Ethno-pharmacological Aspects of *Tagetes erecta*: A Review

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Abstract: The attractive flower *Tagetes erecta* has demonstrated therapeutic potential over the past two decades. Despite the fact that there are several indications for its use, controlled studies are required to ascertain its true efficacy. In this article, the *Tagetes erecta* plant, its characteristics, mode of action, and clinical applications are briefly described. One source of polyphenol bioactive chemicals with intriguing qualities and potential to treat chronic diseases is *Tagetes erecta* flowers. Marigolds come in a variety of varieties, and they are used for a variety of therapeutic purposes, including antibacterial, antidepressant, larvacidal, insecticidal, antimycotic, mosquitocidal, and nematicidal.

Keywords: Tagetes erecta, Genda, Phytochemical screening, Chemical constituent, Pharmacological activity.

INTRODUCTION:

The chemical components found in herbal plants are abundant and can be used to produce pharmacological effects. It's typical to find marigolds in gardens. *Tagetes erecta*, a member of the Asteraceae family and widely known as "Genda phool," is the botanical name for the medicinal plant marigold. Mexican marigolds are widespread ornamental plants with vivid yellow and orange colouring that are indigenous to several nations, including Mexico, America, and India (Burlec et al. 2021). As a flower, *Tagetes erecta* species are found in countries like India, China, Sri Lanka, Indonesia, Jamaica, and Peru (Y. Singh, Gupta, and Kannojia 2020). Around the world, *Tagetes erecta* is grown as a crop, and its flower is used for both social and religious purposes (Thorat and Shirote 2019). It is a typical garden plant with uses in herbal treatments. Every component of the *Tagetes erecta* was utilised to treat various ailments (Siddhu 2014).

For pharmacological response, *Tagetes erecta* is employed in both ayurveda and allopathic systems of treatment. The word Tagetes is derived from the Etruscan name Tages. There are numerous species found there, including those known as Mexican Marigold, Aztec Marigold, and American Marigold. The most widely grown kind is the African marigold (Gong et al. 2012). According to Ayurveda, *Tagetes erecta*'s flower juice can be used to cure bronchitis, rheumatism, and colds by cleansing the blood. Marigolds come in a variety of varieties, and they are used for a variety of therapeutic purposes, including antibacterial, antidepressant, larvacidal, insecticidal, antimycotic, mosquitocidal, and nematicidal. Additionally, the *Tagetes erecta* flower is used to treat fever (Singh, Mrinal, and Thakur 2019). Aqueous tagetes erect extract was used in Central America to wash the bodies after a death to impart its enticing and powerful smell (Burlec et al. 2021). The herb tagetes is quite good at reducing skin irritation and inflammation, whether it is brought on by an infection or physical trauma (Priyanka and Navneet 2013). Thiophenyl moieties have been found in the Tagetes genus, and several thiophenes, including 5-(but-1-ol-3-ynyl)-2,2-bithienyl, have been described by researchers (Tripathi et al. 1992). Thienyl moieties like -terthienyl have also been found in *tagetes erecta* "hairy root" cultures (Gupta et al. 2012).

Taxonomic Classification (Gopi, Elumalai, and Jayasri 2012)**:**

Kingdom	Plantae
Subkingdom	Tracheobionta
Division	Magnoliophyta
Class	Magnoliopsida
Order	Asterales
Family	Asteraceae
Genus	Tagetes
Species	*Tagetes erecta*

VERNACULAR NAME (Y. Singh et al. 2020)**:**

LANGUAGE	**Name**
Sanskrit	Sandu
Hindi	Genda
Punjabi	Tangla
Malayalam	Chendumalli
Urdu	Genda
Gujarati	Guliharo
Bengali	Genda

