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A Laconic Aphorism about the African marigold (*Tagetes erecta* L.)-Review

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A B S T R A C T

Tagetes erecta is widely recognized as marigold, an annual herbaceous plant with enormous vitality of chemical constituents that encounters various ailments without any toxic effects. Despite the commercial interest, few studies in marigold have examined a wide range of pharmacological methods. This report is an overview of marigold research aimed at determining its biochemical compounds, medicinal, nutritional, pharmacological, gastronomic and mutation breeding values. The study's finding underlines a new insight to the prior and pioneering achievement in marigold on culinary values, putative mutants and numerous pharmacological activities that have been explored by other researchers. The potential for marigold that is used in the industrial and medicinal sectors are the more exciting aspects of the study.

Keywords:African Marigold, culinary values, medicinal values, pharmacological activities, putative mutants.

1. Introduction

Marigold, a traditional plant valued for its commercial worth, has lost its medicinal value among locals today, as its beauty overshadows its health benefits. The plant is endemic to Mexico and is recognized as African Marigold. It belongs to the Asteraceae family. The flowers are used in the merriments of the Día de Muertos, to adorn graves and shrines; hence entitled as "flower of the dead" [1]. These wild species are commonly accommodated as an ornamental plant and established in other countries of Asia, Africa, and Europe. In the genus *Tagetes*, there have been 144 scientific names of species rank, while on the contrary 53 species names are accepted [2]. Apart from aesthetics, the medicinal and industrial potentials are intriguing.

For centuries, *T. erecta* has been used as a traditional treatment to treat everything from the common cold to rheumatism. The makeup of a vast number of secondary metabolites has been revealed via pharmacological actions. A valuable natural pigment, lutein that can be isolated from *T. erecta* at a low cost and contains at least 80% carotenoids entailing 79 % lutein and 5 % zeaxanthin[3]. Perhaps, Lutein-deficiency may be one of the causes of age-related vision impairment in the human body. Lutein, derived from marigolds, has been authorized by the European Union as food additives [4]and approved by the Food and Agriculture Organization[5]. The marigold flower which mainly consists of carotenoid-lutein and flavonoid Patuletin are highly demanded, which considerably enhances the uptake of dye to metal mordanting for industrial application studied for the nutritional supplements. Quercetagetin, another useful isolated molecule, has shown potential for the treatment of obesity and diabetes [6].

The leaves are used as an antiseptic in cases of kidney issues, muscle disorders, haemorrhoids, and as a topical treatment for boils and carbuncles, while the blossoms are used for fever, convulsions, astringents, stomach ache, liver problems, scabies, and eye ailments, in contrast to Ayurveda. Rheumatism and bleeding hemorrhoids are alleviated with flower juice [7]. It has therapeutic characteristics, nematocidal effects [8], antibacterial, antifungal, insecticide, and anticancer capabilities and plays an

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important role in aesthetic therapy due to its strong odour [9 -11]. Furthermore, culinary features have presented a strategy to increase food quality by producing food and feed pigments in chicken to ensure that egg yolks and broiler skin have a virtuous coloration [12].

2. Botanical Description

Tagetes erecta is a rapidly growing annual herbaceous flowering plant that generally grows up to 6-8 inches to 3 feet. The aromatic stem is striated to somewhat woody, smooth with minute hair, and has resin channels in the bark. The leaflets are lanceolate to linear lanceolate and serrated, and the leaves are mid-green and pinnately split. The leaf edge is wavy or sparingly toothed. Acute, serrated, with bristles (in the shape of threads) beneath each leaf and the top is sometimes completely bristling with many spherical glands [13]

The flower bears a large doubled layered pom-pom like solitary terminal flower head with a diameter of 5-8 cm, clavate inflated at the apex of the peduncle, involucral bracts, cup-shaped, apex dentate although there are hybrids with a larger diameter and varied colours. The flowering period is approximately 4 weeks from transplanting. In nature, the plant is hermaphrodite and entomophilous. The flowers might be gambong, yellow, golden yellow, or orange in hue. Seeds are an easy way to propagate these plants. For maximum yield, the plant requires direct sunlight, medium or heavy-drained dry or damp soil, and is not appropriate for growing in a shady environment [14].

African Marigold (English), Genda (Hindi), Samanthi (Tamil), Chendumallige (Kannada), Galaghoto (Gujarati), Chendu Mali (Malayalam), Banti (Telugu), Jhandu (Sanskrit), and Makh mal (Marathi) were all common names for *Tagetes erecta*[15].

