Prayogik Rasayan

A Review on Marigold (*Tagetes erecta Linn)*: the Phytochemicals Present and its Biological activities

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Marigold is a hardy annual herb native to Southern Europe and is also cultivated extensively in Asia, India, China and other countries with a tropical climate. Marigold flowers have different fragrances and colors, in which the yellow color is most common.These flowers are edible and also used as colouring agent and spice. A yellow dye obtained from the flower can be used as a spice substitute for colouring and flavouring foods. Lutein is an oxycarotenoid or xanthophylls, it is one of the major constituents and the main pigment of *Tagetes erecta* species. A variety of chemical constituents have been isolated from *Tagetes* species.They are essential oils, carotenoids, flavonoids, terpenoids, thiophenes and phenolic compounds.The important phytochemical constituents present in the different part of the plants are lutein, quercetin, quercetagetin, a glucoside of quercetagetin, syringic acid, thienyl, terpines and phenolic copounds. The leaves are used against muscular-pain, piles, ulcers, wounds and kidney troubles. The flowers are useful in fevers, epileptic, stomachic , astringent, scabies, carminative, liver and eyes diseases.The plant exhibites different pharmacological activities like anti-bacterial, anti-microbial, anti-oxidant, analgesic, hepatoprotective, insecticidal, mosquitocidal, Larvicidal and wound healing activity. It is also used as drug from ancient times in the india for the treatment of cold, rheumatism, bronchitis, ulcers, eye diseases, purify the blood, bleeding, piles etc.

Keywords*:* Marigold (*Tagetes erecta Linn)*, chemical constituents, pharmacological activities, silver nanoparticles synthesis and antibacterial activities.

1. Introduction

The most common *Tagetes* are African marigold, scientifically known as *Tagetes erecta* L. The name *Tagetes* is originated from the name of the Etruscan Tages. It belongs to a Asteraceae family and *Tagetes* genus, containing about 50 species. They grow up to 50-80 cm in height, the leaves are green, lanceolate and between 5 -17 cm in length. The leaves and stems are covered with small hairs, the edges of the leaf can be wavy. This plant needs temperatures between 20°C and 30°C and flowers grow large amount annually in winter and rainfall seasons.[1] It is a herb, commonly known as marigold, native of Mexico and other warmer parts of America and grows also in the tropics and subtropics regions. The plant is locally known as Genda Phool. Historically, marigold has been used all over India, Indonesia and China as a spice, medicinal agent and ornamental purpose. In India, these were introduced by the Portuguese. Marigold flowers have different colors like yellow and orange being the most common. The Marigolds spread quickly because of the ease in cultivation, longer blooming period and beautiful flowers with excellent shelf life. They are extensively used for making garlands,religious sacrifice and exhibitions. *Tagetes erecta* L. is used for the treatment of a various of diseases. It is used as nematocide, cosmetic and medicinal agent. The essential oil of the flower contains antioxidants.

The plant is used against cold, bronchitis and rheumatism.The juice of leaves is treated for earache.The leaves and flowers is used as anti-diuretic and anti-carminative agent.Its flowers have been used for the treatment of ulcers and eye diseases. The extract of the roots are found as laxative.The juice of the leaves of *Tagetes erecta* and *Tagetes patula* are traditionally used as antimalarial and antipyretic. *Tagetes minuta* is traditionally used for repelling mosquitoes and also shows strong larvicidal effect. The juice from *Tagetes patula* contains iodine and is used on cuts and wounds. The juice of its flowers is used as a carminative. The *Tagetes lucida* plant is used in foods and its leaves and flower heads are used to perfume bathing water.Traditionally, the shoots of *Tagetes lucida* and *Tagetes filifolia* have been used for the preparation of native teas in Mexico whereby they act as popular beverages and medicinal preparations for colic and gastrointestinal disorders.*Tagetes minuta* oil has a very strong and penetrating odour that makes a good market in the perfumery world.*Tagetes* species contain terpenoids, thiophenes, flavonoids, carotenoids, phenolic compounds

etc.[2] They exhibit various biological activities antibacterial, antimicrobial, antiplasmodial, insecticidal, larvacidal etc.[3,2]

