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Phytochemical and pharmacological activities of *Tagetes erecta* L: An updated review

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Abstract

Different plants have played different roles in our life and are frequently used in food and medicinal purpose. Generally, leaves, stems, roots, and bark are among the components of plants that have received the most attention as medicine. However, flowers are largely considered for ornamental purposes and overlooked as medicine. Considering this, *Tagetes erecta* L. (Family Asteraceae) has a long history of usage in Indian tradition. In Ayurveda, the flower is used as carminative, astringent, stomachic and to treat liver problems, fever, epileptic fits and scabies. Worldwide, more than 53 species of this plant contain several chemical compounds, of which oxy carotenoid lutein has received considerable attention. Plant demonstrates a variety of pharmacological activities ranging from anti-microbial, insecticidal, Mosquitocidal, nematocidal, wound-healing, anti-oxidant to analgesic. Despite the presence of various tannins, glycosides, flavonoids, alkaloids, the plant has not been explored to its full potential. This review enumerates different aspects of this important plant enabling further research.

Keywords: *Tagetes erecta* L., lutein, marigold, pharmacology

1. Introduction

India has a rich heritage of Ayurveda, Unani and Siddha systems of medicine containing enumerated plants to cure illnesses. Natural chemicals generated from plants, such as flavonoids, terpenes, and alkaloids, have drawn a lot of focus lately because of their diverse array of pharmacological qualities, which include cytotoxic and cancer-preventing actions. Herbal medicines have gained in popularity as phytochemistry, the study of plants, has advanced dramatically in recent years. Compounds from plants are essential for the treatment of cancer. Many different types of medicinal plants that are employed in conventional medical operations can be found on the Indian subcontinent. The Indian medical systems have long been viewed as a valuable source of information by many Westerners [1]. The indigenous healthcare delivery method treats diseases with infectious origins using a wide range of plant species and naturally derived chemicals from plants [2]. Secondary metabolites are the active ingredients in a large number of plant-based medications [3-4]. Plants contain a plethora of phytoconstituents like alkaloids, steroids, tannins, phenols, flavonoids, resins, fatty acids, and gums that may have numerous physiological impacts on the body. Using herbs as antibacterial sources was primarily motivated by the growing drug resistance of human ailments against commonly used antibiotics [5-6]. Although *Tagetes erecta* L. (Asteraceae) is an ornamental and medicinal plant, numerous people use it for a variety of purposes including medicinal, aesthetic, and nematocidal. Antioxidants can be found in the floral essential oil. Although marigolds come in a variety of hues, the most popular ones are yellow and orange. Even though most *Tagetes* species have unpleasant, overpowering odors, they are generally highly useful in aesthetic treatments. Today, there are numerous species of the genus *Tagetes* [7].

2. Taxonomical Classification

Tagetes erecta belong to the genus is a strong, branching herb that has spread to other tropics and subtropics, including India and Bangladesh indigenous to Mexico and other hotter parts of the United States. Genus: *Tagetes* Species: *erecta*. This plant is commonly called as 'Genda' in Hindi and 'Sandu' in Sanskrit language [8, 10].

3. Other important species of *Tagetes*

Marigold (*Tagetes erecta*) plant originated in Asia's tropical regions. Around the world, as many *Tagetes* species have been recognized.

Worldwide, there are more than 53 known species, including, *Tagetes minuta* L., *Tagetes biflora* Cabrera, *Tagetes minima* L., *Tagetes apetala* Posada-Ar, *Tagetes terniflora* Kunth, *Tagetes parryi* A. Gray, etc [9].

