


REVIEW

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Curcuma zedoaria Rosc (Zingiberaceae): a review on its chemical, pharmacological and biological activities

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Abstract

Background: Around 80% of human population in the world relies on herbal or phytomedicines for their primary health care needs. The treatment of many diseases and disorders with phytomedicines is considered and observed as very safe with no or minimal side effects. Many medicinal plants and their preparations are practised at home as remedies for treating and preventing various diseases and disorders. For example, medicinal plants and their crude parts such as tulsi, neem, turmeric and ginger are used to cure or treat several common ailments, out of which *Curcuma zedoaria* Rosc commonly known as white turmeric is one of the important crude drugs belonging to Zingiberaceae family and genus *Curcuma*. Traditionally, it has been reported to possess many biological activities been used for many therapeutic actions due to the presence of wide range of phytoconstituents in it. The main objectives of the present work are to carry out extensive review on its chemical, pharmacological and biological activities of plant.

Main body: In the present review article, extensive data on its chemical, pharmacological and biological activities have been collected from various online sources including indexing sites such as Web of Science, Scopus, PubMed and Research Gate and presented. Various articles published in indexed journals and other databases have been collected and reviewed systematically.

Conclusion: The present review investigation is very much helpful for researchers and readers to collectively have valuable information on chemistry, pharmacology and biological effects of *Curcuma zedoaria* Rosc. The present investigation concludes that the white turmeric is found to possess complex range of phytoconstituents such as curcumin, ethyl p-methoxycinnamate, β -turmerone, β -eudesmol, zingiberene, dihydrocurcumin, furanodiene, α -phellandrene, 1–8 cineole, β -elemene and germacrone. Due to the presence of wide range of phytoconstituents, plants have been reported for its diverse biological activities.

Keywords: Anticancer, β -Eudesmol, Biological activities, *Curcuma*, Phytoconstituents, White turmeric

Background

Around 80% of human population in the world relies on herbal or phytomedicines for their primary health care needs. The treatment of many diseases and disorders with phytomedicines is considered and observed as very

safe with no or minimal side effects. Many medicinal plants and their preparations are practised at home as remedies for treating and preventing various diseases and disorders. For example, medicinal plants and their crude parts such as tulsi, neem, turmeric and ginger are used to cure or treat several common ailments, out of which *Curcuma zedoaria* Rosc commonly known as white turmeric is one of the important crude drugs belonging to Zingiberaceae family and genus *Curcuma*. Traditionally, it has been reported to possess many biological activities been

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used for many therapeutic actions due to the presence of wide range of phytoconstituents in it [1]. Many researchers have been scientifically worked on various chemical and biological investigations of white turmeric and they have published research papers in various journals and in scientific databases. Literature search revealed that, till date, no reports have been published on its extensive review about chemical, pharmacological and biological activities of white turmeric. Hence, there is solid need to have collective information about chemical and biological database of plant which will be helpful to other researchers and readers. With respect to this need, we have made an attempt to carry out the present review work.

Main text

Methodology for data collection

In the present review article, extensive data on its chemical, pharmacological and biological activities have been collected from various online sources including indexing sites such as Web of Science, Scopus, PubMed and Research Gate and presented. Various articles published in indexed journals and other databases have been collected and reviewed systematically.