2. Common names

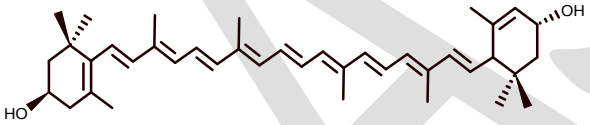
The common names of Marigold *(Tagetes erecta Linn*.) in different regions are - american marigold, african marigold, aztec marigold, marigold, big marigold or saffron marigold in english, gainda in hindi, “tagete rose d'Inde” in french, “stor tagetes” in swedish, “wan shou ju” in chinese, cheonsugug in korean, studentenblume in german, maravilha in portuguese, “flor de muerto” in spanish, barchatcyprjamostojajcie in russian, “senju-giku” in japanese.[4]

3. Chemical constituents

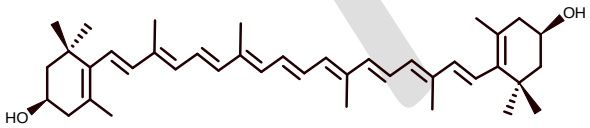
Marigolds (*Tagetes* species) contain essential oils, thiophenes, flavonoids, carotenoids, terpenoids and phenolic compounds.[2]

3.1 Carotenoids

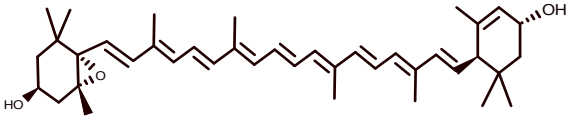
The extract of marigolds contain 93% pigments consisting of all-trans and cis -isomers of lutein and lutein esters (88%), all-trans and cis-isomers of zeaxanthin (5%) and <3% epoxy pigments such as lutein- 5, 6-epoxide.[2] The extract of marigold flowers is used commercially as an additive to poultry feed to improve bird s fat and skin and egg yolk pigmentation. Carotenoids in particularly the dihydroxycarotenoids also referred to as xanthophylls are lutein and zeaxanthin, which are the compounds mainly use for poultry pigmentation. Lutein from marigold extract also suppresses mammary tumor growth and enhances lymphocyte proliferation. For uptake and distribution, free or esterified lutein is absorbed into the bloodstream. Once consumed, free (unesterified) lutein is transported and stored in the liver or skin as diesterified lutein.



Lutein



Zeaxanthin

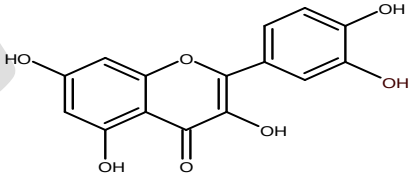


Lutein- 5, 6-epoxide

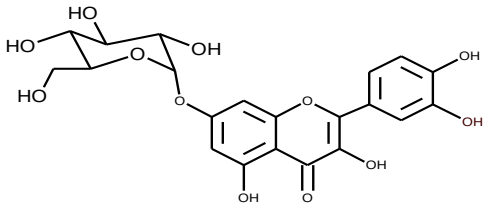
The isomerization of trans- to cis-lutein occurs by heat and the reverse cis- to trans- lutein happens by light in the absence of water in the living marigold flower. It is a chemical signaling mechanism of the marigold plant.The formation of *cis*-lutein gives a signal of heat damage with more evaporation of water and trigger repair mechanisms.The repair goes forward by sunlight and the reverse cis- to trans-isomerization stop the repair mechanisms.[5]

3.2 Flavonoids

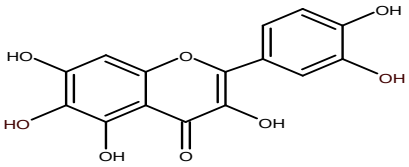
Various flavonoids are identified from the aqueous and methanolic extract of the flowers and leaves of *Tagetes erecta* like as quercetagetin, quercetagetrin and 6-hydroxy kaempferol-7-O-glucoside.The leaves extract also contains kaempferol, kaempferitrin and kaempferol-7-O-rhamnoside. The flowers of *Tagetes erecta* also show the presence of quercetin and 6-hydroxykaempferol-7-O-b-D-alloside.The water-ethanolic extract of *Tagetes patula* flowers contain patuletin and patulitrin and these compounds is only found during and after flowering and isorhamnetin-7-O-b-D-galactoside is indicated from the 90% ethanolic extract of shaded dried flowers of *Tagetes patula.*The methanolic extract of *Tagetes elliptica Sm*. contains eleven flavonol and their glycosides such as quercetin, quercetin-3-galactoside, quercetin-3(3",6"-diacetyl)galactoside, quercetin-3(2",3",4"-triacetyl)galactoside, quercetin-3(6"-galloyl)galactoside, quercetin-3-rhamnoside, quercetin-3-rhamnosyl-galactoside, isorhamnetin-3-rhamnosyl-glucoside, rhamnetin, isorhamnetin-3-galactoside and Myricetin-3-glucoside.The methanolic extracts of the leaves and flowers of *Tagetes argentina*, *Tagetes biflora, Tagetes perezi* and *Tagetes Laxa* hold eleven flavonoids like quercetin-3-methylether, quercetin-3-glucoside, quercetin-5-glucoside, quercetin-7-glucoside, quercetin-3-rhamnoside, quercetagetin-7-glucoside, kaempferol-3-glucoside, kaempferol-7-glucoside, myricetin-3-glucoside, myricetin-7-glucoside and patuletin-7-glucoside.[2]



