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A Comprehensive Review on Phytochemical and Medicinal Properties of Tagetes Erecta (Marigold)

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ABSTRACT: Tagetes erecta, commonly known as Marigold, has been reffered for its medicinal and cosmetic properties for centuries. Its flower extracts have been utilized in traditional medicine and skincare rituals for their anti-inflammatory, antioxidant, and antimicrobial properties. This review aims to summarize the current state of knowledge on the cosmetic applications of Tagetes erecta flower extracts, focusing on topical uses.

The phytochemical constituents of Marigold, including flavonoids, terpenoids, and carotenoids, have been shown to protect the skin against UV-induced damage and oxidative stress, soothe irritated skin, and exhibit antimicrobial activity against acne-causing bacteria. The cosmetic industry can leverage Marigold's versatile properties to address various skin and hair concerns through innovative formulations. Future research directions include investigating Marigold's synergistic effects with other natural ingredients and assessing its stability and efficacy in commercial products.

The potential benefits of Marigold extracts in cosmetic applications underscore the need for further investigation, paving the way for sustainable, natural, and effective skincare solutions. Exploring Marigold's cosmetic potential can facilitate the development of natural and effective skincare products.

Keywords: Tagetes erecta, anti-oxidant, traditional medicine, ayurvedic, anti-inflammatory, phytochemical constituents

I. INTRODUCTION

Tagetes is a term used to describe periodically or fragile, largely herbal products which belongs from the (Asteraceae) family, which includes sunflowers. In 1753, Linnaeus defined it as an organizational structure. The salutary effect of this herbal plant generally possesses a wide range of secondary metabolites produced in the compounds similar as glycosides, alkaloids, flavonoids, tannins, carotenoids etc.[1]

The remedial value of Tagetes erecta, generally known as Marigold, has been honored in different systems of traditional drug for the treatment of different mortal affections. Natural products of plant have been used throughout the traditional history for various purposes. Numerous of these natural products have natural exertion that can involve in medicine discovery and medicine design. The Indian system of drug known as "Ayurveda" uses substantially factory- grounded medicines or phrasings to treat various affections, including cancer. Herbal medicines have great growth eventually in the global request. Exploration work on the chemistry of natural products, pharmacognosy, pharmaceutics, pharmacology and clinical rectifiers have been carried out on herbal medicines and utmost of the leading pharmaceutical pots have revised their strategies in favour of natural products. Numerous herbal remedies collectively or in combination have been recommended in different medical courses for the cure of different conditions. For cosmetic applications, we also observed their antioxidant, tyrosinase inhibitory and anti-inflammatory activities involving the prevention of skin aging or skin whitening.[2] The native approach of delivering healthcare uses a variety of plant species and naturally produced compounds from plants to treat infectious disorders. The main driving force for the use of herbs as antibacterial sources has been the rise in drug resistance in human illnesses to widely used as an antibiotic.[3] The leaves are said to be beneficial for wounds, ulcers, renal problems, muscle aches, and piles. Boils and carbuncles are treated externally with the pulverisedleaves.The area of herbal medicine has

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experienced exponential expansion in the previous few decades. It is becoming more well-known in both developed and developing nations because of its natural origin and little negative effects.[4]Tagetes erecta plants range in height from 0.1 to 2.2 m and have multiple branches. The flowers are big and vary in colour depending on the variety. Flowers come in a variety of yellow and orange tints, including light yellow, golden yellow, bright yellow, deep orange, and bright orange. Although Tagetes species thrive in nearly any type of soil, they prefer soil with adequate drainage. Marigold is a popular plant due to its easy cultural practices,adaptability,abundant flowering, long bloomingtime, problem-free nature, appealing colours, form, size, and acceptable storage quality.Marigolds are commonly used to make garlands during religious occasions. Flowers can be used for a variety of purposes, including wreaths, floral décor, flower baskets, cut flowers, bedding and potting, and product manufacturing. Marigold has the ability to provide natural products utilised in pharmaceuticals, such as meal producing goods, colourant preparation, oil extraction, & pigment extraction (particularly xanthophylls).[5]

