



MINI REVIEW ARTICLE

An update review of biological activity of essential oils from *Curcuma* genus

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Abstract

Curcuma L. is one of the largest genera (about 108 species) belonging to Zingiberaceae family. Many *Curcuma* plants have been used for many purposes, including possessing preservative, flavoring, and medicinal properties. *Curcuma* plants are a prominent material for extracting essential oils (EOs). Over the last five years, many studies have been reported for the biological effects of the EOs isolated from *Curcuma* plants such as antimicrobial, antioxidant, anti-inflammation, anti-trypanosomal, antileishmanial, anti-acetylcholinesterase, antiproliferative, cytotoxic, larvicidal, and insecticidal activities. In this brief review, an updated version of the bioactivities of EOs from different species belonging to *Curcuma* genus are presented.

Keywords

Curcuma, essential oil, bioactivity

Introduction

Curcuma L., one of the largest genera (about 108 species) belonging to Zingiberaceae family, includes perennial rhizomatous herbs. Most of the members of this genus are native to subtropical and tropical localities such as Northern Australia, New Guinea, Southern China, Southeast Asia, India, Africa and Central America (1). The habitat, the flowers, and the shapes of leaves among *Curcuma* species are analogous. The height of them is ranging from 0.5 to 2.0 meters. The members of this genus are characterized by their inflorescence, which has a compound spike with outstanding bracts each subtending a cincinnus of 2–10 flowers, and they are connected with each other forming pouches at the base (2).

A large number of *Curcuma* species have been used for many purposes, including possessing preservatives (3), flavoring (4), and medicinal properties (5). Notably, many species of this genus are known for their traditional medicine to treat many diseases like infectious wounds, pneumonia, abscesses, leucorrhoea, insect bites, diarrhea, and bronchial complaints (6). The chemical compositions and biological activities of numerous *Curcuma* plants have been reported by prior studies (7-10). In addition, *Curcuma* plants are a prominent material for extracting of EOs, and they have been reported to have various biological effects such as anti-inflammatory, antimicrobial, antioxidant, antithrombotic, anticancerous, insecticidal, larvicidal effects, etc. (11). In 2018, Dosoky et al. provided an overview of the chemical profiles and bioactivities of EOs obtained from various species of *Curcuma* genus. Over the last five years, more and more

studies have been reported for the biological properties of the EOs isolated from *Curcuma* species. Thus, an updated version of the bioactivity of EOs from different species belonging to *Curcuma* genus is presented in this brief review.

Biological activity of EOs from *Curcuma* genus

Curcuma longa L.

C. longa L., commonly known as “turmeric”, is a native of Southeast Asia (12). It is also found in other Asiatic countries such as China, India, Nepal (13). A turmeric rhizome powder is considered as one of the major products from this species. It is broadly used as a spice, flavoring or traditional medicine (13). Furthermore, *C. longa* has been reported to possess some bioactivities effects, including antifungal, antioxidant (14), antimicrobial (12), and antileishmanial (15) activities.

The EO obtained from the *C. longa* leaf collected from Thrissur, India was found to be effective against four pathogenic strains such as *Escherichia coli*, *Pseudomonas aeruginosa*, *Salmonella enterica* with a MIC values of 0.625, 0.625, 0.625, and 0.500 mg/mL, respectively (16). Teles et al. provided that the EO of *C. longa* aerial part grown in Sao Luis, Brazil displayed effects against *Staphylococcus aureus* with MIC value of 83.3 µg/mL (17). Moreover, the rhizome EO of *C. longa* from Morona-Santiago province, Ecuador showed strong antimicrobial activities against *Listeria grayi* and *Saccharomyces cerevisiae* with MIC values of 8.98 mg/mL, followed by *S. aureus* (48.75 mg/mL), *Enterococcus faecalis* (89.5 mg/mL), *Micrococcus luteus* (89.5 mg/mL), *Klebsiella oxytoca* (89.75 mg/mL), *Proteus vulgaris* (89.75 mg/mL), *E. coli* (44.88 mg/mL), *P. aeruginosa* (89.5 mg/mL), and *Candida albicans* (89.75 mg/mL) (18).