Cultivation and collection of *Tagetes erecta*:
Native to South and Central America, particularly Mexico, marigold is an annual herb. In places with tropical climates like China, India, and Asia, it is widely cultivated. Temperatures between 20°C and 30°C are required by the plant. The *Tagetes erecta* plant can reach a height of 50–80 cm. The leaves range in size from 5 to 17 cm, are lanceolate, and are mid-green (Y. Singh et al. 2020). Light orange, deep orange, golden yellow, and bright yellow are the colours of these types' flowers, which can range in size from 4 to 6 cm (diameter). Marigolds must be grown in well-drained, fertile, sandy loam soil with a pH of 7.0 to 7.5. The three seasons of rainy, winter, and summer are the easiest times to cultivate marigolds (R. Singh et al. 2020). Plants can be multiplied through seeds or cuttings. The seeds are sown in nursery beds in. When March is halfway through, after seeding and seedlings, the seed germinates in 5-7 days (Parashar et al. 2021). After a month, plant the seeds with a 40-by-30-cm spacing in fields.Depending on the soil and season, irrigation should be given every 7 to 8 days. Additionally, nitrogen, potassium oxide, and phosphorus anhydride fertiliser were administered in accordance with plant needs. At the beginning of June, buds begin to form, and a few weeks later, flowers appear. The three-month blooming period ends at the end of October. Depending on the cultivar, the flowers are harvested when they reach their maximum size (Parashar et al. 2021) (Lin, Lee, and Chang 2014).

Phytochemical constituents:
The chemicals that plant produce as part of their defence against infection, pathogens, and microorganisms are known as phytochemical components. The plant's scent and colour depend on a few chemicals. These substances have a positive impact on the treatment of many illnesses (Harborne 1998). The secondary metabolites and key chemical components of plants, including terpene, essential oil, flavonoids, carotinoids, sesquiterpenes, tannin, and sterol, all play a role in how they respond pharmacologically (Gong et al. 2012). Methanolic extract of *Tagetes erecta* contain almost 50 chemical constituents such as quinic acid, quinic acid hexoside, dihexoside, galloyl hexoside, shikimic acid hexoside,theogallin, phenylalanine, syringic acid-hexoside, methyl-gallic acid, digalloyl-hexoside, tryptophan, digalloyl-hexoside ii, syringic acid-hexoside ii, digalloyl-dihexoside ,digalloyl-hexoside iii, galloyl-syringic acid-hexoside i, chlorogenic acid, galloyl-syringic acid-hexoside ii, trigalloyl-dihexoside,syringic acid, trigalloyl-hexoside i, galloyl-syringic acid-hexoside iii, syringic acid-(dihydroxydimethoxybenzoic acid)-hexoside i , sinapoyl alcohol, syringic acid-(dihydroxydimethoxybenzoic acid)-hexoside ii, ellagic acid-hexoside i,quercetagetin−7-o-(ac-pen-hex)-3-o-hexoside i, galloyl-eudesmic acid-hexoside i, ellagic acid-hexoside ii, n-malonylphenylalanine, quercetagetin-3-o-hexoside ,galloyl-eudesmic acid-hexoside ii, trigalloyl-hexoside ii, quercetagitrin (quercetagetin-7-o-β-glucopyranoside), syringic acid-(dihydroxydimethoxybenzoic acid)-hexoside iii ,quercetagetin-7-o-dihexoside, quercetagetin-7-o-(ac-pen-hex)-3-o-hexoside ii, quercetagetin-7-o-(galloyl-hexoside), ellagic acid, quercetagetin-3-o-hexoside-7-o-(galloylhexoside), di-syringic acid hexoside i,di-syringic acid hexoside ii, syringic acid-(hydroxytrimethoxybenzoic acid)-hexoside, kaempferol 3-o-hexoside i ,quercetagetin, patulitrin, kaempferol 3-o-hexoside ii , isorhamnetin 3-o-hexoside, 8-hydroxyquercetagetin, quercetin ,zeaxanthines and lutin (Burlec et al. 2021). About 19 phytoconstituents present in methanol extract of leaves of *Tagetes erecta*. The major bioactive compound present are Tetra decanoic Acid, 2,6,10- Trimethyl 14 – ethylene – 14 – Pemtadecme, N – Hexadecanmic acid, 15-Hydroxy penta decanoic acid and Stigmasterol. Twenty two naturally occurring phytoconstituents present in the ethanolic extract of *Tagetes erecta* flower such as β – sitosterol, β- daucosterol, 7-hydroxysitosterol, lupeol, erythrodiol, erythrodiol-3-palmitate, 1-[5-(1-propyn-1-yl)-[2,2-bithiophen]-5-yl]- ethanone, α- terthienyl, quercetagetin , quercetagetin- 7-methyl ether, quercetagetin-7-O-glucoside, kaempferol, syringic acid , gallic acid, 3-β-galalctosyl disyringic acid, 3 α galalctosyl disyringic acid, 6-ethoxy-2,4-dimethylquinolin, oplodiol, (3S,6R,7E)-hydroxy-4,7-megastigmadien-9-one, palmitin, ethylene glycol linoleate and n-hexadecane. Chemical compounds present in the stem as leaves of *Tagetes erecta* plant as 4'- methoxy-eupatolitin-3-O-glucoside, kaempferitrin, rutin, betasitosterol, daucosterol and gallic acid (Shetty et al. 2015).