Chemical composition

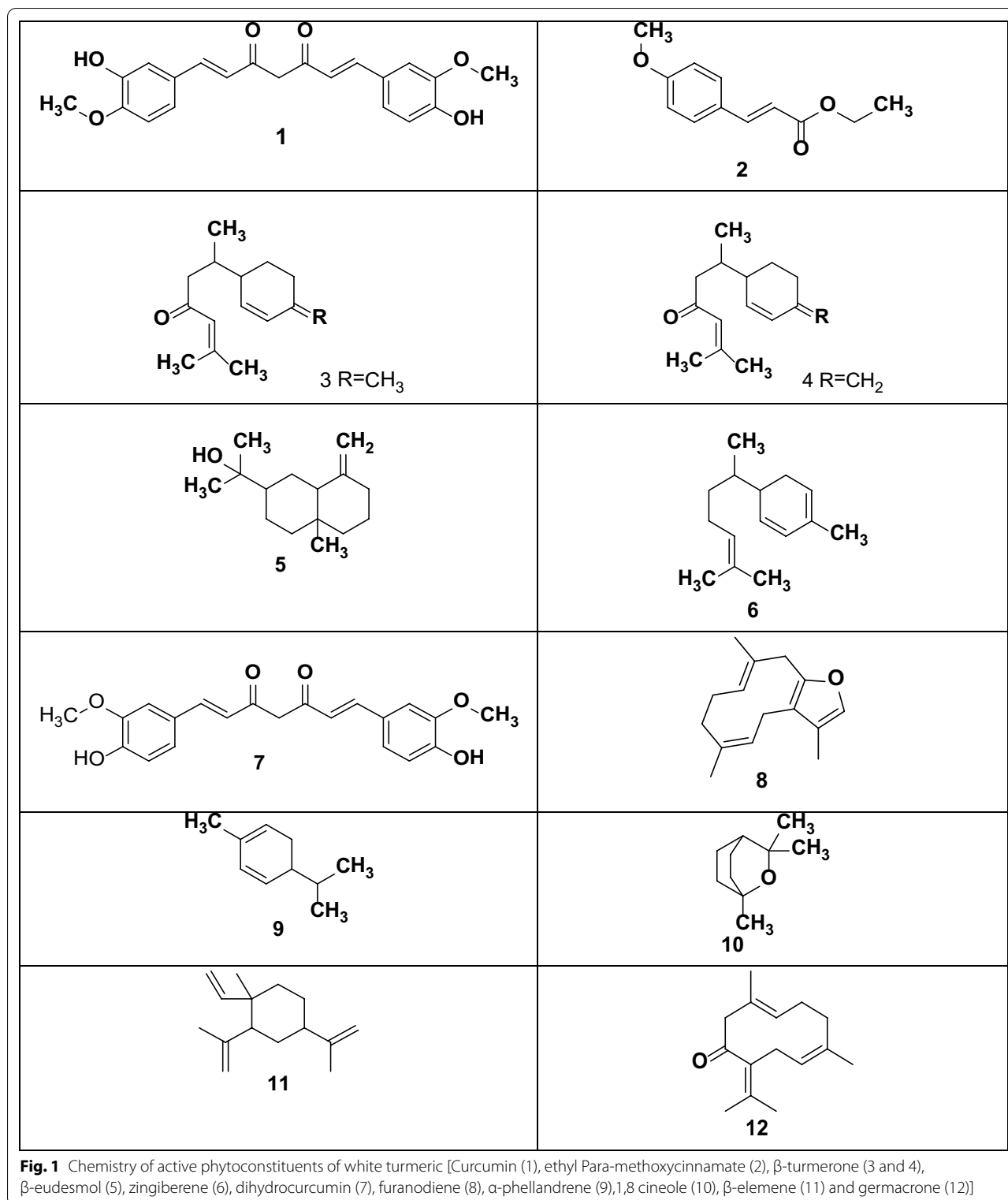
White turmeric is found to possess different types of primary and secondary metabolites. The main components of plant are starch, curcumin, essential oil and Arabic gums. The rhizome of the plant is found to possess more than 10 sesquiterpenes which include curcumin (1), ethyl p-methoxycinnamate (2), β -turmerone (3 and 4), β -eudesmol (5), zingiberene (6), dihydrocurcumin (7), furanodiene (8), α -phellandrene (9), 1,8 cineole (10), β -elemene (11) and germacrone (12). The chemistry of important chemical components of white turmeric is presented in Fig. 1 [1].

Pharmacological and biological activities

Antimicrobial activity

Sudipta et al. have reported antimicrobial activity of *Curcuma zedoaria* Rosc against two gram-positive bacteria such as *Staphylococcus aureus* and *Bacillus subtilis*, three gram-negative bacteria such as *Enterococcus faecalis*, *Escherichia coli* and *Pseudomonas aeruginosa*, three fungal strains namely *Aspergillus niger*, *A. flavous*, *fusarium oxysporum* and one yeast called *Candida albicans* and activity is done by means of agar diffusion method [3]. Chachad et al. have reported antimicrobial activity of *Curcuma zedoaria* Rosc using nutrient agar medium whereas antifungal activity is measured using potato dextrose agar against various fungal strains [4]. Philip et al. have reported antibacterial activity of *Curcuma zedoaria* Rosc against two gram-positive bacteria namely *Bacillus*