- **Morphological characteristics -**

Although there are some perennial bushes, Tagetes species are usually fragrant, annual plants. Some of their morphological characteristics are: -

a) **Stems:** Upright, branching, and frequently tall depends on the species, from 0.1- 2.0 meters.
b) **Leaves:** Sharply complex leaves, featuring leaflets that have curved edges and ranges from lanceolate to linear-lanceolate. There are oil glands on the leaves that release a distinct, pungent smell when crushed.
c) **Flowers:** Arranged in flower heads, or capitula. This can be found apart or in corymbs. The ray Traditionally are yellow, orange, or multicolored, flowers whereas disk florets are typically orange or yellow.
d) **Seeds:** Long, black achenes, frequently with two to three retrorsely thorny leaf blades which rise from the pappus.[6]

II. BOTANICAL DESCRIPTION (T. ERECTA)

Widely used garden plants like marigolds are upright, branching, and quite coarse, reaching a height of around one meter. But there are also miniature or short forms. The leaves have cutting edges and severe incisings. Solitary, long-stalked, and thickening upward flower heads are present. The blooms are orange, brownish-yellow, or brilliant yellow.[7]

2.1 Synonyms -

Tagetes erecta has various synonyms and regional names. It is usually referred to as the African marigold or Aztec marigold. These are below some Tagetes erecta's main botanical and common synonyms -

Figure no.1. African marigold

Figure no.2. Aztec marigold

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Figure no.3. Mexican marigold

1. African Marigold
2. Aztec Marigold
3. Mexican Marigold[1]

2.2 Taxonomical Classification -

Scientific classification of T. erecta L as follows: -

Kingdom: Plantae,
Order: Asterales
Family: Asteraceae
Genus: Tagetes
Species: T. erecta
Binomial name: T. erecta L[1]

2.3 Geographical distribution and habitat:

The most common Tagetes are African marigold, scientifically known as Tagetes erecta L. The title Tagetes is begun from the title of the Etruscan Tages. It has a place to a Asteraceae family and tagetes sort, containing almost 50 species. They develop up to 50-80 cm in stature, the clears out are green, lanceolate and between 5 - 17 cm in length. The leaves and stems are secured with little hairs, the edges ofthe leaf can be wavy.

This plant needs temperatures between 20°C-30°C
and blossoms develop expansive sum every year in winter and precipitation seasons.It is a herb, commonly known as marigold, local of mexico and other hotter parts of america and develops too in the tropics and subtropics regions.The plant is locally known as Genda Phool.

Truly, marigold has been utilized all over India, Indonesia and China as a flavor, therapeutic operator and fancy reason. In India, these were presented by the Portuguese. Marigold flowers have distinctive colors like yellow and orange being the most common. The Marigolds spread rapidly since of the ease in development, longer blossoming period and lovely flowers with fabulous rack life. They are broadly utilized for making garlands,religious give up and shows. Tagetes erecta L. is utilized for the treatment of a different of maladies. It is utilized as a nematocide, restorative and restorative specialist.
The essential oil of the blossom contains cancer prevention agents.[8]