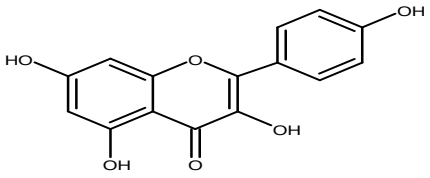
Quercetin



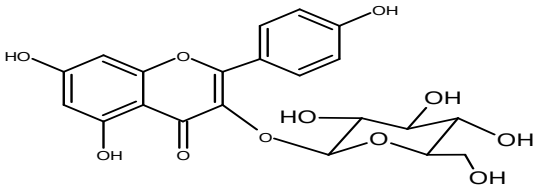
Quercetin-7-O-glucoside



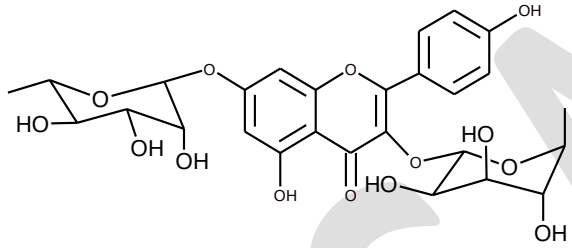
Quercetagetin



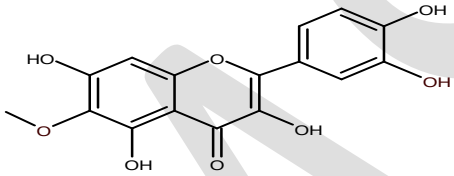
Kaempferol



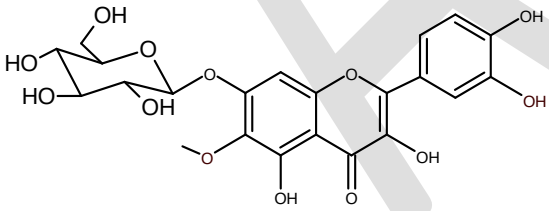
Kaempferol-3-O-glucoside



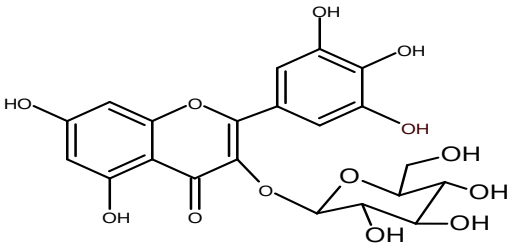
Kaempferitrin



Patuletin



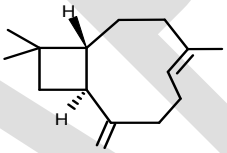
Patulitrin



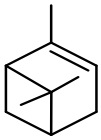
Myricetin-3-O-glucoside

3.3 Terpenoids

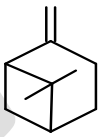
There are 35 compounds indicated in the essential oil of the leaves and flowers of 6 *Tagetes* species like *Tagetes erecta, Tagetes patula, Tagetes minuta, Tagetes filifolia, Tagetes tenuifolia* and *Tagetes lucida.* The essential oil of the *Tagetes erecta, Tagetes minuta, Tagetes patula* and *Tagetes tenuifolia* contain ocimenones, tagetones, dihydro-tagetone and piperitone.But the main constituent of *Tagetes filifolia* and *Tagetes lucida* is methyl chavicol. The essential oil of the leaves and flowers of *Tagetes erecta* contain several terpenes like geraniol, a-pinene, b-pinene and menthol. The essential oil of the flowers of *Tagetes erecta* also contain many other constituents including b-caryophyllene, d-carvone, p-cymene, eugenol, limonene, piperitone, piperitenone, terpinolene and 3 acyclic monoterpene ketones such as 3,7- dimethyloct-1-en-6-one; 3,7-dimethyloct-1,7-dien-6-one and 3,7-dimethyl-5-hydroxyoct-1-en-6-one. The essential oil of the leaves of *Tagetes erecta* also indicates the presence of b-phellandrene, ocimene, dipentene, linalool and tagetone.The essential oil of *Tagetes erecta* also shows the presence of aromadendrene, eudesmol, camphene, carvacrol, b-farnesene, myrcene, sabinene and thymol.[2]



