

ANTIMICROBIAL POTENTIAL OF MARIGOLD: A COMPREHENSIVE REVIEW

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Article Received on 25 March 2026,
Article Revised on 16 April 2026,
Article Published on 01 May 2026,

<https://doi.org/10.5281/zenodo.19873964>

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How to cite this Article: Naina A. Tupat*,
Manjushri V. Lokhande, Ashwini S. Kohare,
Rita N. Soyam. (2026). Antimicrobial Potential
Of Marigold: A Comprehensive Review. World
Journal of Pharmaceutical Research, 15(9), 65-
83.

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ABSTRACT

Those bright marigolds, known scientifically as *Tagetes erecta* L., stand out because they can hinder many tiny invaders while packing a mix of natural chemicals. When skin acts up or bellies feel off, people have long turned to these flowers. What's inside? A team of compounds - flavonoids, carotenoids, phenolics, thiophenes, terpenes, oils, tannins, saponins - that don't let germs settle in. Power shows up by tearing down what harms germ walls, stopping key processes dead in their tracks, shutting down necessary enzymes, messing up DNA replication, causing internal disruption in cells, even jamming communication lines between bacteria. Lab tests show marigold juice works against hard-to-kill microbes such as *Staphylococcus aureus*, *Escherichia coli*, *Candida albicans*, plus *Fusarium* varieties - pointing toward usefulness in persistent infections. While everyday application seems harmless at first glance, issues arise due to possible sun reactions, allergy risks,

and a total lack of extended human trials. The ability to destroy pathogens is clear, although fluctuating natural ingredients within the plant lead to inconsistent results. Medical progress stalls because extracts differ wildly, animal testing remains rare, besides nearly absent evidence from real patients. Close inspection of *Tagetes erecta* reveals its form, preferred habitats, and long-standing role in traditional healing. Its effectiveness ties back to specific substances that stop damaging microorganisms through observable actions. Yet uncertainties appear alongside gaps in current scientific understanding. Progress will depend on refining methods and exploring more deeply its possible uses in medicine. Even with unresolved issues, interest grows around new directions this plant might open for study.

KEYWORDS: Tagetes spp., marigold, phytochemistry, antibacterial activity, leaf extract, flower extract, natural products, antimicrobial agents.

1. INTRODUCTION

A single type of healing herb, *Tagetes erecta*, holds many natural elements suitable for making lab-made medicines, both standard and non-standard ones.^[1] Every section of this plant finds purpose in addressing different health issues. Different forms of it show effects against microbes, fungi, insects, larvae, while also helping mood and reducing swelling. Scientists found numerous active substances inside, each carrying distinct medical traits.^[2] Long ago, people turned to such green life for remedies, pulling out chemical parts rich in protection against cell damage. Blooms especially pack a mix of built-in shields - phenols and flavonoids - that fight harmful molecules. These key components, mainly flavonoids plus acidic phenolics, stand strong in balancing unstable atoms within the body.^[3]

Some grow as tall as 80 centimeters, these *Tagetes* plants - around fifty kinds - all part of the daisy family. Standing over half a meter high, their narrow green leaves run anywhere from 5 to 17 centimeters in length.^[4] Blossoms appear around midsummer, staying visible until frost sets in. About five inches wide, these soft round flowers slowly open. Oil from the plant holds a noticeable aroma, blending compounds like laggerone with valeric acid, and ocimene alongside limonene. Hidden inside are high levels of carotenoids - important for those preparing remedies. The bloom's appearance matters too, appreciated beyond its chemical makeup.^[3] One plant holds several working parts. Early tests spot methyl-3,5-dihydroxy-4-methoxybenzoate first. Thienyl turns up with ethyl gallate nearby. Under lab settings, quercetagenin comes into view. Not far behind, quercetin makes an appearance quite regularly. Leaves and petals hold phenols deep inside. Over here, synergic acid shows up again and again. The flowers of *Tagetes erecta*, along with their stems, pack these chemicals. A few made it straight into medical products. Every substance takes a different road to application.^[2] Bright orange, yellow tones in flowers Blame it on high levels of carotenoids found in *Tagetes erecta*. Zeaxanthin shows up most often - lutein tags along too.^[5]