PHYTOCHEMICAL SCREENING METHODS:
A good technique for finding secondary metabolites in plant materials such leaves, fruits, bark, and flowers is phytochemical screening. Detection of secondary metabolites such as alkaloids, glycosides, carbohydrates, proteins, amino acids, saponins, tannins, terpenes, etc. is done using plant extract (Veerachari and Bopaiah 2012).

- **Detection of alkaloids:** Warm up and filter plant extract after dissolving 1% v/v HCL in it. For the subsequent test, filtrate is utilised:
  a) Mayer's Test: Take a test tube, fill it with plant extract, and then place a side-by-side layer of Mayer's reagent (potassium mercuric iodide). Precipitates with a white, creamy, or yellow colour indicate the presence of alkaloids (Ganesh, Kumar, and Saranraj 2014).
  b) Hager's Test: Add plant extract to a test tube before adding Hager's reagent (saturated picric acid solution) on either side of the test tube. Precipitates take on a yellowish colour when alkaloids are present.
  c) Wagner's Test: Take a test tube, fill it with plant extract, and then place Wagner's reagent on either side. The reddish-brown colour of the precipitates indicates the presence of alkaloids (Khalid et al. 2018).
  d) Dragendroff's Test: Dragendroff's reagent (Bismuth potassium iodide solution) should be added side by side with the plant extract in a test tube.
  Precipitates with a yellow or orange colour indicate the presence of alkaloids (STEPHEN and Ejikeme 2016).
- **Detection of carbohydrates:** Filter after combining 2g of plant extracts with 5 ml of pure water. The test for the identification of carbs is run using a filter.
  a) **Molisch's Test:** Take a test tube, fill it with plant extract, a few drops of Molisch's reagent, and 2 millilitres of concentrated sulfuric acid.Precipitates are coloured purple because of the presence of carbohydrates.

b) **Benedict's test:** Add some plant extract to a test tube before adding Benedict's reagent and heating it on a water bath. The production of orange-colored precipitates is caused by the presence of carbohydrates (Yadav and Agarwala 2011).

c) **Fehling's Test:** Add plant extract to a test tube before adding an equal number of drops of Fehling solutions A and B and heating on a water bath. The brick-red colour of the precipitation is caused by the presence of carbohydrates (Elzagheid 2018).

- **Detection of flavonoids:**

a) Alkaline Reagent Test: Add plant extract and 2N sodium hydroxide to a test tube.
The presence of flavonoids was indicated by the yellow colour (Khalid et al. 2018).
b) Lead acetate Test: Add a few drops of 10% lead acetate solution after adding a few drops of plant extract to a test tube.The production of yellow precipitates is caused by the presence of flavonoids (Rajvanshi and Dwivedi 2017).
c) Shinoda test: Take a test tube, fill it with plant extract, then add Mg chloride, a few drops of concentrated hydrochloric acid, and watch the pink colour emerge (Tripathi 2013).

- **Detection of phytosterols**

a) **Salkowski's Test:** Plant extract should be added to a test tube, which should then be agitated with some chloroform and conc. Slowly adding sulfuric acid to the test tube's side. Triterpens (phytosterol) indicate the production of red or golden yellow colour (Khalid et al. 2018).

b) Libermann Burchard's test: Add plant extract to a test tube before adding Libermann-Burchard Reagent (acetic anhydride concentrated sulphuric acid).
Triterpenoids were present as evidenced by the formation of the blue-green colour (phytosterol) (Rajvanshi and Dwivedi 2017).