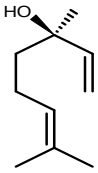
b-caryophyllene



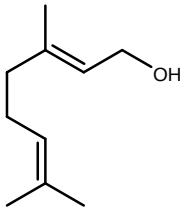
a-pinene



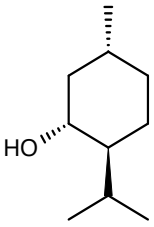
b-pinene



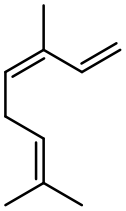
Linalool



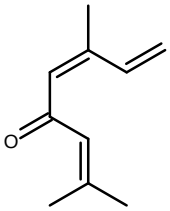
Geraniol



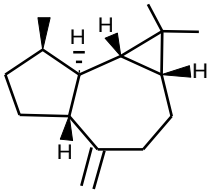
(-)-Menthol



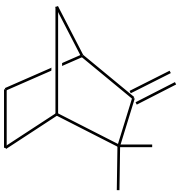
Ocimene



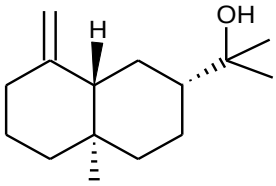
Ocimenone



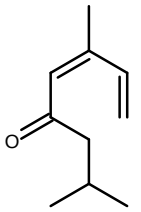
Aromadendrene



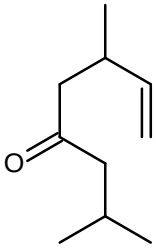
Camphene



Eudesmol

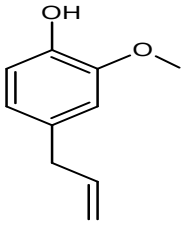


Tagetone

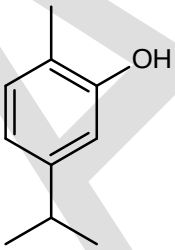


Dihydro-tagetone

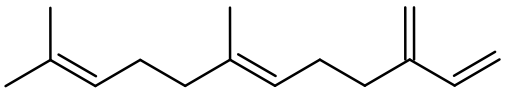
Myrcene



Eugenol



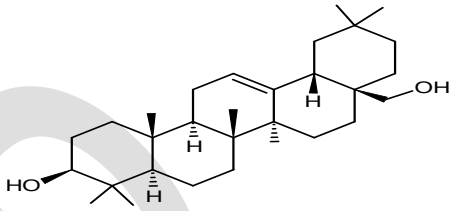
Carvacrol



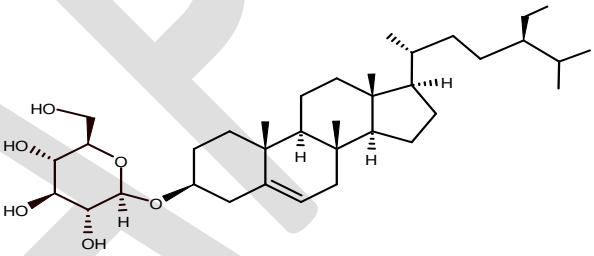
b-farnesene

3.4 Phenolic compounds

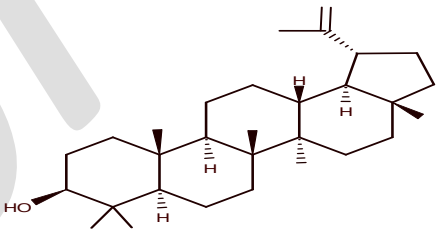
The ethanolic extract of marigold (*Tagetes erecta*) flowers contain several phenolic compounds like erythrodiol, erythrodiol-3-palmitate, β- daucosterol, lupeol, β – sitosterol, 7-hydroxy sitosterol etc. The dried flowers of *Tagetes erecta* also indicates the presence of another phenolic compounds such as syringic acid, eugenol, carvacrol and thymol with various other components such as ethyl gallate and methyl-3,5-dihydroxy-4-methoxy-benzoate.[4,2]