What gives marigold its power to fight microbes lies in how its natural chemicals team up. One after another, flavonoids like quercetin, luteolin, and patuletin block key enzyme actions, break down outer layers of cells, halt genetic material production. Instead of just one route, terpenes and oils - limonene, ocimene, tagetone - weaken bacteria and fungi by harming their walls or changing internal balance. From deep within *Tagetes* plants come thiophenes, sulfur-

rich substances that strike hard at both types of bacteria plus fungal invaders. As for phenolics, they flood microbial insides with reactive oxygen, warping proteins and fracturing DNA strands. Because these plant-based agents hit from several angles at once, stubborn germs still fall when exposed^[6]

Lab tests show golden shower plant parts block fungus spread. Alcohol-based solutions from leaves, flowers, or roots slowed *Fusarium* growth on plates. Higher doses worked better than lower ones. Strength of effect climbed as solution amount rose. This pattern points to a clear link between quantity used and result seen.^[7] What stood out was how well the alcohol-based leaf extract worked. Instead of water, using ethanol pulled more active compounds from *T. erecta* leaves. This version blocked fungi much better. Testing revealed it nearly stopped *Fusarium solani* cold - especially when used strong. Same went for *Fusarium moniliforme*; results hit full suppression under lab conditions. Strength depended on dose, but peak performance reached total shutdown.^[8]

One thing you notice about marigold (*Tagetes erecta*) is its ability to fight dangerous microbes using several methods at once, which slows down microbial adaptation. Rather than pinning everything on one approach, it draws from a range of chemicals found in nature - flavonoids, phenolic acids, terpenoids, along with sulfur-packed thiophenes. Each compound hits different weak spots in bacteria and fungi, reducing their odds of lasting long. Thanks to this blend, germs struggle to build defenses over time. Power here comes not from force, but from having many way to strike.^[9,10] Peeling away the surface spells trouble right away. After that, vital inner tools stop working - simple as that. Twisted blueprints mess up what they're made of. Everything falls apart after a point. The end shows up sooner than expected.^[9,11] Fighting back gets tough for bacteria when hit by parts of *Tagetes erecta*, since each piece acts differently yet lines up somehow.^[10,12] Not long ago, scientists spotted something odd - marigold juice blocking germs that laugh at common medicines. It also slows down some nasty molds you wouldn't want near wounds. That quiet lab result? Could mean doctors one day mix it into plans when pills stop working. Slowly, this plant quirk may reshape how we fight hard-to-kill bugs deep inside bodies.^[11,12]

2. BOTANICAL DISCRIPTION^[13,14,15]

➤ Leaf

Leaves wear green. On stems, they sit across from each other - sometimes just a little off. These leaves are oddly shaped, but only on certain parts - not bark, trunk, or limbs. The flat

part of the leaf stays under two inches long.



Fig. No. 1: Leaf.

➤ **Flower**

Flowers show up in shades like orange, sometimes leaning into gold, then shifting toward yellow. Their tones range where warmth meets light in uneven patches across petals.

A flower part stands out - its tube shape narrow, two centimeters long, built for females only. Inside, five male parts take space, stretched thin like threads. The pollen holder runs straight, topped with a fuzzy tip that catches what it needs. Not every bloom works this way, but this one does.



Fig.No. 2: Flower.

➤ **Root**

A twisty taproot spreads out with thin, threadlike offshoots. Though round in cross section, the stalk can feel grooved or flat-sided depending on age. Firm yet greenish in texture, it sometimes shows fine lines along its surface. When pressed, tiny ducts under the skin give off a mild aroma.



Fig. No. 3: Roots.

➤ **Seed**

Brownish black, around 8 to 10 millimeters long, with a jagged rim. The pappus sticks together, measures 4 to 4.5 millimeters, its parts sit crooked.



Fig. No. 4: Seeds.

3. TRADITIONAL USES^[16]

1. When it comes to handling different kinds of skin problems - say, swelling from infection or sores due to injury - Tagetes stands out. This plant helps ease conditions like varicose veins, breast tissue inflammation, blocked oil glands, tears near the anus, oozing sores on the face, swollen blood vessels around the lower bowel, along with many outer layer troubles. Its role shows up clearly where healing matters most.
2. Some people apply marigold - or Tagetes - directly on the skin to help with small problems such as sun damage or tiny burst blood vessels. The juice from its stalk, they say, might clear up hardened patches, rough growths, or bumpy spots over time.
3. Focusing on a Tagetes plant, Macer said, might sharpen sight while lifting spirits.
4. Over there in South Asia, bright yellow and orange Tagetes blooms often dress up temples and sacred spots. These blossoms also wind into garlands. People hand them out during weddings instead of keeping them hidden. At memorials, they appear too, tucked

beside quiet moments. Events of all kinds carry their color - offered not because rules say so but because hands reach for beauty when words fall short.