3. **National and International Status**

T. erecta is a Mexican annual flowering herb that thrives in most temperate areas. It is commonly grown in India, China, and other tropical nations because it requires a substantial amount of annual winter and rainfall to thrive [16]. India accounts for around 75-80 percent of global marigold production, which is estimated to be around 6 lakh tonnes. India uses almost 80% of the produce and exports to savvy countries like Japan, Sri Lanka, Iran, North African countries, the United States, and the United Kingdom. Following France, Africa, Mexico, Myanmar, Bangladesh, and Indonesia as the most diverse countries, India and Thailand contain at least 50 species apiece.

The southern half of the country produces the most marigold; Andhra Pradesh, Uttar Pradesh, and Tamil Nadu are the top marigold producing states in India, followed by Maharashtra, Orissa, Karnataka, Uttar Pradesh, and Kerala. In Tamil Nadu, Erode is the largest marigold producer and key trade centre in India [17].

4.Chemical Compositions

T. erecta flower extracts were subjected to a comprehensive phytochemical investigation, which revealed 22 naturally occurring chemicals with different carbon skeletons [18].They were β-Sitosterol; Daucosterol; Hydroxysitosterol; Farganasterol; Erythrodiol; 2,2',5',2''-Terthienyl; quercetagetin-7-methyl ether; Quercetagitrin; Quercetagetin; Kaempferol; Syringic acid; 3,4,5-Trihydroxybenzoic Acid; 3-α-galactosyl disyringic acid, 3-β-galactosyl disyringic acid, 2,4-dimethyl-6-ethoxyquinoline; Oplodiol; 3-Hydroxy-4,7-Megastigmadien-9-One; ethylene glycol linoleate; Palmitin; erythrodiol 3-O-Palmitate; hexadecane**.**

The components of *T. erecta* extracts from Italian [19], Chinese [20], and Brazilian [21] essential oil have been discovered in numerous investigations. Table 1. summarises the peak data on EO of *T. erecta* leaf extracts.

The primary pigment and one of the significant constituents of *Tagetes erecta* L. is lutein. It is an oxy-carotenoids with highly delocalized polyene backbone subjugated by two cyclohexene end rings (Fig. 1)

There is a lot of chemical diversity in this genus, as well as a lot of aromatic compounds [22]. They produce a prevailing, aromatic essential oil. Acyclic monoterpene ketones and monoterpene hydrocarbons are the main odorants in Tagetes essential oils, with miniscule quantities of sesquiterpene hydrocarbons and oxygenated substances [23]. The primary chemical structures of the key chemical components included in *T. erecta.* extract is shown in Figure 1.

Table 1 - Major Compound in EO of *T. erecta* leaf extracts.

Major Compounds	Italian EO (%)	Chinese EO (%)	Brazil EO (%)
3-Cyclohexen-1-One, 2-Isopropyl-5-Methyl-	-	14.1	-
Caryophyllene	2.0	4.2	-
Cis-Ocimene	1.1	8.8	-
Indole	1.4	-	-
Limonene	15.6	13.1	9.7
Myrcene	1.0	-	-
Piperitenone	-	-	5.9
Piperitone	24.2	-	45.7
P-Menthatriene	-	1.5	-
p-vinylanisole	-	1.1	-
Sabinene	1.1		-
Terpinolene	28.5	37.9	-
β - Ocimene	4.7	3.0	-
β -elemene	-	1.7	-