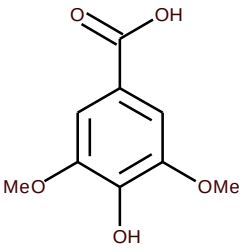
Erythrodiol



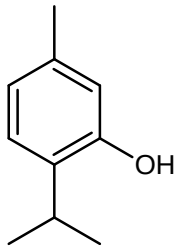
β- daucosterol



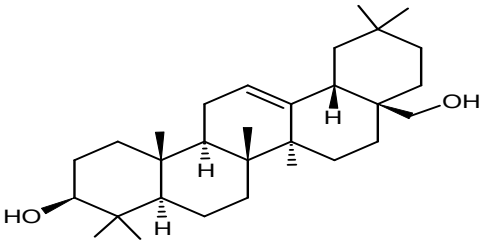
Lupeol



Syringic acid



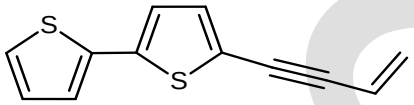
Thymol



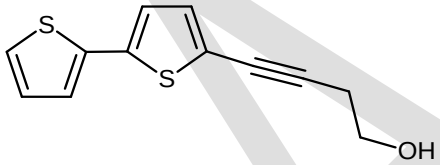
β – sitosterol

3.5 Thiophenes

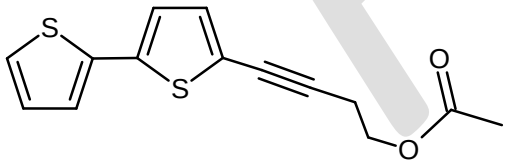
Several thiophenes are isolated from the root of *Tagetes erecta*. The ethyl acetate extract of the roots of *Tagetes erecta* contain a bithienyl derivative like 2-hydroxy methyl -non-3-ynoic acid- 2[2,2']-bithiophenyl-5-ethylester. The whole dried plant of*Tagetes erecta* indicates the presence of 5(but-1-ol-3-ynyl) -2,2'-bithienyl. The fresh roots of *Tagetes minuta* shows a terthienyl and 5(3-buten-1-ynyl)-2,2'-bithienyl. The flowers, stems and roots of *Tagetes patula* contain 4 thiophenes such as 5(3-buten-1-ynyl)-2,2'-bithienyl, 2,2'; 5'2"-terthienyl, 5(4-hydroxy-1-butenyl)-2,2'-bithienyl and 5(4-acetoxy-1-butenyl)-2,2'-bithienyl.[2]



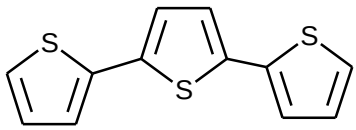
5(3-buten-1-ynyl)-2,2'-bithienyl



5(4-hydroxy-1-butenyl)-2,2'-bithienyl



5(4-acetoxy-1-butenyl)-2,2'-bithienyl



2,2'; 5'2"-terthienyl

4. Pharmacological activities

Different parts of the marigold (*Tagetes erecta L.) plant* is used as medicines, cosmetic and ornamental agent traditionally from ancient times. This plant leaves are used as an antiseptic agent and to cure of kidney troubles, muscular pain, pile, applied to boils, colds, rheumatism and bronchitis. The flowers are used to relief fever, epileptic, astringent, carminative, stomachic, scabies, liver and eyes diseases and purify blood. This plant is also used as anti-microbial, anti-oxidant, anti-plasmodial, anti-depressant and anti-cancer agents.[1,2,3]

4.1 Anti-bacterial activity

The flower parts show maximum inhibitory action against *Neisseria gonorrhoeae*.[6]The essential oil of the leaves of *Tagetes erecta* exhibit moderate antimicrobial activity against *Bacillus subtilis* and *Bacillus anthraces,* while slight activity is indicated against *Escherichia coli, Klebsiella pneumoniae, Salmonella typhimolium, Staphylococcus aureus, Pseudomonas agalactiae etc.*The aqueous, methanol, ethyl acetate, chloroform or petroleum ether extracts of the roots of *Tagetes erecta* show significant anti-bacterial activity against three Gram-positive bacterias such as *Staphylococcus aureus*, *Bacillus subtilis* and *Micrococcus luteus* and two Gram-negative bacterias like *Escherichia coli* and *Pseudomonas aeruginosa,* with minimum inhibitory concentrations (MIC) for the extracts ranging between12.5-100µg/mL**.** The flavonoids such as patulitrin is one of the constituents responsible for its anti-bacterial activity.[3,2]