5. Fresh marigold petals give a natural color when processed carefully. These plant-based tones go into treats eaten by humans or fed to livestock. Extracted slowly, the hue fits right into everyday items meant for consumption. From garden to plate, it travels without synthetic help. Nature's palette shows up bright in meals and feed alike.
6. From ancient times, folks have used *Tagetes* leaves to help heal cuts and sores. These greens also come into play when dealing with stomach ulcers or swollen veins. When it comes to kidney troubles, people turn to this plant too. Sore muscles find relief through its application. Ground up, the leaves become a paste spread on painful skin lumps. Boils and deep infections respond well to this natural touch.

4. ETHANOMEDICAL USES

Tagetes erecta Linn flowers have been utilised historically since antiquity. Folk medicine uses this plant's different parts, especially its bloom, to treat a variety of illnesses. Leaves are applied to boils, kidney problems, muscle aches, and piles in addition to being utilised as an antiseptic. According to Ayurveda, the flower is used to treat fever, epileptic fits, astringent, carminative, stomachic, scabies, liver problems, and eye disorders. They are claimed to purify blood, and flower juice is used to treat bronchitis, rheumatism, colds, and bleeding piles.^[17,18] was utilised by the Cherokee as a yellow dye and skin wash.^[17,18,19] In India, floral juices are sometimes used as a cure for piles and as a blood purifier. In Brazil, vermifuge is made from infusions of flowers and leaves. Decoctions of flowers and leaves were employed as carminatives and diuretics by Mexicans. Marigold was utilised by the Aztecs to treat eye problems. Marigold is used to treat muscle spasms and joint pain in Brazil and Mexico. *Tagetes* is also used in folklore to treat anaemia, irregular menstruation, abdominal pain, and pain in the muscles and bones. *Tagetes* is used internally to treat diarrhoea, cough, colic, and indigestion. externally applied to rheumatism, ulcers, eczema, and painful eyes.^[19,20,21]

5. PHYTOCHEMICAL CONSTITUENTS

Compound Class	Specific Compounds	Distribution in <i>Tagetes</i> Species	Key Functions & Properties	Variability & Influencing Factors	References
Carotenoid	Lutein, Zeaxanthin	Predominant in flower petals of <i>T. erecta</i> and <i>T. patula</i> ; highest in <i>T. erecta</i>	Major pigments responsible for yellow-orange coloration;	Lutein:zeaxanthin in ratio ranges from 4:1 to 19:1; levels	C. Zhu <i>et al.</i> (2021), A.J.Melende

			potent antioxidants; protect against oxidative stress; linked to eye health (macular pigmentation)	depend on species, cultivar, maturity, and growing conditions	z-Martinez <i>et al.</i> (2021)
Carotenoid	β -Carotene, α -Cryptoxanthin, Antheraxanthin	Minor components in flowers of various species	Provitamin A activity (β -carotene), antioxidant effects	Present in lower concentrations; fluctuates with environmental factors	W.Liu <i>et al.</i> (2023) M. Gonzanlez-Castejon <i>et al.</i> (2022)
Flavonoid	Patuletin (and its glycosides)	Major flavonoid in <i>T. patula</i> , especially in flowers	Strong antioxidant and anti-inflammatory properties; contributes to UV protection in plants	Concentration varies with cultivar and plant part	Y.Chen <i>et al.</i> (2021)
Flavonoid	Quercetin and Kaempferol (as glycosides)	Found in leaves and flowers across multiple <i>Tagetes</i> species	Antioxidant, anti-inflammatory, potential anticancer effects	Levels influenced by growth stage and environmental stressors	J.H.Kim <i>et al.</i> (2023)
Flavonoid	Myricetin, Isorhamnetin, derivatives	Detected in some <i>Tagetes</i> species	Additional antioxidant and phytoprotective roles	Presence varies between species and chemotypes	P. Rajedran <i>et al.</i> (2022)
Thiophene	α -Terthienyl	Mainly in roots, trace amounts in aerial parts; more prominent in <i>T. patula</i> and <i>T. minuta</i>	Potent antimicrobial, antifungal, nematicidal, and phototoxic activities; active under UV light	Biosynthesis induced by biotic/abiotic stress; affected by soil and climate	U. Lopez-Aroche <i>et al.</i> (2021)
Thiophene	BBT, BBTOAc, other derivatives	Identified in root exudates and extracts	Enhanced bioactivity, especially against nematodes and soil-borne pathogens	Structural diversity increases efficacy across pathogens	I.Marroti <i>et al.</i> (2023)
Essential Oil	Ocimene, Dihydrotagetone, Tagetone,	Characteristic of <i>T. minuta</i> ; high yield in flowers and leaves	Insect-repellent, antimicrobial, fragrance	Strongly influenced by geographic	S.N. Garg <i>et al.</i> (2022)