subtilis and *Staphylococcus aureus* and two gram-negative bacterial strains namely *Escherichia coli* and *Pseudomonas aeruginosa* [5]. Islam et al. have reported antibacterial activity from ethanol extract of *Curcuma zedoaria* Rosc against 8 pathogenic bacteria namely *Bacillus cereus*, *Staphylococcus aureus*, *Sarcina lutea*, *Bacillus magaterium*, *Escherichia coli*, *Pseudomonas aeruginosa*, *salmonella typhi*, *Shigella boydi*, and antifungal activity against three species of fungi *aspergillus niger*, *candida albicans*, *Saccharomyces cerevisiae* [6]. Israr et al. have reported antibacterial activity of ethanolic extract using Mueller–Hinton agar against gram bacteria's [7]. Banisalam et al. have reported antibacterial activity from chloroform, petroleum ether, methanol extract by comparing *in vivo* and *in vitro* systems. *In vivo* comparison was performed and two gram-negative bacteria namely *Escherichia coli*, *Pseudomonas aeruginosa*, and against two gram-positive strains against *Bacillus cereu* and *Staphylococcus aureus* using agar well diffusion method [8]. Anastasia et al. have reported antibacterial activity from extract against *Enterococcus faecal* [9]. Batubara et al. have reported antibacterial activity from essential oil extract plant against *Streptococcus mutans* by using microdilution method. The essential oil is diluted in DMSO to obtain a concentration stock of (10,000 $\mu\text{g/ml}$) and made it several concentrations added in well plates and also TSB medium and bacterial inoculant were added and this is incubated at 37 °C for 24 h and minimum inhibitory concentration was determined [10]. Silalahi et al. have reported antimicrobial activity against gram-negative bacteria namely *Salmonella paratyphi*, *Salmonella typhi*, *Vibrio parahaemolyticus*, *Vibrio minicus*, *E coli*, *Shigella* and gram-positive bacteria namely *Bacillus cereus*, *Bacillus magaterium*, *Bacillus subtilis*, *staphylococcus aureus*, *Sarcinlutea* [11]. Joyjamras et al. have reported antimicrobial activity from water and 95% ethanol extract of against *staphylococcus aureus* by agar diffusion method and minimal inhibitory concentration was determined by using microdilution method [12]. Handharyani et al. have reported antimicrobial activity from nanoparticle extract of *Curcuma zedoaria* Rosc to CRD (chromic respiratory disease) in chicken mainly infected by *Escherichia coli* and *mgalliseptiu* [13]. Rmwetal et al. have studied that methanol extract from leaves and petroleum ether extract of rhizome for its antimicrobial activity against gram-negative, gram-positive, bacteria and fungi *Staphylococcus aureus*, *Bacillus cereus*, *Bacillus magaterium*, *Sarcina lutea*, *Escherichia coli*, *Pseudomonas aeruginosa*, *salmonella typhi*, *Shigella boydi*, and fungi *candida albicans*, *aspergillus niger*, *Saccharomyces cerevaceae* were used for study [14]. Riyas et al. have reported active constituent of extract (β -Elemene) has potential antimicrobial effect and



also antitumor activity [15]. Cristiane et al. have studied antifungal activity of alcohol extract of plant against yeast of genus oropharyngeal candidiasis [16]. Batubara

et al. have reported teeth biofilm degradation activity test by checking antibacterial activity by using essential oil. It mainly deals with microdilution method by TSB medium

by synthetic saliva, 3% glucose and bacterial inoculant and it is incubated for 24 h at 37 °C and washed with phosphate buffer and absorbance is measured at 595 nm by using microplate reader [10].

Anti-venom activity

Lim et al. have reported anti-venom activity of extract of white turmeric. It inhibits activity effect on binding of anti-cobra antibody venom to antigen, cobra venom, in the modification of enzyme-linked immune sorbent assay (ELISA). Extract produces toxin activity extending concentration time of diaphragm muscle after envenomation and had a potency to protect cellular proteins from venom degradative enzymes [2]. Chaveerach et al. have reported antidote activity from extract of *C. zedoaria* Rosc against cobra antidote. The plant material collected and kept it for DNA extraction by TAB procedure and appropriate DNA concentration were determined by using UV (160A) and DNA was extracted by PCR with ISSR primers [17].

