DOI:10.36295/ASRO.2020.231010]