4. Cultivation and economic value

We refer to *Tagetes erecta* as "Marigold Flowers". Inflorescence are not just utilized as colour and spice; they may also be consumed. The flower's yellow dye can be used in place of saffron to colour and flavour dishes. This could be an allusion to the flowers' use as food colouring. In most temperate regions, the resilient annual herb marigold, which is native to Southern Europe, thrives. Inconspicuously wavy or coated in microscopic hairs, the leaves and stems may have serrated leaf edges. One to five feet is the maximum height of the plant. Their lance-shaped, mid-green leaves have an average diameter of 5 cm, a maximum height of 50 cm, and a range in size from 5 to 17 cm. The best marigolds in the world, according to popular opinion, are grown in India. Marigold flowers are exported from India to affluent nations including Japan, Sri Lanka and Iran, the nations of North Africa, the US, and the UK. Most marigolds are grown on the country's southern peninsula. The two Indian states that produce the most marigolds are Andhra Pradesh and Uttar Pradesh, with Tamil Nadu coming in third.

The states with the most land that is covered in marigolds are Andhra Pradesh, Tamil Nadu, Kerala, Orissa, Maharashtra, Karnataka and Uttar Pradesh. There are numerous *Tagetes* plants that are used commercially as foods, spices, pigments, medications, and decorative items. The countries with at least 50 species each per square kilometre include India and Thailand. In order of having at least 50 species each are India, France, Mexico, Africa, Bangladesh and India. The primary commercial species of *Tagetes erecta* has spread its flowers to China, Sri Lanka, Jamaica, and Peru. India's biggest marigold producer and most significant marigold trading hub are both

located in the southern Indian state of Tamil Nadu's city of Erode [11].

5. Macroscopic characteristics

The inflorescence of *Tagetes erecta* has a pleasing aroma, brilliant colours, and a mildly bitter flavour. It is 3 to 5.5 mm thick and 2 to 3 cm long. The calyxes are ovate and dark green, and the bloom is vivid orange [12, 13].

6. Transverse section of flower

There are cortical pieces and fibrovascular bundles in the transverse section of the calyx. The cells are tightly spaced and rectangular in the cortex. Veins, epidermis, and a vein that passes through the semen part are all apparent in the transverse portion of the corolla [12, 13].

7. Chemical constituents

T. erecta, a plant species, has been subjected to phytochemical analysis, revealing numerous chemical components, including triterpenoids, carotenoids, flavonoids, and thiophenes. The plant comprises phenolics, syringic acid, quercetin, and a quercetagenin glucoside [14], vinyl, ethyl gallate and quercetin [10, 11]. Lutein, a xanthophyll, the primary pigment found in *T. erecta* and has two cyclic end groups and a C-40 isoprenoid structure [17]. Other carotenoids identified in the flower include zeaxanthin, violaxanthin, neoxanthin, phytoene, and phytofluene. Using silica gel column chromatography to fractionate ethanol extract, 22 components were identified, including erythrodiol-3-palmitate, daucosterol, 7-hydroxysitosterol, 3-galactosyl, syringic acid, lupeol, erythrodiol, and, syringic acid, kaempferol, gallic acid, quercetagenin, quercetagenin-7-methylether, n-hexadecane, palmitin, ethylene glycol linoleate, and 7-megastigmadien-9-one. GC-MS detected 18 active compounds, including terpenoids, suggesting potential antioxidant, antimycotic, and analgesic effects [18-21].