Anti-fertility activity

Nicolas Xavier Ongako et al. have reported anti-fertility activity from ethanol extract of *C. zedoaria* Rosc on seminiferous tubule cells in rat testis. They have observed decreases in number of spermatogenic cell layer and mitosis count in administration of white turmeric rhizome with p value < 0.05. Study has reported rhizome-containing curcumin has good anti-fertility effect in rats [18].

Hypotensive activity

Lim et al. have reported the hypotensive effect of *C. zedoaria* Rosc on endothelium in hypertensive rats and results were compared against Captopril as standard agent [2].

CNS depressant activity

Lim et al. have reported CNS depressant activity from extract of methanol of *C. zedoaria* Rosc. They have isolated germacrone, curzerenone and germacrone epoxide and investigated for its CNS depressant effect [2].

Insecticidal activity

Lim et al. have reported insecticidal activity of *C. Zedoaria* Rosc oil for its significant larvicidal activity against the two mosquito species [2]. Phukerd et al. have reported insecticidal activity of *C. zedoaria* Rosc against potential dengue vector mosquito. The results of investigation showed the highest larvicidal effect is due to the presence of essential oil [19]. Herika Line Marko De Oliveira et al. have reported insecticidal activity of *C. zedoaria* Rosc oil towards two mosquito species like

Anopheles dirus; it shows major vector in Thailand, and it showed highest susceptibility to zedoary oil [20]. Sutthanon et al. have reported larvicidal activity of *C. Zedoaria* Rosc essential oil by synthesizing silver nanoparticles against *Culex quinquefasciatus* [21].

Antihyperglycemic activity

Lim et al. have reported Antihyperglycemic activity of *C. zedoaria* Rosc methanol extract of leaf in dose-dependent manner in glucose-loaded mice. The methanolic extract of rhizome showed significantly reduced concentration of serum glucose in mice [2]. Juni Hand Ajani et al. have reported Antihyperglycemic activity of essential oil extract of *C. Zedoaria* Rosc in Streptozotocin-induced hyperglycaemic [22].

Antihyperlipidemic/antihypercholesterolemic activities

Lim et al. have reported hydroethanolic extract of *C. zedoaria* Rosc for its antihyperlipidemic activity, in experimental adult male rats at dose of 200/400 mg/kg [2]. Silalahi et al. have reported *C. zedoaria* Rosc extract at dose of 200–400 mg/kg was found to be effective in reducing total cholesterol level. They also reported cholesterol lowering action due to disrupting intestinal cholesterol absorption, increasing excretion of bile acid through its choleric effect [11]. Zarashenas et al. have reported antihyperlipidemic effect via decreasing the level of triglyceride (*in vitro* study) by the hydroalcoholic extracts of *c. zedoaria* rhizome [23]. Rahmawati et al. have studied the extracts of *C. zedoaria* Rosc for its antihypercholesterolemic effect [24]. Sara Tariq et al. have reported extract of *C. zedoaria* Rosc for its antihypercholesterolemic and antihyperlipidemic activities [25].

Anti-platelet activity

Kim et al. have studied the pharmacological effects of white turmeric in their investigation. They have studied the anti-inflammatory, antitumor, antibacterial, immunological activity, cytotoxic and antifungal activity. They also have studied the *in vitro* inhibitory effect in collagen, platelet activation factor (PAF)-induced platelet aggregation [26].

Antirolithiatic activity

Velu et al. have reported antirolithiatic activity of ethyl extract of *C. Zedoaria* Rosc with the help of *in vitro* single gel diffusion technique and by *in vivo* ethylene glycol-induced urolithiasis model assessed in Wistar rat. The extract of different concentrations was added to gel formed and decrease in crystal size was measured for 5 days using travelling microscope [27].

Anti-protozoal/antiamoebic activity

Lim et al. have reported *C. Zedoaria* Rosc rhizome extract against protozoan *babesia gibsoni* with IC_{50} value 41.7 $\mu\text{g/ml}$. The alcoholic extract of *C. zedoaria* root exhibited antiamoebic activity *in vitro* against *Entamoeba histolytica* strain NIH:200 [2].