	Tagetenone		applications; used in perfumery and agrochemicals	origin, harvest time, and distillation method	
Essential Oil	Limonene, Piperitone, Piperitenone	Abundant in <i>T. patula</i> essential oil	Aromatic, antimicrobial, insecticidal properties; contributes to strong scent	Chemotype variation observed within species	R. Perenz-Sanchez <i>et al.</i> (2021)
Essential Oil	Limonene, (Z)- β -Ocimene, Dihydrotagetone	Dominant in <i>T. erecta</i> oils	Pleasant aroma; used in cosmetics and natural pesticides	Composition changes with plant maturity and ecological conditions	J.Zhang <i>et al.</i> (2023)
Other Compound	Caffeic acid, Chlorogenic acid, Gallic acid (phenolic acids)	Present in leaves, stems, and flowers of several <i>Tagetes</i> species	Antioxidant, anti-inflammatory, role in plant defense mechanisms	Content varies significantly with genotype and environment	B.R.Rao <i>et al.</i>
Other Compound	Tannins	Found in leaves and stems	Astringent properties, defense against herbivores, antimicrobial effects	Higher tannin content in mature plant tissues	v. sharma <i>et al.</i> (2021)
Other Compound	Saponins	Distributed in various plant parts	Membrane-disrupting agents; contribute to antifungal and antiparasitic activity	Concentrations vary; may synergize with thiophenes	Y,liu <i>et al.</i> (2023)

6. MECHANISM OF ACTION

Mechanism of Antimicrobial Action of Marigold (*Tagetes erecta*.) A bloom named marigold - particularly the sorts tagged as *Tagetes erecta* and *Tagetes patula* - holds strength against numerous tiny invaders. That ability springs from compounds within, teaming up without effort. Thiophenes take part, along with flavonoids and terpenoids tagging in. Phenols join too, while essential oils mix into the blend, backed by alkaloids stepping forward. Together, these pieces build a powerful result. Explained by focusing on a few main steps:

1. Disruption of Microbial Cell Membrane^[37]: Inside marigold, thiophenes mingle with oily parts that reach into microbe walls, making them leaky. Because of this shift, what is

held inside - like salts, enzymes, genetic material - spills out. With their inner world unraveling, microbes collapse, unable to survive. Bacteria and fungi meet their end through this breakdown.

2. Inhibition of Cell Wall Synthesis^[38]: When plant pieces such as phenolics or flavonoids step in, they interfere with bacterial tools responsible for constructing cell walls. These disruptions leave the walls shaky. Gram-positive kinds tend to feel this effect more than others.

3. Protein Denaturation and Enzyme Inhibition^[38]: Marigold substances grab onto microbe catalysts, holding firm. As a result, vital protein jobs in the microbes fail to run smoothly. This interference causes critical activities to drag or freeze altogether. Without functional catalysts, power production stumbles badly. Meanwhile, duplicating genetic material runs into trouble to.

4. Interference with Nucleic Acid Synthesis^[39]: Beyond their scent, some plant compounds slip between DNA strands of microbes. These particular molecules mess up enzymes that manage genetic copying. As a result, tiny invaders struggle to multiply or even function. One type, built with sulfur rings, acts like a wedge where it does not belong. Replication halts when such blockers take hold.

5. Generation of Reactive Oxygen Species (ROS)^[37]: Under sunlight or body-like settings, compounds from Tagetes plants produce unstable oxygen forms that push cells into stress mode. When these reactive molecules build up, they harm fats, enzymes, and genetic material inside microbes. Damage piles up until the microbe can no longer survive. The result is breakdown of harmful organisms at a cellular level.

6. Antifungal Action via Ergosterol Disruption^[40]: Fungal membranes lose stability when marigold compounds interfere with ergosterol production. This shift weakens structure, slowing down spore sprouting along with threadlike spread. Growth halts as the internal balance breaks apart.

7. Quorum Sensing Inhibition^[41]: Fungal membranes lose stability when marigold compounds interfere with ergosterol production. This shift weakens structure, slowing down spore sprouting along with threadlike spread. Growth halts as the internal balance breaks apart.