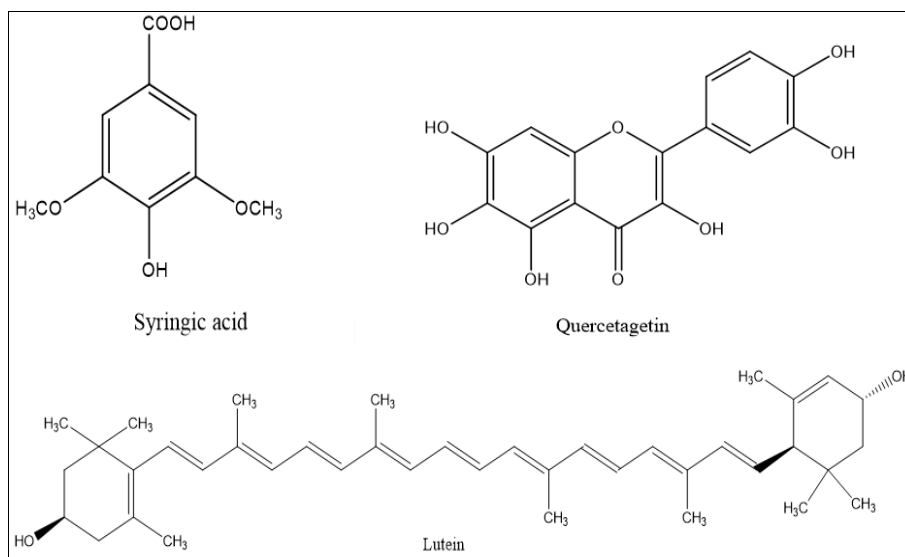


Fig 1: Chemical constituents

8. Traditional uses [17]

1. For treating various skin issues such as inflammation caused by infections or physical damage like ulcers, *Tagetes* is an exceptionally beneficial herb for varicose veins, mastitis, sebaceous cysts, anal fissures, impetigo, haemorrhoids and other cutaneous ailments.
2. Marigold, known as *Tagetes*, is thought to offer benefits as a topical remedy for minor skin issues like sunburn

and broken capillaries. There is also a belief that the sap extracted from its stem may be effective in the removal of corns, warts and calluses.

3. Macer noted that observing a *Tagetes* plant could improve vision and uplift mood.
4. In South Asia, the vibrant yellow and orange *Tagetes* flowers are commonly employed to adorn religious landmarks and structures, as well as to create garlands.

- Furthermore, they serve as gifts and decorative elements at weddings, memorial services, and various other events.
5. Pigments derived from *Tagetes* are extracted and put to use as food dyes for both people and animals.
 6. *Tagetes* leaves possess medicinal properties that make

them suitable for treating wounds, ulcers, piles, kidney problems, and muscle soreness. Additionally, powdered *Tagetes* leaves are applied topically to address boils and carbuncles.