Anti-ulcerogenic activity

Lim et al. have reported extracts of *C. Zedoaria* Rosc for its anti-ulcerogenic effect in stress-induced ulcer in mice. The n-hexane soluble fraction was found to be more effective than methanol soluble fraction. The effect was comparable to that of standard drug Omeprazole [2].

Hepatoprotective activity

Lim et al. have reported the sesquiterpenoids furanogermentone isolated from *C. Zedoaria* Rosc for its hepatotoxic activity in carbon tetrachloride-induced liver lesion in mice [2]. Marikawa et al. have studied the hepatoprotective effect of 80% aqueous acetone extract of *C. zedoaria* Rosc rhizome against D-galactosamine/lipopolysaccharide-induced acute liver injury in mice. They have reported potent protective effects of sesquiterpenes and curcumin from *c. zedoaria* rhizome in mice [29]. Dilpreet Singh has reported that essential oil obtained from *C. zedoaria* for its hepatoprotective activity and also they have compared bioavailability with that of conventional formulation [30].

Immunomodulatory effect

Faradilla et al. have reported that polysaccharide from *C. zedoaria* Rosc rhizome has good antitumor activity against sarcoma 180 cells and is able to increase macrophage activity *in vitro* at dose 300 mg/kg indicating its immunostimulatory effect [31].

Wound healing activity

Xu et al. have studied polysaccharides of *C. zedoaria* Rosc for its wound healing effects on a diabetic rat model with platelet-rich plasma exosomes assembled on chitosan/silk hydrogel sponge [33].

Cardiotonic activity

Zershenas et al. have reported cardioprotective of isolated compound of *C. zedoaria* Rosc. They have isolated Zingiberene, 1,8 cineole, camphor, camphene and borneol and also investigated for potent cardiotonic effect [23].

Antiviral activity

Lakshmi Narayanan Venu et al. have isolated Germa-crone and Curcumin from *C. zedoaria* Rosc. rhizome and studies for antiviral activity against H_1N_1 , HSV-1 which showed good antiviral potentials [36].

Anti-diarrhoeal activity

Md. Golam Azam et al. have induced diarrhoea by castor oil in mice and they investigated that the onset of diarrhoea was significantly prolonged by administration of ethanol extract of leaves of *C. zedoaria* Rosc in dose-dependent manner in 3 h and amount of stool was also decreased by ethanolic extract as compared to control animal [37].

Antipyretic activity

Gina Batoy Barbosa et al. have studied the ethanol extract of white turmeric for its antipyretic effect using the Brewers yeast administered fever inducing method and results of investigation suggested that extract showed good antipyretic effect [38]. Md. Golam Azam et al. have studied the ethanol extract of white turmeric decreases the yeast elevated body temperature in short period of time, when compared with control group. The plant extract at concentration of dose 500 mg/kg shows with $P < 0.01$ value at 2–3 h. The results of study were with Paracetamol standard in the treated animals [37]. Marina Silalahi et al. have reported the antipyretic effect of ethanolic extract of in yeast-induced body temperature in rats in dose-dependent manner at dose 750 mg/kg and it was compared with Paracetamol as standard [11]. Gina Batoy Barbosa et al. have reported the antipyretic effect of ethanolic extract in yeast administered fever inducing method on rats and it was compared with standard antipyretic agent Paracetamol [38]. Lim et al. have reported the antipyretic effect of ethanolic extract of Rhizome in the yeast-induced body temperature in rats by dose-dependent manner at a dose 750 mg/kg and it was compared against standard Paracetamol as antipyretic agent [2].

Antiproliferative activity

Heshu Sulaiman Rahman et al. have studied the zerumbone an isolated compound from white turmeric rhizome for its both *in vivo* and *in vitro* anticancer activity. The reported the good antiproliferative activity of studied compound [39]. Prati Bajracharya et al. have studied the effects of chloroform soluble fraction of white turmeric on normal myometrial and leiomyomal cells proliferation. The stained, normal myometrial and

leiomyomal cell proliferation was inhibited by treatment with extracted components [40].