C. longa leaf EO from Thrissur, India showed cytotoxic activities against MCF-7 and MDA-MB-231 cells with IC₅₀ values of 40.74 and 45.17 µg/mL, respectively (16). Le et al. provided that the rhizome EO and its major compounds such as *ar*-Curcumene, curcione, β-sesquiphellandrene of *C. longa* collected from Vietnam showed cytotoxicity and anti-trypanosomal activity. Accordingly, the rhizome EO and its components possessed cytotoxic activities against WI38 and J774 with IC₅₀ values of 46.00 and 44.11 nL/mL, 23.15 and 24.03 µg/mL, 43.64 and 25.06 µg/mL, 19.11 and 21.02 µg/mL, respectively (19). Furthermore, they also possessed anti-trypanosomal effect against *Trypanosoma brucei* with IC₅₀ values of 3.17 nL/mL, 13.38, 1.38, and 9.89 µg/mL, respectively (19).

The EO isolated from *C. longa* leaf grown in Thrissur, India showed potent DPPH, ABTS, and H₂O₂ Radical scavenging activities with IC₅₀ values of 8.62, 9.21, and 4.35 µg/mL, respectively (16). Meanwhile, the rhizome EO of *C. longa* from Morona-Santiago province, Ecuador also possessed ABTS and DPPH radical scavenging activities with IC₅₀ values of 0.871 and 16.512 mg/mL (18). Teles et al. showed that the EOs of *C. longa* aerial part from Sao Luis, Brazil possessed antileishmanial activity against *Leishmania amazonensis* by inhibiting intracellular amastigote and antipromastigote. Accordingly, this EO

showed antipromastigote effect with IC₅₀ value of 405.5 µg/mL, while IC₅₀ of 63.3 µg/mL was intracellular amastigote activity towards the same parasite (17).

Curcuma aromatica Salisb.

C. aromatica is widely known as “wild turmeric”. This species has been used as a medicinal plant to treat skin eruptions, sprains, bronchitis, hiccup, cough and leukoderma. The EOs isolated from this species have been reported to have various bioactivities, including antibacterial, antifungal, and antioxidant activities (20).

Albaqami et al. provided that the leaf EOs of *C. aromatica* from Thrissur, India has been reported to exhibit cytotoxic activities against MCF-7 and MDA-MB-231 with IC₅₀ value of 55.75 and 67.11 µg/mL (16). In addition, the EO of *C. aromatic* leaves possessed DPPH, ABTS, and H₂O₂ radical scavenging effects with IC₅₀ values of 15.23, 13.28, and 8.38 µg/mL, respectively (16). This sample EO was also found to be effective against *P. aeruginosa*, *E. coli*, *S. aureus* and *S. enterica* with MIC values of 0.62, 1.00, 0.75, and 1.25 mg/mL, respectively (16). Xiang et al. provided that the rhizome EO of *C. aromatica* from China had an inhibitory effect on some bacterial and fungal strains, including *E. coli*, *P. aeruginosa*, *S. aureus*, *C. albicans*, and *S. cerevisiae* with MIC values of 593.25, 598.75, 595.46, 176.92, and 183.18 µg/mL, respectively (21). Moreover, the anti-inflammatory inhibition of EOs from this plant on TPA-induced mice ear edema has also been reported. Accordingly, at dose of 25, 50, and 100 mg/kg, the anti-inflammation of this EO was 21.65, 44.04, and 68.26%, respectively (21). In addition, EO also possessed cytotoxic activities against LNCaP and HepG2 cells with IC₅₀ values of 1.14 and 168.94 µg/mL, respectively (21). Meanwhile, Parida et al. provided that the EO of *C. aromatica* rhizome from forest areas of Eastern Ghats, India showed cytotoxic effect against MCF-7 cell with IC₅₀ value of 42.6 µL/mL (20).

Curcuma aeruginosa Roxb.

C. aeruginosa is a perennial herb widely found in Southeast Asia (22). The *C. aeruginosa* rhizome has been used extensively in traditional to cure stomachache, diarrhea, uterine pain, tumours, bronchitis, and fungal infections, etc. (20-22).

Fitria et al. demonstrated the cytotoxic effects of the rhizome EO of *C. aeruginosa* from Bogor, Indonesia using brine shrimp (*Artemiasalina*) lethality test and against MCF-7. Accordingly, this EO possessed cytotoxic activities against *A. salina* and MCF-7 cell with LC₅₀ values of 78.2 and 161.0 µg/mL, respectively (23). The rhizome EO of *C. aeruginosa* grown in Malaysia had an inhibitory effect on *S. typhimurium*, *E. coli*, *S. aureus*, *B. cereus* with the inhibition zones of 6.33, 9.00, 9.67, 10.00 mm, respectively (24). In addition, the rhizome EOs from twenty genotypes of *C. aeruginosa* from Tropical Biopharmaca Research Center, Indonesia were found to be effective against *S. mutants*, *S. aureus* and *E. coli*. The results showed that the sixteen out of twenty genotypes displayed activity against *S. aureus* with inhibition zones ranging from 0.52 to 4.79 mm. The five out of twenty genotypes possessed antibacterial effects against *S. mutants* with inhibition zones ranging

from 1.44 to 4.45 mm whereas *E. coli* were inhibited by the only one out of twenty genotypes with inhibition zone of 3.32 mm (25).