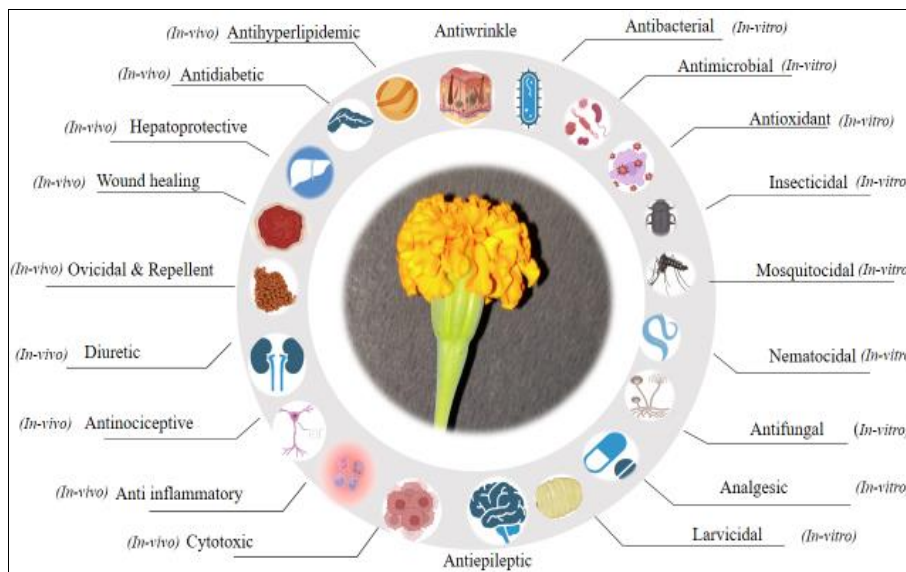


Fig 2: Different activities of *Tagetes erecta* L

9. Pharmacological activity [22]

Table 1: Different pharmacological activities of *Tagetes erecta* L

Sr. No.	Activity	Study findings	In-vitro/in-vivo	Models/Assay	Reference
1	Antibacterial activity	Patulitrin, a flavonoid, has been found to have antibacterial activity against <i>Klebsiella pneumoniae</i> strains, exhibiting the highest zone of inhibition of 29.50 mm.	In-vitro	By Disc diffusion assay	[23]
2	Antimicrobial activity	Of the extracts tested, 71% showed antibacterial activity against the NG strain susceptible to antibiotics, while 10% were found to inhibit the penicillinase-producing NG strain GC1-182. The flower components of <i>T. erecta</i> were found to be particularly effective at inhibiting the NG strain.	In-vitro	By disc susceptibility assay.	[24]
3	Antioxidant activity	<i>Tagetes erecta</i> exhibits higher reducing power, superior superoxide anion scavenging activity, and greater DPPH antioxidant activity. In vitro models, ethanolic extract has antioxidant properties.	In-vitro	DPPH, reducing power and super oxide radical scavenging activity	[25]
4	Hepatoprotective activity	Following the administration of 400 mg/kg of <i>T. erecta</i> 's ethyl acetate fraction orally, rats exhibited a return to normal levels of bilirubin and other serum marker enzymes. Additionally, signs of recovery were observed in the liver following the injection of 400 mg/kg of EATE extract and carbon tetrachloride (CCl4). It's worth noting, however, that the ethanolic extract caused an increase in the levels of bilirubin, ALP, ALT, and AST in the bloodstream	In-Vivo	By carbon tetra chloride induced hepatopathy model	[26]
5	Insecticidal activity	Subsequent to petroleum ether and the ethanol extract fractions, it was observed that the chloroform fraction displayed the most significant toxicity to both larvae and adults of <i>Tribolium castaneum</i> . No fatalities were observed. This suggests that in <i>T. erecta</i> flowers, <i>Tribolium castaneum</i> may possess resistance to certain pesticide.	In-vitro		[27]
6	Mosquitocidal activity	The chloroform soluble fractions demonstrated the maximum toxicity for all instar larvae of <i>Cx. Quinquifasciatus</i> Having effective mosquito-repelling properties are <i>Tagetes erecta</i> flowers.	In-Vivo		[28]
7	Nematocidal activity	For the management of <i>M. incognita</i> , <i>T. erecta</i> was identified. Okra's plant development characteristics were greatly enhanced by all leaf amendments at various dosages, and the number of root knot infections was decreased when compared to the untreated control.	In-vitro		[29]
8.	Wound healing activity	The presence of flavonoids in hydroalcoholic extracts may account for their improved wound healing activity by speeding up the healing process.	In-Vivo	Burn wound model, Excision wound model in albino mice.	[30]
9.	Analgesic and	Significant analgesic and dose-dependent (at 100 and 300 mg/kg)	In Vivo	Acetic-acid induced	[31]