4.2 Anti-microbial activity

The *Tagetes erecta* flower part shows maximum inhibitory action against Neisseria gonorrhoeae (NG) strain.The anti-microbial activity is used in Colombian traditional medicine for dermal infections. About 71% of the crude extract exhibits antibacterial activity against the antibiotic susceptible NG- strain, but 10% of the extract inhibits penicillinase producing NG-strain.[3]

4.3 Anti-cancer activity

The marigold plant is used as a medicinal herb for various therapeutic activities. The ethanol and ethyl acetate extracts of marigold flowers exhibits anti-cancer activity and also shows inhibitory effects on elastase and tyrosinase enzymes. These two extracts shows anti-cancer activity against the lung cancer and the colon cancer.[1]

4.4 Anti- inflammatory and anti- nociceptive activity

The anti-inflammatory and anti-nociceptive activity of methanol, chloroform and ether fraction of *Tagetes erecta* is exhibited by using acetic acid induced writhing in mice and carrageenan induced paw dropsy in the rat. The hydro-alcoholic extract of leaves of *Tagetes erecta* also shows anti-inflammatory and anti-nociceptive activity in mice.[1]

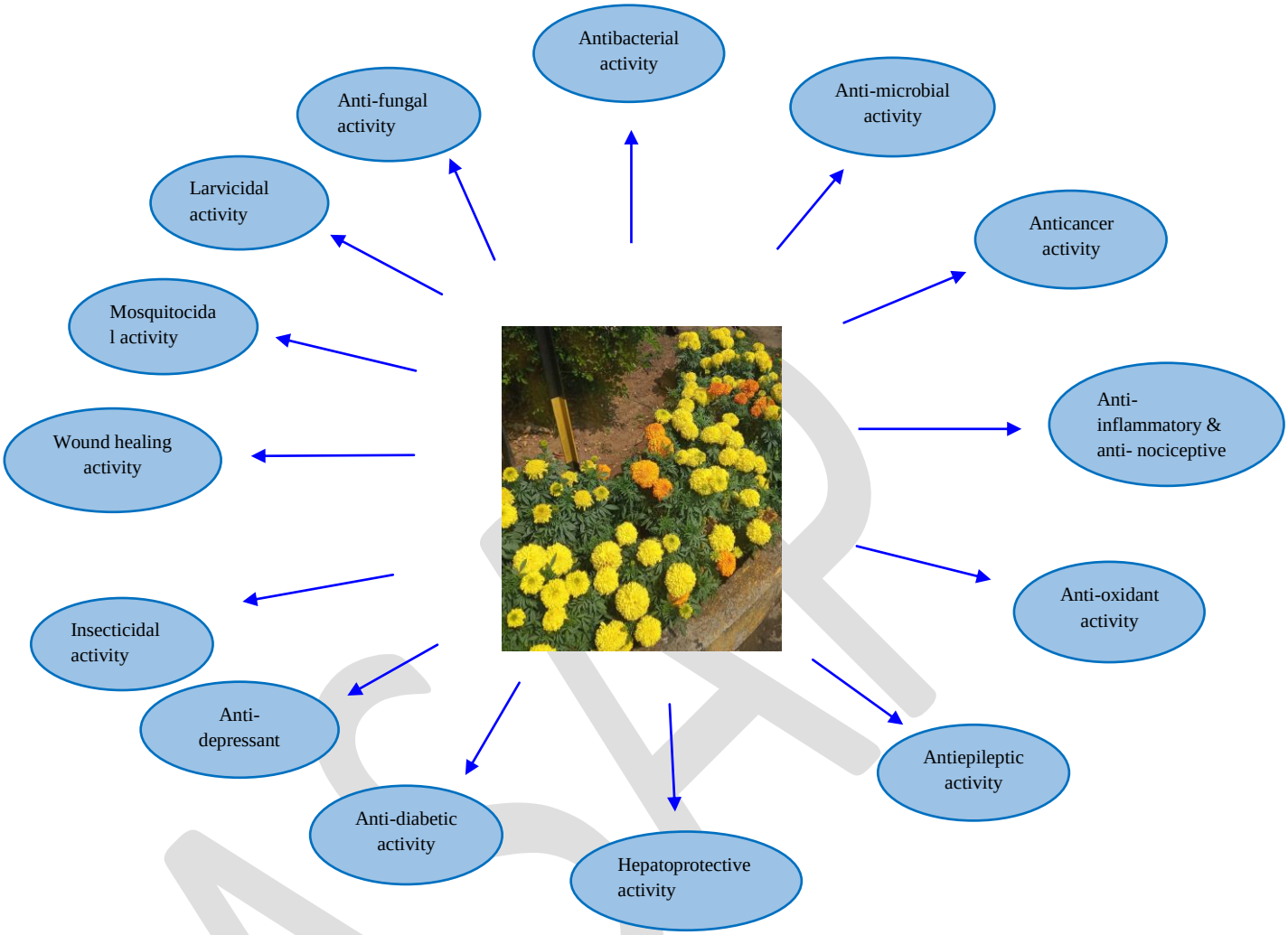


Figure 1: Schematic presentation of biological activities of flowers & leaves of Marigold (Tagetes erecta) plant.

4.5 Anti-oxidant activity

The ethanolic extract of marigold *(Tagetes erecta)* flowers shows anti-oxidant activity by three different tests like reducing power, DPPH and superoxide radical scavenging activity.*Tagetes erecta* exhibits better reducing power than the standard ascorbic acid and DPPH antioxidant activity and superoxide anion scavenging activity show less than standard.The essential oil of flowers of *Tagetes erecta* also shows anti-oxidant activity. Generally carotenoids like luteins are responsible for antioxidant activity of marigold.[1,2]


4.6 Antiepileptic activity

The ethanolic extract of *Tagetes erecta* exhibits antiepileptic activity.This extract reduces the seizure threshold in epileptic patient sand thus decreases epilepsy**.**This ethanolic extract is also used *in vivo* models such as pentobarbitone induced sleeping time, spontaneous locomotor activity, convulsions, helplessness test and forced swim test model.[1]

4.7 Hepatoprotective activity