Analgesic activity

Marina Silalahi et al. have studied analgesic effect of ethanolic extract of white turmeric. The mild analgesic effect has been reported on the basis of writhing inhibition. They also have investigated ether extract of rhizome, leaves and stems with moderate analgesic activity based on writhing inhibition method [11]. Lim et al. have studied analgesic effect of methanolic extract of white turmeric rhizome using acetic acid-induced writhing assay. They have also investigated petroleum ether extracts of rhizome, leaves and stem for its moderate analgesic activity with writhing inhibition assay [2].

Anti-inflammatory activity

Arif Ullah et al. have studied anti-inflammatory effect of ethanolic extract of *Curcuma zedoaria* Rosc against carrageenan-induced inflammation in rat paw model. Diclofenac sodium was used as standard agent and compared against control groups [41]. Marina Silalahi et al. have studied anti-inflammatory effect of petroleum ether and chloroform extract of rhizomes of *Curcuma zedoaria* Rosc. The results of investigation showed that test samples showed $P < 0.001$ when compared to standard drugs with respect to its anti-inflammatory effect. The petroleum ether extract at 200 mg/kg and chloroform extract at 400 mg/kg showed maximum anti-inflammatory effect [11]. Angel et al. have studied anti-inflammatory activity of extract of *Curcuma zedoaria* Rosc in rats. In their study, they have administered 0.1 ml of 1% w/v solution of carrageenan on right hind paw and the inflammation assessed as difference between zero-time linear circumference of injected paw, percentage of inhibition of oedema were calculated. The anti-inflammatory effect of extract was evaluated as degree of oedema inhibition [42]. Moshiur Rahaman et al. have studied anti-inflammatory activity of methanolic extracts of white turmeric *C. Zedoaria* Rosc in albino rats. The results of investigation were compared with standard drug indomethacin [43].

Antioxidant activity

Sudipta et al. have investigated antioxidant activity of essential oil of extracts obtained from rhizomes of white turmeric using DPPH, ABTS and reducing power assay by scavenging method [3]. Atiqur Rahman et al. have investigated oil extracted from leaves of white turmeric for scavenging activity of DPPH radical method [45]. Omer Abdalla Ahmed Hamdi et al. have reported antioxidant activity of *Curcuma Zedoaria* Rosc by oxygen radical antioxidant capacity assay method by using

quercetin as standard agent [34]. Angel et al. have reported antioxidant activity of *Curcuma zedoaria* Rosc by measuring DPPH free radical scavenging activity and ferric reducing power [42]. Woo-Young Cho et al. have studied extract of *Curcuma zedoaria* Rosc for its antioxidant activity by measuring free radical scavenging activities, nitric oxide (NO) levels and activity determined by measuring inducible nitric oxide synthase (INO's) and cyclooxygenase-2(COX-2) expression in lipopolysaccharide (LP's) stimulated RAW 264.7 cells [46]. Lim has studied antioxidant activity of hydroethanolic extract of *Curcuma zedoaria* Rosc using DPPH scavenging assay method employing ascorbic acid as standard [2]. Sumathi et al. have studied radical scavenging activity extract of *Curcuma zedoaria* Rosc using DPPH, ABTS, hydrogen peroxide and inhibition by nitric acid and superoxide generation method. The results of investigation showed that extract is having potent antioxidant activity [47]. Zeeshan et al. have investigated scavenging and reducing activity of isolated compound of *Curcuma zedoaria* Rosc against 2,2-diphenyl-1-picrylhydrazyl (DPPH) [48].

Anticancer/antitumor activity

Lakshmi et al. have reported anticancer activity of isolated compounds from white turmeric against human leukaemia, lung, murine lymphoma and nasopharyngeal carcinoma by [49]. Wiwik Susanah Rita et al. have investigated *in vitro* anticancer testing of essential oil extracted from rhizome against myeloma cells. They have investigated α -pinene, camphene, 1, 8-sineol, camphor, 1-ethyl-1methyl-2,4bis (1-methyl ethylene) cyclohexane, furanodiene and germacrone against murine myeloma cells [50]. Marina Silalahi et al. have reported anticancer activity of hexane and dichloromethane against four cancer cell lines (caski, MCF-7, PC-3&HT-29) [11]. Yujin Shin et al. have studied anticancer activity of rhizome of white turmeric on ovarian cancer by activation of mitochondria from cytotoxic activity. The results of their investigation showed that polysaccharides and protein bound polysaccharides of white turmeric are responsible for growth inhibition of sarcoma [51]. Chandrashekhar Singh et al. have studied the cytotoxic effects of rhizome of white turmeric, on human and murine cancer cell and evaluated its tumour reducing properties *in vivo* mice models. The investigation of study also suggested that Isocurcumenol was active component from white turmeric responsible for inhibition of proliferation of cancer cell, *in vivo* tumour reductions at dose of 35.7 mg/kg bw [52]. Eun Bee Jung et al. have studied methanolic extract of white turmeric on cancer cells viability and protein expressions related to apoptosis. The results of their investigation suggest that extract mainly suppresses the cell proliferation in dose-dependent manner. They have

