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Study on the inhibition of the growth of skin pathogens by turmeric (*Curcuma longa* L.) essential oils

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Abstract

In Vietnam, turmeric is grown in Dak Lak, Dak Nong, Lam Dong, Quang Ngai, Nghe An, Bac Giang, Bac Ninh, Hung Yen, Hai Duong, Son La, Vinh Phuc and other provinces. The study's goal was to examine the chemical components and antimicrobial activity of turmeric essential oils on skin pathogens, which is critical. By the GC-MS method, nineteen chemical components in turmeric essential oil have been identified, of which six are hydrocarbons (such as 39.42% monoterpenes and 3.58% sesquiterpenes), and the rest are oxygenated hydrocarbons (8.09% alcohols, 3.12% aldehydes, and 44.24% ketones). The turmeric essential oils exhibited inhibitive effects on all of the test organisms. They showed excellent in vitro antimicrobial activity against all the tested skin pathogens, including gram-positive bacteria and yeast strains, with zones of inhibition ranging from 10.13 to 21.64 mm in diameter. The turmeric essential oils were most active against antibiotic-susceptible *Staphylococcus epidermidis* (MIC = 0.15 µL/mL). The MICs for turmeric essential oils ranged from 0.06 µL/mL to 0.68 µL/mL for all test microorganisms. These research results are a valuable premise for the development of research and the application of turmeric essential oil in medicine.

1. Introduction

Turmeric (*Curcuma longa* L.) is a rhizomatous herbaceous perennial plant of the Zingiberaceae family, native to tropical South Asia, but now widely cultivated in the tropical and subtropical regions of the world (Noura and William, 2018).

In Vietnam, turmeric is grown in Dak Lak, Dak Nong, Lam Dong, Quang Ngai, Nghe An, Bac Giang, Bac Ninh, Hung Yen, Hai Duong, Son La, Vinh Phuc, and other provinces. The deep orange-yellow powder known as turmeric is prepared from boiled and dried rhizomes of the plant. It has been commonly used as a spice and medicine, particularly in Asia. The curcuminoid pigments and volatile oil, which are the major secondary metabolites of the rhizome, have been shown to be largely responsible for the pharmacological activities of turmeric powder, extracts, and oleoresins (Noura and William, 2018). There are extensive in vitro and in vivo investigations on essential oils and extracts of turmeric that show hepatic and cardioprotective, hypoglycemic, anti-amyloidogenic, antifungal, parasiticidal, antioxidant, insect repelling, chemo-resistance, and radio-resistance activities (Li *et al.*, 2017). This wide variation may be related to the chemical composition of the essential oil, which varies considerably among the cultivars, maturity stages, and cultivation practices (Kai *et al.*, 2020). These data indicate that this essential oil may be used as a food preservative because its action on fungi and fumonisin contamination would increase the shelf life of agricultural products. In addition, the essential oil could decrease lipid peroxidation and other processes mediated postharvest by free-radical formation. Future studies are needed to characterize the active essential oil components, in-situ assays, and establish their toxicity, determine the cost-benefit balance, and develop the essential oil components into environmentally sustainable biopesticides (Avanço *et al.*, 2017). In particular, the antimicrobial activities of essential oils have formed the basis of many applications, including raw and processed food preservation, pharmaceuticals,

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alternative medicine, and natural therapies. The main advantage of natural agents is that they do not enhance antibiotic resistance, a phenomenon commonly encountered with the long-term use of synthetic antibiotics. There are reports that the active principles of essential oils from various plants have antibacterial activity against skin pathogenic bacteria (Yang *et al.*, 2009). As a result, the current study was conducted to investigate the inhibition of the growth of skin pathogens by turmeric essential oils derived from turmeric rhizomes grown in Vietnam, which is very important, both scientifically and practically.

2. Materials and methods

2.1 Materials

The turmeric was harvested from the Krong Pac district of the Dak Lak province, Vietnam, in March 2023. The turmeric essential oil was obtained by steam distillation after drying with Na_2SO_4. The sample was stored in the Department of Food Science and Technology, University of Science, Vietnam National University, Hanoi. The tested bacterial strains (*Staphylococcus epidermidis, Propionibacterium acnes, Malassezia furfur,* and *Candida albicans*) were obtained from the Institute for Quality Testing and Inspection. *Staphylococcus epidermidis* was cultured at 37°C for 24 hrs with corynebacterium media (10 g casein peptone, 5 g yeast extract, 5 g glucose, and 5 g NaCl per liter). *Propionibacterium acnes* strains were cultured at 37°C for 48 hrs in potato dextrose agar broth under anaerobic conditions before the assay. *Malassezia furfur* was grown at 37°C for 24 hrs on yeast extract, malt extract, and agar containing 1% olive oil. *Candida albicans* was also cultured at 37°C for 24 hrs in yeast extract and malt extract agar broth.