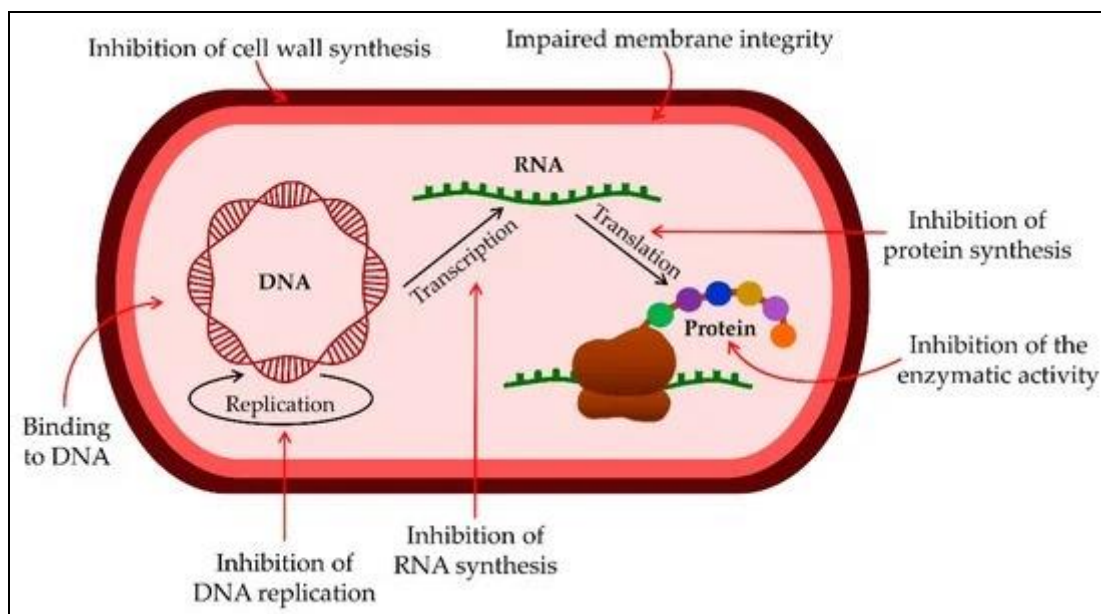


Fig. No. 5: Mechanism of Antimicrobial Action.

7. ANTIMICROBIAL STUDIES

What fights germs in medicine and industry? Antimicrobial substances do. Scientists now push harder to design fresh types of them because old ones fail more often. Resistance grows, answers must change. A natural material called chitosan shows promise - it blocks many microbes, breaks down safely in nature, works well inside bodies. Yet how it acts depends on what kind of germ meets which physical traits. Another option rises: carbon dots. These tiny particles glow oddly, play nice with living tissue, open doors for attack strategies. Their power shifts based on structure and target.^[42]

What was thought to cause brain diseases turns out to fight microbes too. These amyloid bits poke holes in germs' outer layers. Clumping invaders together is another trick they seem to use. New medicines might come from this surprising trait.^[43] Some tiny metal particles, like those made with silver and special carbon rings, show strong ability to fight microbes by slowly giving off active silver ion.^[44,45]

Now researchers dig into fresh ways to fight dangerous microbes. Some antibiotics evolve slowly, whereas new compounds aim at stubborn bugs. Clues pop up in odd places - tiny particles spark ideas, natural extracts help, even rival germs pitch in. One never-before-seen form of *Bacillus subtilis* turns out to block *S. aureus*, along with *E. coli*. Little by little, findings grow from tests run in labs worldwide. Progress creeps ahead, one fragment at a time, while researchers keep examining substances active against common lab microbes -

Staphylococcus aureus, Bacillus subtilis, E. coli, or Candida albicans too.^[46] From a quiet start, some versions of 2-phenyl-quinoline-4-carboxylic acid suddenly worked well on S. aureus and E. coli. The strongest one stood out - on purpose - noticed by how much it slowed growth.^[47] Surprisingly some tetracyclic 1,4-benzothiazine compounds worked better than fluconazole on C. albicans.^[48]