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III. SIX IMPORTANT SPECIES OF GENUS TAGETES -

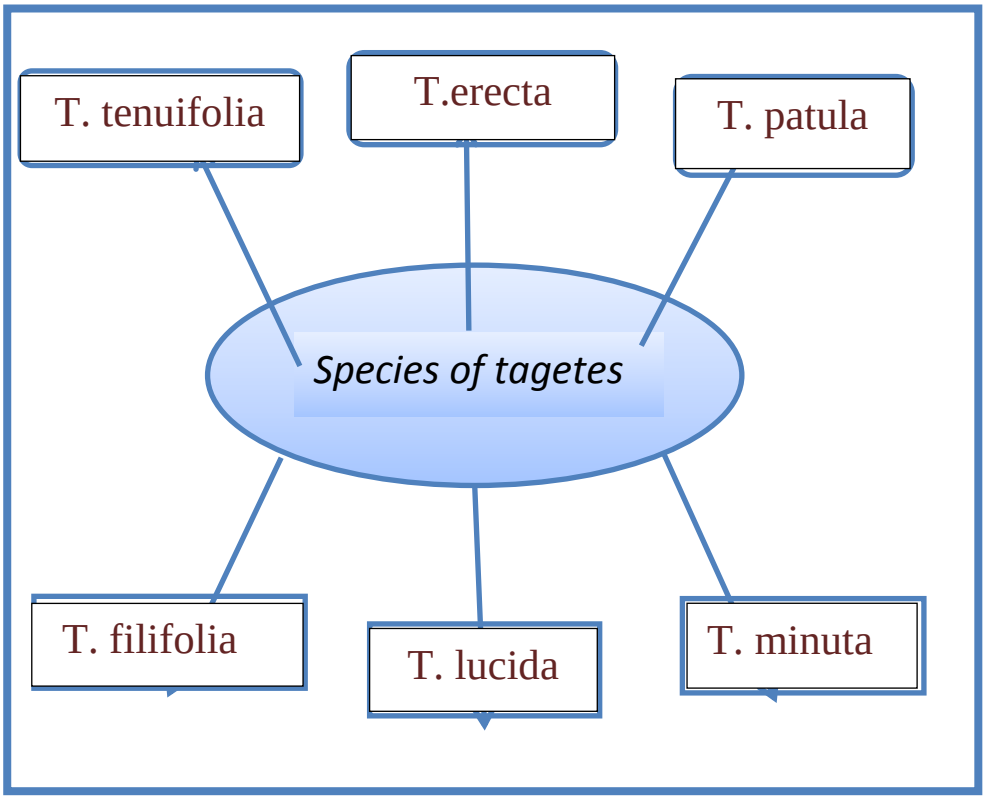

Figure no.4. Most important species of Genus tagetes[9]

IV. PHYTOCHEMICAL COMPOSITION

The plant Tagetes erecta, commonly referred to as marigold, is a major source of flavonoids, carotenoids, terpenoids, and essential oils, among other phytochemicals. Many of its therapeutic qualities, such as its antibacterial, anti-inflammatory, antioxidant, and anticancer effects, are attributed to these bioactive chemicals. An extensive list of the main phytochemicals (bioactive compounds) present in Tagetes erecta is presented below[6]-

4.1. Carotenoids - The most important bioactive compounds in Tagetes species is carotenoids, particularly in T.erecta. The flower petals are especially rich in these pigments.[10]

A. Lutein and zeaxanthin -In Tagetes erecta, the two main carotenoids are "lutein" and "zeaxanthin". These substances are widely recognized for their ability to lower the risk of age-related macular degeneration, therefore improving eye health.[10]

B. β-carotene - Another significant carotenoid with antioxidant properties is "β-carotene", which also acts as a precursor to vitamin A.[10]

4.2 Flavonoids- Another important constituent of bioactive compounds in Tagetes species areflavonoids, which provides antioxidant and anti-inflammatory properties.[11]

A. Quercetin and kaempferol -Tagetes erecta has a significant number of flavonoids, including as quercetin and kaempferol, which support the plant's anti-inflammatory and antioxidant properties. Both quercetin and kaempferol have been investigated for their potential anticancer effects and are known to prevent cells from oxidative stress.[11]

B. Coumarins and Tannins- Small amounts of coumarins and tannins are also found, which are added in the plant's astringent and antibacterial qualities.[11]

4.3.Essential Oils-Tagetes species' essential oils are complicated combinations of volatile

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substances, mostly terpenes and terpenoids. The arrangement can differ widely between species and even within those species that are based on their geographic location and Environmental components.[6]