also performed cell viability assay on human hepatoma HePG₂ cells and human breast cancer cell MCF-7 [53]. Prosanto Pal et al. have investigated anticancer activity of methanolic extract of white turmeric against Ehrlich's carcinoma cell line in Swiss albino rat. They have used trypan blue and MIT assay method (*in vitro*) and *in vivo* activity was performed by using EAC cells-induced mice at dose 100 and 200 mg/kg bw, and dose-dependent cytotoxicity observed in ($P < 0.05$) [54]. Romen Meitei Lourebam et al. have investigated ethyl acetate extract of white turmeric on MDA-MB231 breast cancer cell line with help of MTT assay technique and mechanistic pathway was established with confocal microscopy, western blot technique, wound healing migration assay and cell cycle analysis and reports of their investigation proved that ethyl acetate extract is effective against breast cancer cell line [55]. TaeKyoung Lee et al. have studied cytotoxic effect of methanolic extract of white turmeric against gastric cancer AGS cells lines. In this study, they have also investigated sesquiterpenes compounds (10-epoxide, curcumenol-9 and curcuzedoalide and 12 known sesquiterpenes) which are mainly isolated from extract against human gastric cancer cells lines [56]. Shaikh et al. have studied aqueous extract of white turmeric against DMBA (7,12-Dimethylbenz anthracene)-induced mammary carcinoma in female Wister albino rats. The result of investigation showed that administration of test drugs at dosage of 5 mg/kg bw exhibited enhanced anticancer effect when compared with standard drug paclitaxel at dose 1 mg/kg bw [57]. Devi RosmySyamsir et al. have reported anticancer effect of pentane extract of white turmeric against various human cancerous cell lines such as breast (MDA-MB and MCF 23.1) lung (A549 and SK-LUL1) and cervical (Hela S3 and Siha) [58]. Quan-Qian Mao has reported that Curcuzedoalide isolated from white turmeric showed inhibition of cell proliferation in AGS cells induces apoptosis [59]. Tomas Zarybnicky et al. have reported Germacrone a natural molecule extracted and isolated from white turmeric for its anticancer activity against breast cancer, liver cancer and glioblastoma cell [60].

Conclusions

The present review concludes that white turmeric is one of the very important traditional herbal medicines. Traditionally, plant and its extracts have been used for management of various illnesses in human beings. Various parts of plant have been reported for the presence of complex phytoconstituents which include curcumin, ethyl p-methoxycinnamate, β -turmerone, β -eudesmol, zingiberene, dihydrocurcumin, furanodiene, α -phellandrene, 1-8 cineole, β -elemene and germacrone. The reports on scientific validation of white turmeric on

its biological and other pharmacological effects showed that plants have good number of biological activities which include antimicrobial, anticancer, analgesic, antipyretic, antiviral, antioxidant, wound healing, anti-inflammatory, insecticidal activity and cardioprotective activities.

Abbreviations

DMBA: 7,12-Dimethylbenz anthracene; GER: Germacrone; ORAC: Oxygen radical antioxidant capacity; P: Statistical analysis.

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Authors' contributions

We have assured that "all authors have read and approved the manuscript". All the authors have equal contribution and participation in this review work. SG has reviewed all manuscripts on *Curcuma Zedoaria* Rosc. SH has collected the data from various journal sites. PK has helped in the paraphrasing and typing the review. KG has helped in the data collection on pharmacological activities of plant. MP has guided and supported in the article corrections and modifications. SS has corrected and modified document along with framing of objectives of the work. All authors read and approved the final manuscript.

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Availability of data and materials

The review work has been carried out by us, and we assure you that it can be provided to you whenever required.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

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Competing interests

Not applicable.

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