2.2 Determination of chemical components in turmeric essential oils

For identification of the chemical constituents present in turmeric essential oils, gas chromatography-mass spectrometry (GC-MS)-QP2010 ULTRA (Shimadzu) equipment, equipped with a column Rxi-1MS 30 m × 0.25 mm × 0.25 µm (Restek) was used. The column temperature was programmed from 80 to 150°C in 23.5 mins at a rate of 3°C/mins and then from 150 to 220°C in 8.85 mins at a rate of 8°C/mins. The used injector temperature was 230°C. The MS conditions were as follows: ionization voltage was 70eV, transfer temperature was 250°C, the carrier gas was helium used at a flow rate of 0.5 mL/mins, and the split ratio of the injector was 1:5. The quantification of turmeric essential oil constituents was performed using gas chromatography on an HP 7820A Gas Chromatograph (Agilent) equipped with a capillary column with dimensions of 30 m × 0.32 mm × 0.25 µm (Agilent), with a temperature of 50°C, 3°C/min, up to 220°C. Samples containing 1 µL of turmeric essential oil diluted (1%) in chloroform with an initial temperature of 200°C in the split ratio (1:50) were injected. The CG-FID worked at a temperature of 220°C. Drag gas was helium at 3 mL/min. The data acquisition software was Ezchrom Elite Compact Agilent (Don *et al.,* 2019; Sayed *et al.*, 2021).

2.3 Determination of the antibacterial ability of turmeric essential oils

The inhibitive effects on test bacteria were determined by the agar disk diffusion method. The agar disks with a diameter of 8 mm were prepared, and turmeric essential oils, diluted in ethanol to the test concentrations, were added to the agar disks (20 µL) an equal volume (20 µL) of ethanol and erythromycin (2 µg) were used as controls. The inoculated plates were incubated at 37°C for 48 hrs under anaerobic conditions. Other pathogens were incubated at 37°C for 24 hrs under aerobic conditions. After incubation, the diameter of the inhibition zone was measured with callipers (Yang *et al.*, 2009). The activity was roughly estimated by the diameter of the antibacterial round (mm), which was calculated by the formula: D - d (mm), where D is the diameter of the antibacterial round (mm) and d is the hole diameter (mm) (Zhang *et al.*, 2017).

2.4 Determination of the minimum inhibitive concentration

The turmeric essential oils were serially diluted to 0.04 to 40 µL/mL. The 96 well plates were prepared by dispensing 95 µL of culture broth, 100 µL of turmeric essential oil, and 5 µL of the inoculants into each well. A positive control (containing inoculum but no turmeric essential oil) and a negative control (containing turmeric essential oil but no inoculum) were included on each microplate. The contents of the wells were mixed, and the microplates were incubated at the proper temperature and incubation times. The MIC was defined as the lowest concentration of the compound that inhibited microorganism growth. The experiment was performed in triplicate (Yang *et al*., 2009).

3. Results and discussion

3.1 Chemical components of turmeric essential oils

The chemical components of turmeric essential oils, identified by the GC-MS method and quantified by the GC-FID method, are presented in Table 1 and Figure 1.

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Table 1. The chemical components of turmeric essential oils.

No.	Chemical components	Retention time (min)	Retention indices	Proportion (%)
	Monoterpenes			39.42
1	*α*-Phellandrene	2.76	1005	29.18
2	*α*-Terpinene	2.85	1016	3.97
3	*p*-Cymene	3.36	1023	3.43
4	*β*-Phellandrene	4.62	1027	2.84
	Sesquiterpenes			3.58
5	*β*-Curcumene	7.22	1482	1.82
6	*β*-bisabolene	8.18	1508	1.76
	Alcohols			8.09
7	1,8-Cineole	5.29	1030	2.68
8	*α*-Terpineol	6.15	1093	2.47
9	*β*-Atlantol	10.20	1610	1.53
10	Geraniol	20.38	1789	0.72
11	Thymol	22.11	1798	0.69
	Aldehydes			3.12
12	Citronellal	11.60	1637	1.47
13	Myrtenal	16.32	1748	0.84
14	Neral	18.03	1765	0.81
	Ketones			44.24
15	Curzerenone	9.23	1605	1.64
16	*α*-Turmerone	14.15	1667	39.87
17	Germacrone	14.35	1691	1.06
18	*β*-Turmerone	15.09	1703	0.89
19	Carvone	19.12	1782	0.78
	Total			98.45

Note: The percentage (%) is calculated by chromatographic peak area.