The ethyl acetate extract of *T. erecta shows* hepatoprotective activity.When the liver of rats are treated with 400 mg/kg of this extract then this shows a significant hepatoprotective activity. Phytoconstituents such as flavonoids, terpenoids and steroids are responsible for this hepatoprotective activity. [1,3]

4.8 Anti-diabetic activity

The hydro-alcoholic extract of *Tagetes erecta* exhibits anti-diabetic activity. The standard diabetic drug glibenclamide, which increases blood glucose at 30 min followed by subsequently fall up to 120 min. The administration of *Tagetes erecta e*xtracts also increase the glucose levels after 30 min and fall up only after 120 min.[1]

4.9 Anti-depressant activity

The hydro-methanolic flower extract of *Tagetes erecta* shows some anti-depressant activity. The extract is used for anti-depressant effect by a forced swim test in mice. The *T. erecta* flowers significantly inhibit the immobility period in forced swim test in mice.[1]

4.10 Insecticidal activity

The *Tagetes* erecta flowers exhibits insecticidal activity against a stored product insect Triboliumcastaneum. The chloroform, petroleum ether and ethanol extract shows highest toxicity against both the larvae and adults of Triboliumcastaneum. No mortality is observed in control.Thus, the flower of *Tagetes* erecta is used as a pesticide against Triboliumcastaneum.[3]

4.11 Wound healing activity

The marigold extract shows the wound healing activity, which is tested on albino Wister rats.The 36 -male and female rats are randomly selected and divided into 4 groups (A, B, C and D). The test rats are fed normal rat feed, water and oral administration of 1.0ml of the petal extract of marigold.The initial blood picture of the animals are taken before administration of the extracts to the test rats.The results show that *Tagetes erecta* extract increases platelet count, white blood cell count and shortened the bleeding and clotting times.[3,1]

4.12 Mosquitocidal activity

The ethanolic, chloroform and petroleum ether extract of flowers of *Tagetes erecta* exhibits mosquitocidal effects against the larvae of *Culex quinquefasciatus*. [1,3]

4.13 Larvicidal activity

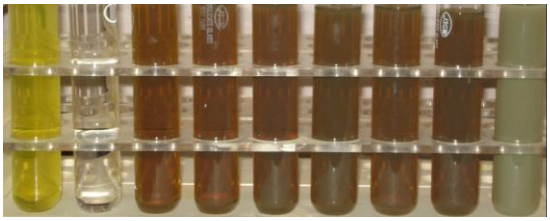
The essential oil of *Tagetes erecta* shows larvicidal activity against Aedes aegypti. The thiophenes in the *Tagetes erecta* mainly are responsible for anti-larvicidal activity. The larvicidal thiophene contents are higher in the roots and flowers.The essential oil is active against larvae of Aedes aegypti with LC90 of 100.84µg/ml and LC50 of 79.78 µg/ml.[3]