- **Detection of glycosides:**

a) Modified brontrager's test: Add plant extract to the test tube. In addition, add 5ml of weak HCl and 5ml of ferric chloride. After boiling for 10 minutes on a water bath, let the mixture cool at room temperature. Then filter the sample and filterate extract using carbon tetrachloride (CCl4) or benzene and an equivalent volume of ammonia solution. Pink to crimson coloration indicates the presence of the anthraquinone moiety.

b) Borntrager's test: Take a test tube, fill it with a plant extract, add 5–10 ml of diluted HCl, and then boil it on a water bath for 10 minutes before filtering. Shake filterate extract after adding an equivalent amount of ammonia solution and CCl4 or benzene. Anthraquinone moiety is indicated by the presence of pink to red colour (Tripathi 2013) (kumar Bargah 2015)

c) **Legal's Test:** Take a test tube, fill it with plant extract, then fill it with water to the same level, add a strong lead acetate solution, shake it, and filter it. Filter the chloroform extract once it has been extracted in the same volume, and let it dry or evaporate. Then, add an NaoH solution to make it alkaline after dissolving some pyridine and sodium nitropruside. The pink colour indicates the presence of glycoside (Pandey and Tripathi 2014).

d) **Baljet test:** Add plant extract to a test tube before dipping it into the sodium picrate solution. Glycoside production produces a yellow to orange colour when present.

- **Detection of saponins:**

a) Froth Test: Take a test tube, fill it with plant extract, add distilled water, and shake it vigorously for 15 minutes in a graduated cylinder. The formation of a layer of foam is a sign that saponins are present (Sibi et al. 2012).
b) Foam Test: Take a test tube, fill it with plant extract or water, and shake it. If foam persists for 10 minutes, saponins are present (Rao et al. 2016).

- **Detection of phenolic compound:**

a) Ferric Chloride Test: Add 5% ferric chloride in plant extract to a test tube.
Blue, green, or black coloured precipitates are produced when phenolic chemical is present (Pasto and Johnson 1979).
b) Potassium dichromate test: Add plant extract to a test tube before adding 10% potassium dichromate solution. The presence of phenolic compound is shown by the formation of yellow precipitates (Arefin, Islam, and Hossain 2015).
c) Gelatin Test: Add plant extract to a test tube before adding an aqueous solution containing 1% gelatin and 10% sodium chloride.
The creation of the white buff colour is caused by the presence of phenolic chemical (Tripathi 2013).

- **Detection of proteins and amino acids:**

a) Millon's Test: Add some plant extract to a test tube before adding a few drops of millon reagent and heating it on a water bath. When white precipitates form and then change to bric red or vanish, an amino acid is present (Ukoha et al. 2011).

b) Ninhydrin Test: Take a test tube, fill it with plant extract, add the ninhydrin reagent, and boil it for a little while. Blue colour formation indicated amino acid present (Tripathi 2013).

c) Biuret Test Take a test tube, fill it with plant extract, and then add a few drops of either 4% NaoH or 2% copper sulphate. White colour indicates that there is protein (Ukoha et al. 2011).

TRADITIONAL USES:

The *Tagetes erecta* is utilised in different parts to treat a range of diseases. The leaves can treat a variety of conditions, including piles, renal issues, muscle aches, ulcers, cut, and earaches. The flower is used to cure scabies, liver issues, fevers, epileptic fits, as well as astringent, carminative, stomachic, and eye and liver disorders. Blood piles, rheumatism, the common cold, and bronchitis are all treated with flower juice (Khulbe 2015).

PHARMACOLOGICAL ACTIVITY:

- **Anti-bacterial activity:** The usage of *Tagetes erecta* was proposed by Bandana Patel, who also demonstrated that it contains ester derivatives of flavinoids. Other researchers have also tried them to see if they have an antimicrobial effect. Using the disc diffusion method, Preeti Verma et al. (2012) examined the Tagetes flowers on five bacterial strains and discovered extract has antibacterial properties (Patel 2013) (Verma and Verma 2012).