A. Tagetes minuta: Usually comprised of tagetone, tagetenone, dihydrotagetone, and ocimene.[6]

B. Tagetespatula: Most commonly has elevated concentrations of piperitenone, limonene, and piperitone.[6]

C. Tagetes erecta: Distinguished by elevated levels of dihydrotagetone, limonene, and (Z)-β-ocimene.[6]

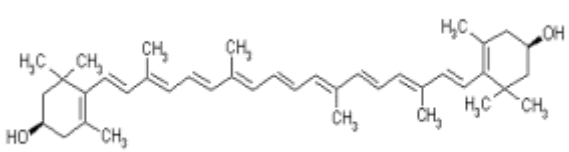
4.4 Chemical constituents -

The majority chemical compounds, including thiophenes, flavonoids, carotenoids, and essential oils, have been isolated as a result of phytochemical investigations conducted on its various elements.[12]

Research has indicated that T. erecta is linked to several biomolecules, including phenolics, syringic acid, methyl-3, 5-dihydroxy-4-methoxybenzoate, quercetin, thienyl and ethyl gallate, and quercetagetin glucoside.The leaves are said to be beneficial for wounds, ulcers, kidney problems, muscle aches, and piles. Boils and carbuncles are treated externally with the pulverized leaves. It is said to possess analgesic, antimycotic, and antioxidant properties. GC-MS analysis has found 18 active chemicals, many of which are terpenoids.[19–21] The flower is used in Ayurvedic medicine to treat fevers, epileptic fits, stomachic ailments, scabies, liver complaints, astringent, carminative, and eye diseases. They are believed to purify blood, and flower juice is administered to treat rheumatism, colds, bronchitis, and bleeding piles.[13] Lutein is an oxycarotenoid, also known as xanthophyll, that shares the basic C-40 isoprenoid structure with all carotenoids. It also has two cyclic end groups, one beta and one alpha-ionone ring. It is the primary pigment and one of Tagetes erecta's key components.[7]Tagetes erecta flowers are mostly composed of carotenoid compounds, which comprise all trans and cis isomers of zeaxanthines (5%), all trans and cis isomers of lutein, and lutein esters (88%).[14]\

The T. erecta floral part β-sitosterol, β-daucosterol, and 7-~ 63 are bioactive phytochemical elements that are present in the plant's flower part and have been confirmed and released previously. https://www.pharmacyjournal.org/ is the International Journal of Pharmacy and Pharmaceutical Science. hydroxysitosterol, erythrodiol, lupeol, and erythrodiol1-[5-(1-propyn-1-yl)-[2,2-bithiophen] -3-palmitate-5-yl]Syringic acid, gallic acid, kaempferol, quercetagetin, quercetagetin-7-methyl ether, ethanone,α-terthienyl, and quercetagetinDisyringic acid 3-β-galalctosyl, 3-α galalctosyl, Oplediol, 6-ethoxy-2,4-dimethylquinoline (3S,6R,7E)-hydroxy-4,7-megastigmadien-9-one, palmitin, ethylene glycol linoleate, n-hexadecane, hexadecanoic acid, 7-tetra decenal (z), vitamin E, and norolean - 12-ene, carotenoid all trans and cis isomers of zeaxanthines, all trans and cis isomers of lutein, and lutein esters.[15]