4.14 Anti-fungal activity

The essential oil of leaves of *Tagetes erecta* shows anti-fungal activity. It inhibits completely of the growth *Pythium aphanidermatum,* the damping-off pathogen, at a concentration of 2000 ppm.[1]

5. Preparation of silver nano-paticles

The silver nanoparticles (AgNPs) of marigold is prepared by mixing light yellow color marigold flower extract with aqueous solution of AgNO3 and kept overnight at room temperature. The formation of silver nanoparticles are observed by colour change. The intensity of color is directly proportional to the formation of AgNPs. The color change is very rapid and the solution is turned brown to dark brown and finally to black.[7]



(a) (b) (c) (d) (e) (f) (g) (h) (i)

Figure 2: **(**a) Marigold flower extract, (b) AgNO3 soln., (c)-(i) AgNPs with times(0,2,4,6,8,10 min & 2 h).[7]

The marigold extract is used as a reducing agent for Ag and a capping agent for silver nanoparticles. The silver nanoparticles have a strong ability to absorb and scatter light.The silver nanoparticle solution colour strongly depends upon the size and the shape of the particles.

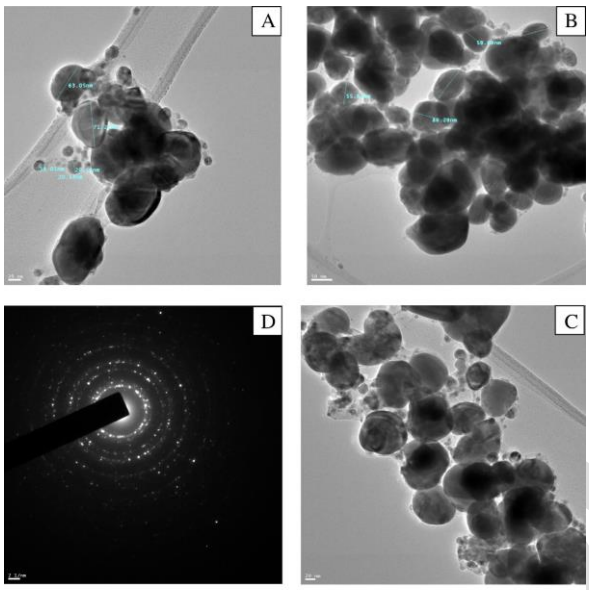


Figure 3: TEM images (A, B, C) of Ag nanoparticles(AgNPs) in low and high magnification, (D) SAED patterns of the silver nanoparticles.[7]

The Ag nanoparticles (AgNPs) is used for anti-bacterial activity against E. coli.[8] The zone of inhibition is wider in case of nano-sized silver than the normal silver.

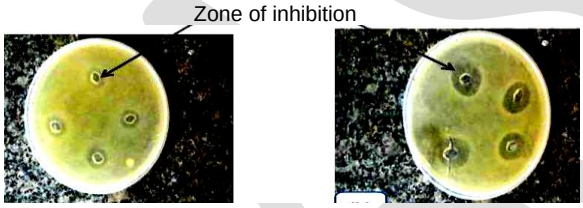


Figure 4**:** (a) Antibacterial activity of bulk silver showing lower zone of inhibition (5 mm), (b) Antibacterial activity of Ag nanoparticle (AgNPs) showing higher zone of inhibition (20 mm).[8]

The reduction of silver ions are occurred due to the water-soluble phytochemicals like flavonoids, tannins, triterpenes, glycosides and alkaloids present in the flower of T. erecta. AgNPs are used for the treatment of microbial infections.Thus, these ecofriendly silver nanoparticles can be used as an excellent antimicrobial agent against multi drug resistant pathogenic microorganisms.

6. Conclusion

The *Tagetes erecta* is an important medicinal plant containing various pharmacologically and medicinally important phytoconstituents. It has many traditional uses in different traditional system. It has a high tinctorial power and good heat and light stability. It is a cheaper source and easily available for yellow and orange color than other natural sources like turmeric, chill and saffron etc. Its flower is a cheaper source as a starting material for the isolation of lutein, the natural pigment that also serves as a nutraceutical. The dipalmitate ester of lutein is used as a major component of eye ointment for its antioxidant property. Its flower also uses as a good source of natural orange colorant in food applications. This review will definitely help the researchers to explore its different phytochemicals, properties and uses of *T. erecta* plant. There is wide scope for researcher using this plant in future as a source of useful phytochemical compound for the pharma industry.

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