- **Hepatoprotctive activity:** *Tagetes erecta* was found to have hepatoprotective properties against the rat model of liver injury brought on by carbon tetrachloride, according to Ranjan Kumar et al. The serum's high levels of ALT, AST, ALP, and bilirubin were increased by the ethanolic extract. In comparison to the CCl4-intoxicated group, the ethanol acetate fraction of *T. erecta* (EATE) at a dose of 400 mg/kg orally considerably reduced the increased serum marker enzymes and level of bilirubin to virtually normal levels. Rats treated with 400 mg/kg of EATE extract and CCl4 showed a considerable improvement in their histological liver alterations, with the exception of cytoplasmic vascular degenerations around the portal tracts, mild inflammation, and foci of lobular inflammation. Flavonoids, terpenoids, and steroids are phytoconstituents that may be beneficial to human health and have hepatoprotective properties (Giri, Bose, and Mishra 2011).

- **Anti-diabetic activity:** The anti-diabetic potential of the *Tagetes erecta* extracts was studied by Sonia Nez et al. They demonstrated that the extracts inhibit alpha-glucosidase and assessed the extracts' ability to prevent the development through a non-enzymatic process, advanced glycation end products (AGEs) 4 are produced (Nuñez et al. 2021). Another researcher presented his in-vitro research, focused on the inhibitory effects of α-glucosidase, α-amylase, and pancreatic lipase, which examined the anti-diabetic and antilipemic actions of quercetagetin derived from marigold inflorescence residues. This study demonstrated the critical efficacy of quercetagetin as a nutraceutical to treat diabetes and obesity because it has potent inhibitory action against alpha -glucosidase and pancreatic lipase as well as a moderate inhibitory effect against alpha-amylase (Wang et al. 2016).

- **Anti-malarial** activityThe aqueous extract of *T. erecta* flowers and *S. nodiflora* extracts of leaves demonstrated antimalarial efficacy in a mouse model, according to Prapaporn Chaniadthe et al. The investigation's findings were presented, demonstrating how T. recta successfully inhibited Plasmodium parasites and shown promise antimalarial action against P. berghei infection without endangering human health (Chaniad et al. 2021).

- **Anti-amnesic activity:** According to Prapaporn Chaniadthe et al., the aqueous extract of *T. erecta* flowers and *S. nodiflora* leaves showed antimalarial effectiveness in a mouse model. Results of the study were reported, showing how *T. recta* effectively inhibited Plasmodium parasites and shown promising antimalarial action against P. berghei infection without harming human health (Raju and Srilakshmi 2018).

- **Mosquitocidal Potency**: The study on *Tagetes erecta*'s ability to repel mosquitoes is presented by Farjana Nikkon and colleagues. The first, second, third, and fourth instar larvae of Cx. Quinquefasciatus were effectively killed by the ethanol, chloroform, and petroleum ether soluble extract of *T. erecta* flowers, however the chloroform soluble fractions are more toxic than the other fractions. Additionally, *T. erecta* exhibits larvicidal efficacy against Aedes aegypti and Meloidogyne incognita larvae (Nikkon et al. 2011).

- **Analgesic Activity:** By using a writhing test, Zeng Yi et al. evaluate the analgesic effectiveness of *Tagetes erecta* extract. By assessing the organ index, looking at the histology, and looking for inflammatory markers in blood tests and serum, researchers examined the anti-inflammatory efficacy of *Tagetes erecta* L. alcohol extract. In LPS-induced inflammatory mice, *Tagetes erecta* L. stem and leaf alcohol extract effectively decreased liver and lung organ indexes, maintained blood stability, significantly decreased the levels of IL-1, IL-1β, IL-6, IL-8, PGE2, iNOS, and NO in serum, and increased levels of the anti-inflammatory factor IL-10. The extract of the leaves and stem of the *Tagetes erecta* then demonstrated good analgesic or anti-inflammatory effect, according to Zeng Yi et al. (Yi et al. 2021).