	antioxidant activity	antioxidant potential was discovered by the investigation.		abdominal writhing	
10.	Larvicidal activity	<i>Tagetes erecta</i> is an excellent source of chemicals with larvicidal activity against <i>Aedes aegypti</i> , with higher levels of larvicidal thiophene found in both the roots and petals.	<i>In-vitro</i>	Analysed by high-performance liquid chromatography analysis.	[32]
11.	Anti-hyperlipidemic activity	In rats, <i>T. erecta</i> extracts successfully lowered all hyperlipidemic indicators, according to the study. Doses of 200 and 400 mg/kg of <i>T. erecta</i> hydroalcoholic extract	<i>In-Vivo</i>	Animal model used	[33]
12.	Anti-diabetic activity	After 30 minutes of administration of <i>T. erecta</i> extracts, glucose levels increased, and a hypoglycemic effect was only evident after 120 minutes.	<i>In-Vivo</i>	Diabetic model	[22]
13.	Anti-epileptic activity	<i>Tagetes erecta</i> ethanolic extract was tested in various <i>in-vivo</i> models, including sleep-induction, convulsion, locomotor activity, and behavioral tests. The extract exhibited antiepileptic properties, but caution is advised when using it for epilepsy treatment, as it may potentially lower the seizure threshold in patients, increasing the risk of seizures.	<i>In-Vivo</i>	Animal model	[34]
14.	Cytotoxic activity	Lutein was isolated from <i>T. erecta</i> rhizomes and <i>In vitro</i> studies on its cytotoxic action against Hep 2 cancer cell lines showed that cell survival was more than 97% at 0.078 mg/ml, indicating that it was less harmful for investigation.	<i>In-vitro</i>	Quantified by TLC and HPLC	[35]
15.	Anti-inflammatory activity	In mice treated with the extract, pain brought on by the acetic acid writhing response was lessened (100, 200, 400 mg/kg).	<i>In-Vivo</i>	Rat paw model	[36]
16.	Antinociceptive activity	<i>T. erecta</i> extract, when injected with 1% v/v acetic acid of 0.1ml for 60 minutes, decreased the quantity of abdominal contractions ($p < 0.05$) in contrast to the control group, which got 0.3 ml of normal saline.	<i>In-Vivo</i>	Chemical induced (Acetic acid) writhing method	[37]
17.	Ovicidal and repellent activity	To extract <i>T. erecta</i> leaves with ethyl acetate, acetone, and methanol for their possess ovicidal, repellent, and oviposition-deterrent properties against the malaria vector.	<i>In-Vivo</i>	Oviposition-deterrence assay	[38]
18.	Anti-fungal activity	Fungal strains used were <i>Candida albicans</i> along with <i>Aspergillus niger</i> as well as <i>Aspergillus flavus</i> and <i>Penicillium chrysogenum</i> against Amphotericin B and fluconazole as positive controls showed good efficacy as it increased zone of inhibition diameter.	<i>In-vitro</i>	By disc diffusion method	[39]
19.	Anti-Cancer activity	5-fluorouracil used as control showed IC50 value in concentration 125µg/ml in which breast cell line (MCF-7) were used.	<i>In-vitro</i>	By cytotoxicity assay	[39]
20.	Diuretic activity	Oral administration of hydroethanolic extract (HETE) at low dosages of 0.01, 0.1, and 1 mg/kg resulted in diuretic effect, increased urine volume, and increased excretion of NA ⁺ in both male and female NTR and SHR.	<i>In-Vivo</i>	Animal model	[40]
21.	Anti-wrinkle agent	The methanol extract significantly ($^a p < 0.05$) inhibited hyaluronidase and elastase with IC50 values of 11.70±1.79 µg MI (-1) and 4.13±0.93 g mL (-1) and better inhibited MMP-1 than standard oleanolic acid.	<i>In-vitro</i>	By RP-HPLC activity	[41]

10. Toxicity profile

According to one study, marigold extract's lutein (Flora GLO) is safe to consume. In a 13-week study and a 4-week pilot research, the product's safety assessment identified no clinical symptoms or negative consequences connected to lutein consumption during the trial [42]. Human studies revealed that taking lutein supplements for a year at a dose of 30 mg/day had no negative effects on subjects, but did increase serum lutein levels and macular pigmentation [43]. The safety of supplementing pure lutein and its marigold ester for four and thirteen weeks was studied, respectively. There are lutein and its ester in natural sources. Additionally, lutein and its ester may interconvert after being absorbed. Ester-free lutein is more readily available than lutein and absorbed effectively in the intestinal villi.

In this study, biochemical and histological parameters were evaluated to assess the toxicity of the two forms. There has never been an attempt to compare the toxicity of lutein and ester. Rats were determined to be safe when given these two

versions at different doses, which ranged from 4 to 400 mg/kg. The idea that adding them to one's diet won't affect internal organs is confirmed by the doses we used, which are 20-2000 times higher than the daily recommended quantity [44]. Previous studies revealed that the *Tagetes erecta* flower's ethanol extract's chloroform fraction was physiologically more active than the flower's ethanol extract or petroleum ether fraction [18]. The results of this investigation show that the chloroform fraction is not acutely harmful to rats, supporting the use of *Tagetes erecta* flowers in conventional medical practices. Additional long-term toxicological studies (Chronic toxicity) are needed before it may be approved as a therapy [45-46].