***Curcuma zedoaria* (Christm.) Roscoe**

C. zedoaria is a medicinal plant and is widely found in Asia regions. This species was also used as food and spices (26). In Asia traditional medicine, the plant parts of *C. zedoaria* commonly used to treat tuberculosis, stomach diseases, blood stagnation, enlargement of spleen, toothache, and leukoderma (27). Furthermore, studies demonstrated that the rhizome of this plant possessed various biological effects, including antitumour(28), antimicrobial(29), and anti-inflammatory (30) activities.

The rhizome EO of *C. zedoaria* from Vietnam possessed anti-trypanosomal effect against *Trypanosoma brucei* with IC₅₀ values of 2.51 nL/mL while this EO had also cytotoxic activities against WI38 and J774 with IC₅₀ values of 46.64 and 26.81 µg/mL, respectively (19). In addition, the EO of *C. zedoaria* rhizome from Odisha, India has been reported to possessed antibacterial and antioxidant effects (31). Accordingly, this EO was active against various microbial strains, including *B. subtilis*, *S. aureus*, *E. coli*, *E. faecalis*, *A. niger*, *P. aeruginosa*, *C. albicans*, *A. flavus* and *F. oxysporum* with MIC values ranging from 6.25 to 50 µg/mL (31). Meanwhile, this EO possessed ABTS and DPPH radical scavenging activities with IC₅₀ values of 1.28 and 2.58 µg/mL, respectively (31). In addition, Bressanin et al. demonstrated that the EO from *C. zedoaria* showed acaricidal effects against *Rhipicephalus microplus* larvae and engorged females. At dose of 15 mg/mL, this EO exhibited a larvae mortality of 100% *R. microplus* larvae while 98.6% efficacy on engorged females at dose of 80 mg/mL (32). Meanwhile, Junior et al. provided that the EO isolated from *C. zedoaria* rhizome possessed low acaricidal effect on *Dermacentor nitens* with the control percentage of 4.9% (33).

***Curcuma caesia* Roxb.**

C. caesia is a medicinal herb, native to Central and North East India (34) and also found in South east Asia (35). The rhizome extracts of this species has been reported to use in the treatment of antihelmentic, epilepsy, leprosy, hemorrhoids, cancer, and disorder (36).

The rhizome EO of *C. caesia* from Malaysia showed potent DPPH radical scavenging and anti-inflammatory effects with IC₅₀ values of 48.08 and 121.7 µg/mL, respectively. Furthermore, this EO was also found to be effective against *B. subtilis* and *B. cereus* with MIC value of 7.5 µg/mL while *S. cerevisiae* was sensitive to this EO with MIC value of 2.5 µg/mL (37). Borah et al. provided that the leaf EO of *C. caesia* from Assam, India possessed anti-inflammatory, antioxidant, and antimicrobial activities. Accordingly, this EO showed DPPH radical scavenging and anti-inflammatory effects with IC₅₀ values of 1.487 and 182.5 µg/mL. Moreover, this EO also had an inhibitory effect on *B. subtilis*, *S. aureus*, *B. cereus* and *S. typhimurium* with MIC values of 10.0, 2.5, 5.0, and 10.0 µL/mL (35). In addition, the EO of *C. caesia* rhizome from Pradesh, India has been reported to have anti-acetylcholinesterase and

free radical scavenging effects. The results showed that the rhizome EO possessed the DPPH, ABTS, hydrogen peroxide, and nitric oxide radical scavenging with IC₅₀ values of 186.33, 109.41, 103.45, and 190.55 µg/mL, respectively (38) while this EO had anti-acetylcholinesterase activity with IC₅₀ values of 156.33 µg/mL (38).

***Curcuma zanthorrhiza* Roxb.**

C. xanthorrhiza is an endemic species to Indonesia and also distributed in Thailand, Malaysia, Sri Lanka, and Philippines. In traditional medicine, this plant is used to treat heart disorders, diabetes, anticancer, hepatitis, hypertension, liver complaints, and rheumatism. Furthermore, the extracts from *C. xanthorrhiza* were also reported to possess some bioactivities, such as anti-inflammatory, antihypertensive, antihepatotoxic, antidiuretic, antioxidant, antifungal, and antibacterial activities (39).