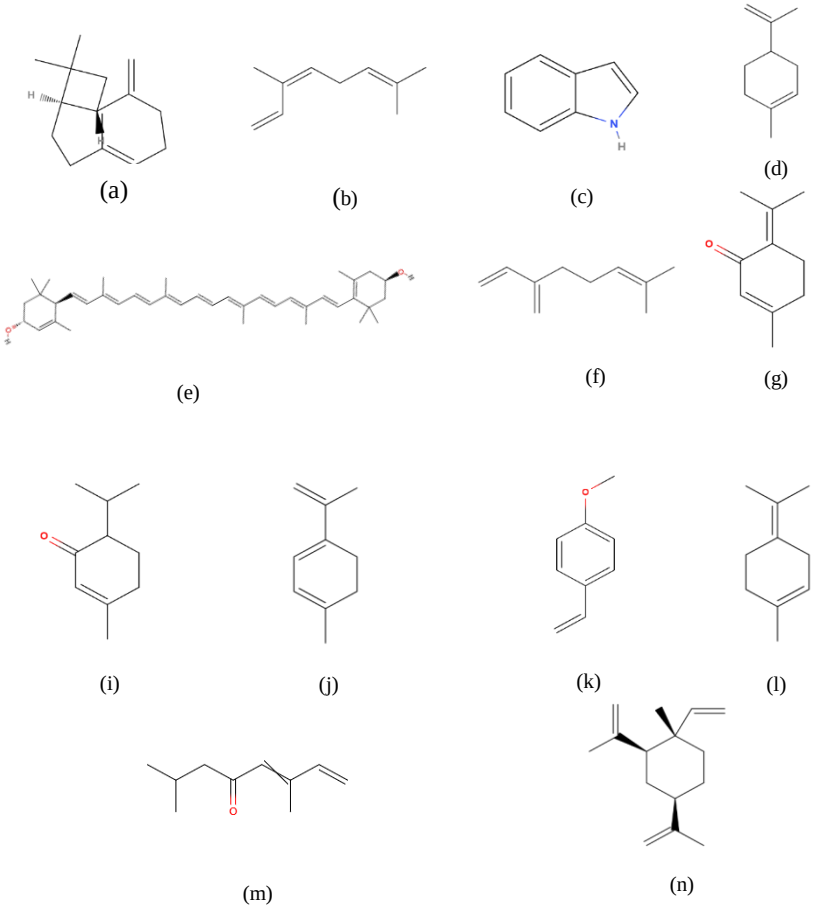

Figure 1 - (a) Caryophyllene, (b) Cis-Ocimene, (c) Indole, (d) Limonene, (e) Lutein, (f) Myrcene, (g) Piperitenone, (h) Piperitone, (i) P-Menthatriene, (j) p-vinylanisole,(k) Terpinolene, (l) β–Ocimene, (m) Tagetone, (n) β–elemene

5. Pharmacological Relevance

Being a potent plant with high commercial importance, it exhibits a beautiful way in pharmacology. The investigations on marigold's pharmacological actions are organised under the headings below.

5. 1. Antibacterial studies

The leaves extract of *T. erecta* showed a substantial inhibitory action against bacteria strains such as *Alcaligenes faecalis, Bacillus cereus, Campylobacter coli, Escherichia coli, Klebsiella pneumoniae, Pseudomonas aeruginosa, Proteus vulgaris, Streptococcus mutans, and Streptococcus pyogenes* [24] while, the floral extract exhibited a greater inhibitory effect against *Neisseria gonorrhoeae* and *Klebsiella pneumoniae*[25]. The two primary components of *T. erecta* extract, quercetagetin-7-arabinosyl-galactoside [23] and patulitrin showed significant antibacterial activity against the pathogenic microorganisms tested [24].

5. 2. Antifungal studies

Hexane and methanol extracts of *T. erecta* revealed the inhibitory effect against two fungal strains *Ganoderma lucidum* and *Alternaria alternata*. The minimum inhibitory concentration was reputed between 7.5 and 13.3 mg/mL [26].

5. 3. Antinociceptive Studies and Anti-Inflammatory Studies

The extract of *T. erecta* using methanol, chloroform and ether fractions reported significantly a most effective antinociceptive activity against acetic acid-induced writhing in mice, whereas the methanolic extract and ether fractions demonstrated the maximal inhibition of oedema formation in mice subjected to carrageenan injection by induction of carrageenan paw oedema. This research found a strong indication of anti-inflammatory properties [27].

5. 4. Antioxidant studies

The ethanolic extract of *T. erecta* flowers determined antioxidant activity by using three different assays DPPH, which reduces the energy and radical scavenging activity of superoxide in different concentrations, where *T. erecta* flower extracts showed better reducing power than ascorbic acid, while the other assays recorded less than standard. As a result, antioxidant properties were revealed [28].

5. 5. Anti- cancer studies

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The ethanolic extracts and ethyl acetate fractions from *T. erecta* flowers showed cytotoxic activity and inhibitory effects on elastase and tyrosinase enzymes [7]. An assay was performed to measure the cytotoxicity of these two extracts in CaCO2 colon cancer cell lines and H460 lung cancer.

5. 6. Hepatoprotective Studies

The serum levels of ALP, AST, ALT, and bilirubin increased significantly after administration of an ethanolic extract of *T. erecta*[29]. At a dose of 400 mg/kg, the ethyl acetate fraction of *T. erecta* showed a significant decrease in increased serum marker enzyme and bilirubin levels near normal compared to the CC14 intoxicated group, while rats treated with 400 mg/kg of EATE extract and CCl4 showed significant recovery with the exception of ballooning degeneration around the portal tracts, minor swelling, and centre of lobular inflammation and the hydoalcoholic*T. erecta* was also found to be an effective treatment for ethanol-induced hepatotoxicity [30]. As a result, the hepatoprotective activity of *T. erecta* is attributed to phytoconstituents found in the plant.