{Table no.1.} - Major constituents of Tagetes erecta

Chemical constituents	Molecular formula	Structure
1. Zeaxanthines	**C40H56O2**	

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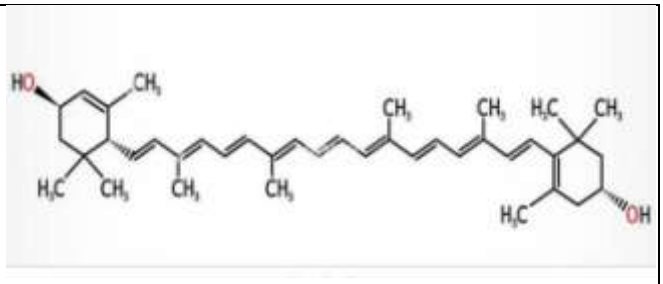
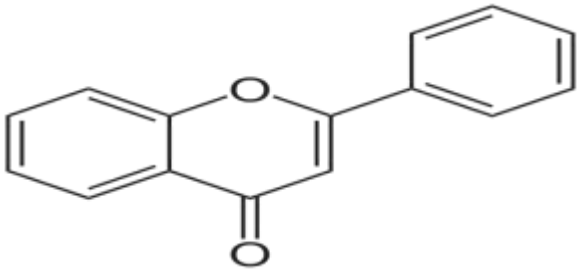
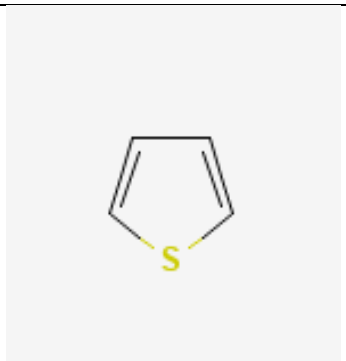
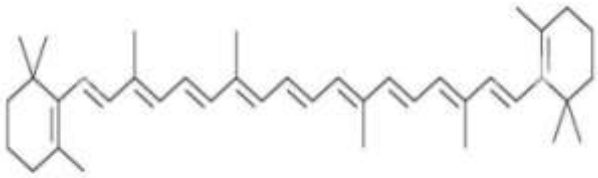
2. Lutein	**C40H56O2**	
3. Flavonoids	**C15H12O2**	
4. Thiophenes	**C4H4S**	
5. Carotenoids	**C40H56**	

4.5 Methods of extraction and analysis -

4.5.1 Solvent and Fractionation Extraction –

The cold temperature percolation method was used to extract the dry powder of the flower petals individually.[16] Various organic solvents, including hexane, toluene, ethyl acetate, acetone, methanol, and water, were used in the process. A conical flask containing 100 ml of hexane and 10 grams of dried powder was placed on a rotary shaker set at 120 rpm for a full day while cotton wool was placed inside. After 24 hours, the extract was centrifuged for 10 minutes at 5000 rpm after being filtered through eight layers of muslin fabric. The solvent was evaporated and the supernatant was collected. After that, the residue was put into several conical flasks that were sealed with cotton wool and held on to contain 100 ml of solvents (toluene, ethyl acetate, acetone, methanol, and water) by a 24-hour rotary shaker running at 120 rpm. After 24 hours, the extract was centrifuged for 10 minutes at 5000 rpm after being filtered through eight layers of muslin fabric. After collecting the supernatant and evaporating the solvents, the dry extract was sealed in airtight bottles and kept at 4°C. To determine the extraction yield, the extracts were weighed. Fractionation - The solvent-solvent

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partition method was used to separate the acetone extract from the flower.[17]

4.5.2 Sequential extraction -

The technique is based on the extraction of the drug's active ingredients utilizing a variety of solvents, from polar to non-polar. Water, methanol, petroleum ether, and chloroform are the solvents that are employed. To prepare the different Tagetes erecta flower extracts, the stepwise solvent extraction method was used. The components were extracted one after the other using solvents in ascending polarity order (non-polar to polar). In this procedure, the material that dissolves in a certain range of polarity in a solvent was extracted, and the residue was then extracted using a different solvent. Using a Soxhlet system, the powder (200 g) was extracted consecutively for 8 hours in petroleum ether, chloroform, and methanol. Following the extraction of methanol, the residual dried marc was macerated in distilled water for three days. The residue was then filtered out, and the filtrate was concentrated to create an aqueous extract. A rotary evaporator was used to concentrate each extract, and an oven dryer set at 35–40 °C was used to dry them. Extracts that had dried were kept for later use.[18]