Septama et al. provided that the essential obtained from *C. xanthorrhiza* was found to be effective against *S. aureus* and *Bacillus subtilis* with MIC values of 31.2 and 7.8 µg/mL, respectively. Furthermore, this EO has increased the ability to the antibacterial effects of ampicillin when combined with this antibiotic, as a result, the biofilm formation of *B. subtilis* and *S. aureus* were inhibited by this synergistic effect(40). Fitria et al. demonstrated the cytotoxic activities of the rhizome EO of *C. zanthorrhiza* from Bogor, Indonesia using brine shrimp (*Artemiasalina*) lethality test and against MCF-7. Accordingly, this EO possessed cytotoxic activities against *A. salina* and MCF-7 cells with LC₅₀ values of 83.6 and 139.8 µg/mL, respectively (23). In addition, the leaf EO of *C. zanthorrhiza* showed DPPH and ABTS radical scavenging activities with IC₅₀ values 55.57 and 24.42 µg/mL, respectively(41).

***Curcuma angustifolia* Roxb.**

C. angustifolia is an endemic species to India and it is a medicinal plant. The rhizomes of this species were used to cure inflammation, intestinal disorders, and bone fracture; the extract from leaves have been reported to have antifungal and antibacterial activities. Moreover, *C. angustifolia* was also known as sources of starch and nutritious plant (42).

The rhizome EO of *C. angustifolia* from Odisha, India was found to be effective against *E. coli*, *S. aureus*, *E. faecalis*, *P. aeruginosa*, *B. subtilis*, *Aspergillus niger*, *Aspergillus flavus*, *Fusarium oxysporum* and *C. albicans* with MIC values ranging from 12.5 to 50 µg/mL (31). Meanwhile, this EO possessed ABTS and DPPH radical scavenging activities with IC₅₀ values of 5.53 and 12.53 µg/mL, respectively (31). Albaqami et al. provided that the leaf EO of *C. angustifolia* from Thrissur, India has been reported to exhibit cytotoxic activities against MCF-7 and MDA-MB-231 cells with IC₅₀ values of 64.17 and 70.31 µg/mL, respectively(16). In addition, this EO also possessed DPPH, ABTS, and H₂O₂ radical scavenging activities with IC₅₀ values of 16.08, 12.81, and 8.08 µg/mL, respectively (16). Albaqami et al. also showed that the leaf EO of *C. angustifolia* was also displayed activity against *P.*

aeruginosa, *E. coli*, *S. aureus* and *S. enterica* with MIC values of 0.75, 1.00, 1.00, and 1.25 mg/mL, respectively (16).

Other *Curcuma* species

Van et al. showed that the rhizome the EO of *Curcuma thorelii* Gagnep. collected from Vietnam possessed potent antibacterial effects against five pathogenic bacteria, including *P. aeruginosa*, *E. coli*, *S. enteritidis*, *S. typhimurium* and *B. cereus* with the diameter of inhibition zone of 23.5, 20.3, 22.8, 23.2 and 22.6 mm, respectively (9). The EO of the whole plant of *Curcuma sahuynhensis* Škorničk. & N.S.Lý from Vietnam showed strong antimicrobial effects against *B. cereus*, *S. aureus*, *E. faecalis*, and *C. albicans* with MIC values of 64 µg/mL (43). The rhizome EO of another species collected from Vietnam, *Curcuma pambrosima* Skornick. & N.S. Lý, was also found to be effective against four tested microbial strains, including *B. cereus*, *E. faecalis*, *S. aureus*, and *C. albicans* with MIC values of 64.0, 64.0, 256.0, and 16.0 µg/mL (44). In addition, the rhizome EO of *Curcuma mutabilis* Škorničk. Showed strong antiproliferative effects against K562 and HCT116 cells with IC₅₀ values of 6.8 and 8.5 mg/mL, respectively while this EO possessed weak DPPH and ABTS radical scavenging activities (45). Kebede et al. provided the DPPH radical scavenging effect of the EOs extracted from three varieties of *Curcuma domestica* Valetton collected from Ethiopia, including Bonga 57/71, HT3/2002, and Dame with IC₅₀ values of 44.32, 32.25, and 23.05 µg/mL (46).