5. 7. Anti-diabetic Studies

Hydroalcoholic extracts of *T. erecta* were studied for their antidiabetic activity, when diabetes was produced using a streptozotocin (60mg/kg) injection into the peritoneum and Glibenclamide as a conventional treatment, an increase in blood glucose was detected at 30 minutes, followed by sequential reductions up to 120 minutes. The hypoglycemic effect was determined after 120 minutes. As a result, hydroalcoholic extracts of *T. erecta* were found to have anti-diabetic action [31].

5. 8. Antidepressant Studies

Pretreatment of Tagetes erecta extracts with fluoxetine and imipramine increased antidepressant activity, whereas pretreatment with PCPA reversed [32]. It was determined that antidepressant action was exerted by enhancing serotonergic neurotransmission.

5. 9. Mosquitocidal Studies

The chloroform fraction was very effective and reported highest toxicity against *Culex quinquefasciatus*and subsequently, the LC50 values (75.48µg/mL, 36.88µg/mL, 17.06µg/mL and 14.14µg/mL) for all *C. quinquefasciatus* instar larvae. As a result, *T. erecta* flower extracts were found to exhibit significant natural mosquitocidal action [33].

5. 10. Larvicidal studies

The essential oil of *T. erecta* has been shown to have larvicidal activities against instars of *Aedes aegypti* [34]. Effectiveness was observed with LC90 of 100.84µg/ml and LC50 of 79.78 µg/ml. Also, the root and flower extract resemble a high content of thiophene which was validated by HPLC. As a result, *T. erecta* was has been identified to be a natural source of larvicidal activity against *Aedes aegypti*.

5. 11. Insecticidal Studies

T. erecta flower extracts have been shown to exhibit insecticidal efficacy against*Tribolium*castaneum (Herbst), a preserved product parasite insect [35]. The chloroform fraction had the maximum toxicity against *T. castaneum*larvae and adults, followed by the petroleum ether fraction and the ethanol extract. As a result, the *T. erecta* flower was found to have insecticidal efficacy against *T. castaneum.*

5. 12. Nematocidal activity

For *Meloidogyne incognita* control, the efficacy of nematocidal activity in four medicinal plants, *Azadirachta indica, Calotropis procera, Datura stramonium*, and *Tagetes erecta*, was determined [36]. Leaf extracts at various dosages significantly improved okra development metrics and reduced root-knot infections when compared to the untreated control. *T. erecta's* root generates alpha-terthienyl, a deadly naturally occurring substance that hinders the development of nematode eggs.

5. 13. Wound healing activity

In excision and burn wound models, hydroalcoholic extracts of *Gymnemasylvestre* (GE) and *T. erecta* Linn. were investigated in albino mice for wound healing efficiency. When mixed with other gels, it showed a significant decrease in wound contraction and increased wound healing activity. *T. erecta* demonstrated better wound healing qualities due to the free radical scavenging effect and phytoconstituents contained in the plant (Hussain et al., 2011). Also, the flower petal paste application exhibited shorter epithelialization time in the surgical wound in Goat which symbolized the wound healing activity [37].

6. Mutagenic studies

The investigation was carried out in two varieties of *Tagetes erecta.* Seeds of marigold cv. Double Orange were subjected to gamma rays with 0 - 600 Grays. [38] and seeds of var. PusaNarangiGainda were subjected to gamma rays with 5-50 Gy [39]. From the study conducted using physical and chemical mutagens reflected that the concentration of mutagen doses is inversely related to seed germination and demonstrated that Gamma rays are more efficient mutagen than EMS for *Tagetes erecta* L [40].

7. Conclusion

Due to various chemical elements employed in human welfare, *Tagetes erecta*, a traditional popular aesthetic and medicinal plant, exhibited a varied pharmacological property can encounter the unwavering problems. The African marigold is an important decorative cum medicinal plant, according to the literature. It is a natural alternative to unnatural synthetic substances that can be employed in modern conventional healthcare without causing negative effects. To improve economic and

pharmacological qualities, mutation breeding can be used to study the inevitable source of new kinds with new putative mutations.

Conflict of Interest

Authors declare no conflict of interest.

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