11. Clinical trials of *Tagetes erecta* [47]

The following includes a list of all recent clinical trials conducted on *Tagetes erecta* with reference to and was compiled as "*Tagetes erecta*" on the official website "clinical trials. Gov." and "PubMed".

Table 2: Clinical trials reported on *Tagetes erecta* L

S. No.	Study title	Conditions	Interventions	Phase	NCT No
1.	Depression Symptoms: An Online Positive Emotion Skills Intervention	Depression and Psychological Stress.	Behavioural: Positive Affect Skills training, Behavioral: 5-week Emotion Reporting	NA	NCT02861755
2.	Marigold study:-A study of RO4917523 versus placebo as adjunctive therapy in patients with major depressive disorder and an inadequate response to ongoing antidepressant therapy	Clinical depression	Drug was Placebo, Drug taken RO4917523 with dose of 0.5 mg Drug was RO4917523 with dose of 1.5 mg	Phase 2	NCT01437657
3.	Online Positive on Emotion Skills Intervention for Symptoms of Depression	Depression and Psychological stress	In behavioural changes positive effect on skills training	NA	NCT01964820
4.	Study of Adjunctive Ganaxolone Treatment in Children and young adults with Cyclin-dependent kinase-like 5 deficiency disorder	Cyclin-dependent kinase-like 5 deficiency disorder	Drug 1: Ganaxolone Drug 2: Placebo	Phase 3	NCT03572933
5.	Trial Comparing <i>Calendula officinalis</i> with aqueous cream" Essex" to treat skin reactions of PORT Breast cancer	PORT Breast Cancer	Drug: Calendula Weleda cream (Weleda AG, Sweden) contains extracts of marigold plant (10%), wool fat and sesame oil Drug: Essex® cream (schering-plow), without parabens	Phase 3	NCT01688479
6.	Morpho-functional changes after oral supplementation of anti-oxidants and anti-inflammatory treatment in age-related macular degeneration	Dry AMD	Other: Macuprev Group Other: Placebo Group	NA	NCT03919019
7.	Efficacy of safety study of Dietary supplements in Chronic smokers having hyperlipidemia	Chronic Smokers and Hyperlipidemia	Other: Placebo Dietary Supplement of BioTurmin Dietary Supplement: BioTurmin-WD Dietary Supplement: MaQxan (<i>Tagetes erecta</i> flower extract)	NA	NCT02100202
8.	Mobile peer support for OUD Recovery	Opioid use disorder	Behavioral: Mobile Phone App	NA	NCT05405712
9.	To find out if set dance is beneficial for Parkinson's patients, a randomized controlled feasibility experiment	Parkinson's Disease	Intervention group	NA	NCT01757509
10.	Effects of Bend beauty's anti-aging formula on Inflammatory markers	Inflammation and Skin disorder, Skin Pigment Inflammatory Response of Skin Inflammation	Dietary Supplement was Anti-Aging Formula Dietary Supplement was Fish Oil Other was Inert Placebo	NA	NCT03862872
11.	Following up on the brain in patients with myotonic dystrophies for five years	Myotonic Dystrophy 1, 2	Medical history Neurological clinical examination Neuropsychological testing Brain MRI	NA	NCT02729597
12.	Multicenter Observational Study of Myotonic Dystrophy: 1	Myotonic Dystrophy Type 1	-	NA	NCT02308657
13.	OPTIMAS (Optimal timing of Anticoagulation after acute Ischaemic Stroke) A Randomised Controlled Trial	Stroke and Acute Atrial Fibrillation	Direct oral anticoagulant (DOAC)	NA	NCT03759938

12. Conclusion

According to the review of the literature, *T. erecta* is a significant source of numerous pharmacological and therapeutic benefits. In the foreseeable future, there is a tonne of room for research as a source of beneficial phytochemical compounds for the pharmaceutical business. Each species has unique flowers and leaves that vary in colour, size, and shape yet all have tremendous therapeutic significance. Researchers will benefit from a better understanding of the plant and its functions, which will also change the way people think about flowers in the future.

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