Narayanankutty et al. showed the biological properties of the EOs of *Curcuma amada* Roxb. obtained from different methods, including microwave assisted extraction, steam distillation, ultrasound assisted extraction, and hydrodistillation (47). Accordingly, these four EOs possessed the strongest antibacterial effect against *P. aeruginosa* (MIC = 4.0, 4.5, 3.0, 4.0 µg/mL, respectively), followed by *S. enteritidis* (MIC = 5.5, 5.5, 3.5, 4.3 µg/mL, respectively), *E. coli* (MIC = 6.0, 6.5, 4.0, 4.5 µg/mL, respectively), *S. enteritidis* (MIC = 6.5, 8.5, 4.8, 5.0 µg/mL, respectively) (47). Moreover, these four EOs had larvicidal activities against *Aedes aegypti*, *Culex tritaeniorhynchus*, and *Armigeres subalbatus*, in which the EOs from microwave assisted extraction showed the highest effect with LC₅₀ values of 75.22, 32.12, and 34.17 µg/mL, respectively (47). Furthermore, two pests of stored foods such as *Sitophilus oryzae* and *Tribolium castaneum* were inhibited by the EOs extract from these four methods. The result showed that these four EOs showed fumigant toxicity against *S. oryzae* with LC₅₀ values of 36.4, 32.7, 24.3, 23.7 µg/L of air, respectively while RC₅₀ values of 7.22, 6.17, 4.26, 5.08 µg/L of air, respectively; and LD₅₀ values of 188.7, 165.2, 140.6, 156.4 µg/mm² respectively were shown by the repellent and contact toxicities towards the same pest (48). Meanwhile, *T. castaneum* was sensitive to the four EOs with LC₅₀ values of 26.2, 28.1, 16.6, 15.8, respectively for fumigant toxicity whereas RC₅₀ values of 9.54, 9.28, 6.12, 6.58 µg/L of air, respectively; and LD₅₀

values of 208.5, 199.4, 178.6, 169.7 µg/mm², respectively were shown by the repellent and contact toxicities towards the same pest (47).

The rhizome EOs of six *Curcuma* species from China, including *Curcuma elata* Roxb., *Curcuma kwangsiensis* var. *Nanlingensis* N. Liu et X.Y. Ma, *Curcuma nankunshanensis* N. Liu, X.B. Ye & Juan Chen, *Curcuma sichuanensis* X.X. Chen, *Curcuma yunnanensis* N. Liu & S.J. Chen, and *Curcuma rubescens* Roxb. have been reported to possess several biological properties. For instance, these EOs possessed cytotoxic activities against LNCaP and HepG2 cells with IC₅₀ values of 18.40 and 167.75, 16.58 and 156.43, 3.04 and 163.56, 1.26 and 183.50, 7.93 and 153.06, 3.15 and 198.18 µg/mL, respectively (21). Also, the rhizome EO of these species had an inhibitory effect on some bacterial and fungal strains, including *E. coli*, *P. aeruginosa*, *S. aureus*, *C. albicans* and *S. cerevisiae* with MIC values ranging from 423.25 to 676.47 µg/mL, 215.20 to 598.75 µg/mL, 403.46 to 693.64 µg/mL, 176.92 to 396.46 µg/mL, and 183.18 to 436.62 µg/mL, respectively (21). Moreover, at dose of 25, 50 and 100 mg/kg, the anti-inflammation of these EOs was 24.61, 30.34, 54.64% (*C. elata*); 11.74, 22.56, 36.19% (*C. kwangsiensis* var. *nanlingensis*); 23.8, 37.74, 55.23% (*C. nankunshanensis*); 13.19, 25.64, 68.43% (*C. sichuanensis*); 10.3, 21.93, 29.8% (*C. yunnanensis*); and 8.26, 12.34, 20.54% (*C. rubescens*), respectively (21).

Curcuma xanthella Skornick is a rare species and it was discovered as a new species from Vietnam in 2013. Recently, Van et al. provided that the EOs isolated from the aerial parts of this species collected from two different habitats (sandy coastal soil and red basaltic soil) in Binh Chau-Phuoc Buu Nature Reserve, Vietnam. Accordingly, these EOs had an inhibitory effect on five bacterial strains, including *Staphylococcus saprophyticus*, *S. aureus*, *Salmonella enteritidis*, *Listeria monocytogenes*, and *Vibrio parahaemolyticus* (48).

Conclusion

This brief review showed the update synopsis of the biological properties of EOs isolated from *Curcuma* plants which were reported in the last five years. These EOs possessed various bioactivities such as antimicrobial, antioxidant, anti-inflammation, anti-trypanosomal, antileishmanial, anti-acetylcholinesterase, antiproliferative, cytotoxic, larvicidal and insecticidal activities.

Authors' contributions

Hong Thien Van designed this article, searched the data and resolved all the queries of editors and reviewers. Hong Thia Le participated in editing as well as providing many valuable comments to complete the manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

Ethical issues: None.

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