- **Antioxidant activity:** The diphenyl-1-picrylhydrazyl (DPPH), thiocyanate, b-carotene bleaching, free radical scavenging activity, and oxidation of deoxyribose assays were used to measure the essential oil's antioxidant activity. The findings of this study show that *Tagetes erecta* essential oil has high antioxidant activity at the dose level demonstrated, but not as much as a-tocoferol. The present study's findings regarding the antioxidant activity of *Tagetes erecta* essential oil suggest that camphor and methyleugenol may be involved (Gutierrez, Luna, and Garrido 2006).

- **Antifungal activity:** Using the disc diffusion method with amphotericin-B and fluconazole as positive controls, the antifungal activity of *Tagetes erecta* extract was assessed against Candida albicans, Aspergillus niger, Aspergillus flavus, and Penicillium crysogenum strains of fungi. The diameter of the zone of inhibition was used to calculate the antifungal activity. The *T. erecta* petal extract then demonstrated good efficacy in extending the diameter of the zone of inhibition by an in-vitro approach as compared to the sample. This study showed that *Tagetes erecta* petal extract may have beneficial potential efficacy against fungus infection.

- **Anti-cancer activity**: By employing the Breast cancer line (MCF-7) and a cytotoxicity assay to test the anti-cancer activity of an ethanolic patal extract of *Tagetes erecta*, 5-fluorouracil was utilised as the control. In a cytotoxicity test, the IC50 value was found to be 125µg/ml when compared to the standard. This study showed that *Tagetes erecta* petal extract may be a useful lead that may be investigated for usage in the treatment of breast cancer (Vedam V. A, Stanley Xavier, and Chellathai David 2019).

- **Anti-depressant activity:** Numerous studies have demonstrated *Tagetes erecta*'s antidepressant properties. Because of the polyphenolic and flavinoids it contains, it has an antidepressant effect. Shalini *et al*., (2018) description of cognitive deficiencies can be utilised to guide the Forced Swim Test and Tail Suspension Test (Tripathi et al. 2018).

- **Wound healing activity**: The comparative effectiveness of *Tagetes erecta* and centella asiatica extracts on albino rat wound healing is the subject of a study by Sandipan Chatterjee et al. To test the wound-healing potential of *T. erecta* leaves and *C. asiatica* aerial parts, hydroalcoholic extracts of the plant parts were utilised. In the excision wound model, the group treated with *T. erecta* extract displayed greater percentages of wound contraction, decreased epithelization times, and scar formation, whereas the group treated with *C. asiatica* extract displayed worse results. In the dead space wound model, *C. asiatica* (500 mg/kg) and *T. erecta* (250 & 500 mg/kg) extracts improved the granulation tissue weight and granulation breaking strength. Treatment with the hydroalcoholic extract of Centella asiatica and Tribulus erecta has positive effects on many stages of wound healing, including fibroplasias, collagen synthesis, and wound contraction, which leads to quicker healing. The hydroalcholic extraction of Tagetes erecta has a high efficacy to heal the wound, according to a comparison of these plants (Chatterjee et al. 2011).

- **Anti-inflammatory**: The study demonstrated the efficacy of *Tagetes erecta* hydromethanolic extract against carrageenan-induced paw oedema. By activating the signalling pathway, *Tagetes erecta* extract alters cell signalling mediators and inhibits the inflammatory response (Chatterjee et al. 2009).

CONCLUSION:

According to a thorough literature assessment, *Tagetes erecta* is a prominent medicinal plant with a wide pharmacological spectrum. Numerous pharmacological and therapeutic activities of the plant, including antibacterial activity, wound healing activity, hepatoprotective activity, mosquitocidal activity, antioxidant activity, anti-depressant activity, etc., are caused by the presence of various chemical constituents in the plant. One of the most significant medicinal herbs for treating inflammation is *Tagetes erecta*. Diabetes, cancer, liver disease, and wounds can all be successfully treated with it. Future research will need to analyse *Tagetes erecta*'s separated principles in a scientific manner using a variety of imaginative experimental models and clinical trials in order to comprehend its mechanism of action, identify new active ingredients, and broaden its therapeutic effects. As a result, *Tagetes erecta* can be thought of as a treatment for a number of illnesses and needs to be further studied.

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