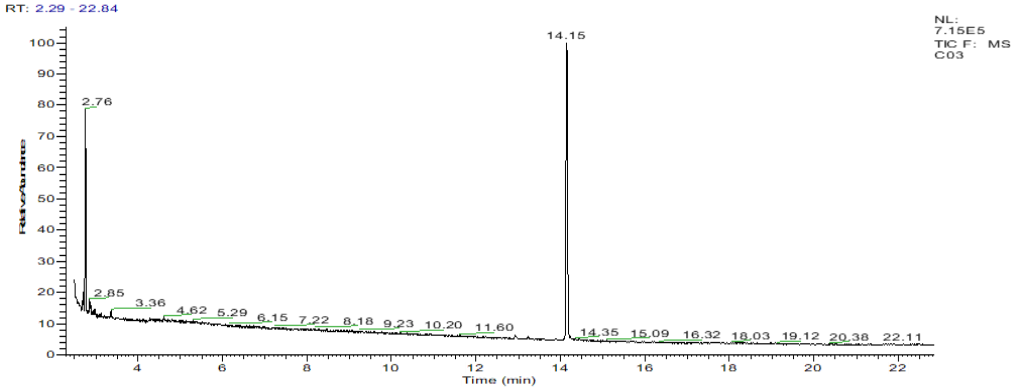

Figure 1. The content of the chemical components is calculated as a percentage of the chromatographic peak area.

The analysis of the chemical compounds in the turmeric essential oil by the GC-MS method identified nineteen compounds in Table 1. A total of six chemical components were hydrocarbons (such as 39.42% monoterpenes and 3.58% sesquiterpenes), and the rest were oxygenated hydrocarbons (8.09% alcohols, 3.12% aldehydes, and 44.24% ketones). The main components belonged to the terpene group and terpenoids, such as 29.18% *α*-phellandrene, 3.97% *α*-terpinene, 4.43% *p*-cymene, 2.84% *β*-phellandrene and 39.87% *α*-turmerone. The results of this study are also consistent with those reported elsewhere (Avanço *et al.,* 2017; Noura and William, 2018; Guimaraes *et al.,* 2020). Sesquiterpenes in plants are related to the protective function of these compounds against fungi, bacteria, insects, and other pests for plant preservation (Avanço *et al*., 2017).

3.2 Antimicrobial activity on skin pathogens of turmeric essential oils

The in vitro antimicrobial potential activity of turmeric essential oils against the tested skin pathogens was quantitatively assessed by the presence or absence of inhibition zones and MIC values. The agar disk diffusion method was employed as a susceptibility screening test to evaluate the activity of turmeric essential oils against

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Table 2. Antimicrobial activity of skin pathogens of turmeric essential oils.

No.	Experimental strains of microorganisms	Drug-resistance patterns of skin pathogens (MIC, μg/mL)	Diameter of antibacterial round (mm)	MIC values (μL/mL)	
				Erythromycin	Turmeric essential oils
1	*Staphylococcus epidermidis*	Susceptible	16.17±0.05	0.15	0.42
2	*Propionibacterium acnes*	Susceptible	16.24±0.04	0.16	0.43
3	*Malassezia furfur*	-	10.13±0.03	-	0.68
4	*Candida albicans*	-	21.64±0.08	-	0.06

four skin pathogens. The results of the study are shown in Table 2.

They showed excellent in vitro antimicrobial activity against all the tested skin pathogens, including gram-positive bacteria and yeast strains, with zones of inhibition ranging from 10.13 to 21.64 mm in diameter. The antibacterial activities of turmeric essential oils were further evaluated by determining the MIC, which is the lowest concentration yielding no growth. The turmeric essential oils exhibited inhibitive effects on all of the test organisms. The turmeric essential oils were most active against antibiotic-susceptible *S. epidermidis* (MIC = 0.15 μL/mL). The MICs for turmeric essential oils ranged from 0.06 μL/mL to 0.68 μL/mL for all test microorganisms. These activities may be attributed to *α*-phellandrene, *α*-terpinene, *p*-cymene, *β*-phellandrene, *α*-turmerone, 1,8-cineole, *α*-terpineol, curzerenone, *β*-atlantol and germacrone. In conclusion, turmeric essential oils are quite interesting from a pharmaceutical standpoint because of their antibacterial properties against skin pathogens. For instance, *S. epidermidis, P. acnes,* and *M. furfur* are known to worsen skin acne in humans, and turmeric essential oils may be good candidates for medicated acne care formulations. The results of this study are also consistent with the results of Noura and William (2018).

4. Conclusion

By the GC-MS method, 19 chemical components in turmeric essential oil have been identified, of which six are hydrocarbons (such as 39.42% monoterpenes and 3.58% sesquiterpenes), and the rest are oxygenated hydrocarbons (8.09% alcohols, 3.12% aldehydes, and 44.24% ketones). The turmeric essential oils exhibited inhibitive effects on all of the test organisms. They showed excellent in vitro antimicrobial activity against all the tested skin pathogens, including gram-positive bacteria and yeast strains. The turmeric essential oils were most active against antibiotic-susceptible *S. epidermidis.*

Conflict of interest

The author declares the research results in this article to be completely honest. The data has never been used or rotated from other research projects in any form.

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