8. SAFETY AND TOXICITY STUDIES

Section	Key Findings & Precautions
Toxicity Studies	- Acute: Safe up to 5,000 mg/kg in rats. ^[49] - Sub-chronic: No adverse effects at 1,000 mg/kg/day for 90 days. ^[50] - Genotoxicity: No mutagenic potential in standard assays. ^[51]
Allergenic Potential	- Risk: Contact dermatitis (florists/gardeners). - Cross-reactivity: Sensitivity in Asteraceae allergy sufferers. ^[52-53]
Phototoxicity	- Mechanism: Thiophenes may cause UV-induced ROS (skin irritation). ^[54] - Precaution: Avoid sun exposure post-topical use of thiophene-rich extracts. ^[55]
Reproductive Safety	- Animal Study: No fetal adverse effects at 1,000 mg/kg/day in rats. ^[56] - Human Data Needed: Limited evidence for pregnancy/lactation safety.
Herb-Drug Interactions	- Anticoagulants: Vitamin K in some species may interfere. ^[57] - CYP450 Enzymes: Flavonoids may affect drug metabolism (uncertain clinical significance). ^[58]
Contamination Risks	- Heavy Metals: Accumulate from soil; require rigorous testing. ^[59] - Pesticides: Agricultural practices must minimize residues. ^[60] - Adulteration: Synthetic dyes used to enhance color; demand quality control. ^[61]

9. LIMITATIONS

No.	Limitation	Brief Description	References
1	Variation in phytochemical composition	Antimicrobial activity varies with geography, climate, soil, plant age, and harvesting season, causing inconsistent results.	B. Salehi <i>et al.</i> (2018)
2	Lack of extract standardization	Different plant parts, solvents, and extraction methods reduce reproducibility and comparison across studies.	N. Mejia-Resendiz <i>et al.</i> (2022)
3	Predominantly in vitro evidence	Most studies are limited to laboratory assays, with insufficient in vivo and clinical validation.	P. Gupta <i>et al.</i> (2012)
4	Reduced activity against Gram-negative bacteria	Gram-negative bacteria show resistance due to their protective outer membrane.	S. Walia <i>et al.</i> (2020)
5	High MIC values	Effective antimicrobial action often requires high concentrations, limiting practical formulation use.	S.Dutta <i>et al.</i> (2017)

6	Phototoxicity and skin sensitivity	Thiophenes like α -terthienyl may cause phototoxic reactions, restricting topical applications.	W.M. Rampone <i>et al.</i> (1986)
7	Stability and formulation challenges	Volatile compounds are prone to oxidation, leading to reduced efficacy during storage.	F.Bakkali <i>et al.</i> (2008)
8	Limited long-term safety data	Insufficient toxicological and drug-interaction studies, especially for prolonged oral use.	WHO (2023)

10. FUTURE PROSPECTS^[70]

Tagetes (Marigold) Innovation & Applications

— 1. HEALTH & NUTRITION

- | |
- | |— Personalized Nutrition
 - | | |— Tailored supplements based on genetics & health needs
- | |
- | |— Nutraceutical Beverages
 - | | |— Functional drinks with Tagetes extracts
- | |
- | |— Novel Food Applications
 - | | |— Plant-based meats & innovative food products

— 2. PHARMACEUTICAL & THERAPEUTIC

- | |
- | |— Drug Discovery
 - | | |— Screen compounds for anti-inflammatory & anticancer uses
- | |
- | |— Combination Therapies
 - | | |— Tagetes as adjuvant to enhance conventional drugs

— 3. ADVANCED DELIVERY & FORMULATION

- | |
- | |— Novel Delivery Systems
 - | | |— Nanoencapsulation for improved bioavailability
- | |
- | |— Cosmeceuticals

- | └─ Skincare with cosmetic + therapeutic effects
- |
- | └─ 4. SUSTAINABLE COSMETICS
- | |
- | | └─ Sustainable Beauty
- | | └─ Eco-friendly products with responsibly sourced Tagetes
- |
- | └─ 5. AGRICULTURAL INNOVATION
- |
- | └─ Bioengineering
- | └─ Develop pest-resistant Tagetes varieties
- |
- | └─ Sustainable Agriculture
- | └─ Use in crop rotation & soil health management

11. CONCLUSION

Flowers like *Tagetes erecta* pack a punch when it comes to fighting microbes. Their strength lies in natural chemicals - think flavonoids, thiophenes, terpenoids, phenolics, even aromatic oils. Instead of just one way of working, they target germs by breaking down cell coverings while also blocking key life processes inside them. Because of this double move, harmful bugs struggle to survive around these extracts. Resistance seems less likely compared to common lab-made drugs. Lab tests show solid results, yes, yet real-world proof still trails behind. One big snag? Each plant batch varies; there is no uniform measure so far. Medical trials on people remain sparse. Still, what we see hints at usefulness beyond petri dishes. Medicine makers might find value here, if more live testing follows. For now, the flower stands halfway between tradition and science.

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