4.5.3 Maceration Extraction -

This is a basic and conventional extraction technique involves submerging the plant material in a solvent, like ethanol or methanol, in order to extract the targeted chemicals. This technique is frequently applied to Tagetes erecta in order to extract flavonoids, phenolic acids, and other beneficial substances. The powdered plant materials that were crushed and underwent maceration. For four days, the powdered substance was immersed in 90% ethanol. Twice a day, the mixture was stirred. The combination was filtered and the marc was pressed after the fourth day. There were three repetitions of this process. After mixing the whole alcoholic fraction, the ethanol was allowed to evaporate. The material that had a syrupy consistency was boiled in a water bath until a dry extract was produced. Tagetes erecta flowers were so extracted and their ethanolic extract was marked and kept in a desiccator until needed later.[19]

V. PHARMACOLOGICAL PROPERTIES

5.1 Antioxidant properties -

Three distinct assays were utilized to measure in vitro antioxidant activity: DPPH, reducing power, and super oxide radical scavenging activity at varying doses. Ascorbic acid is the standard in all three assays; Tagetes erecta outperforms it in terms of reducing power, although super oxide anion scavenging activity and DPPH antioxidant activity are below standard. Investigations were conducted on the extracts' antioxidant activity as well as the antioxidant chemicals' composition. The extracts containing varying amounts of total phenolic and flavanoids showed significant variation with different solvents ($P<0.05$). The extract containing ethyl alcohol/water (7:3, v/v) had the highest amount of total phenolic and flavanoids, with 62.33 mg GAE/g and 97.00 mg RE/g, respectively (Chivde et al., 2011).[20]

5.2 Anti-Inflammatory Effects -

It has been found that Tagetes erecta, a plant of the Asteraceae family, has significant anti-inflammatory effects.[21] Its flower heads have potent anti-inflammatory properties in their extracts.[22] In addition, Tagetes erectus L. leaves were traditionally used in Indian traditional medicine to reduce inflammation and pain. Additionally, it has been discovered that Tagetes erecta extract has antinociceptive and anti-inflammatory qualities (23). Toll-like receptor 4 (TLR4)/MD-2 complex is the target of the polyphenol-enriched extract from its petals, which reduces inflammation.[24]

5. 3 Antimicrobial Activity -

It was shown that multiple Tagetes erecta flower solvents had antibacterial action against the following bacteria: Bacillus cereus, Escherchia coli, Campylobacter coli, Klebsiella pneumoniae, Pseudomonas aeruginosa, Proteus vulgaris, Streptococcus mutans, and Streptococcus pyogenes. The flavonoid has a maximal zone of inhibition (29.50 mm) for Klebsiella pneumoniae and has antibacterial action against all strains tested. The flavonoid Patuletin found in glycosidic form Patulitrin as well is one of the potential factors for its antibacterial activity.[25]

Ruddock et al. investigated that the antibacterial activity of 19 plants used in traditional Colombian medicine for cutaneous illnesses using a disc susceptibility assay. The T. erecta flower's various sections showed the greatest inhibitory activity against the NG strain.[26] Rhama and Madhavan demonstrated in a different investigation that one of the main causes of T. erecta's antibacterial action is the presence of flavonoids such as patulitrin.[27] Numerous scientists have looked into the possibility of antimicrobial action

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in various Tagetes erecta extracts. Padalia and Chanda used hexane, toluene, acetone, methanol, ethyl acetate, and water to extract T. erecta flowers. They examined the extracts antibacterial properties against four strains of fungus, eight-gram positive bacteria, and eight-gram negative bacteria. Aqueous extract demonstrated activity against E. aerogenes, P. pseudoalcaligenes, and P. morganii. Nearly all strains of gram-negative bacteria were inhibited by the polar solvent's methanol and acetone. The most effective extract against K. pneumoniae was hexane. Acetone and ethyl acetate showed the strongest antibacterial efficacy against L. monocytogenes and B. cereus when applied to gram-positive bacteria. Hexane extract works similarly against B. cereus and C. rubrum. Eight grams of positive and eight grams of negative strains were studied, K. pneumoniae and B. cereus were prevented by all solvent extracts excluding aqueous extract.[28]

5.4 Skin soothing and wound healing properties –

Several cell types, including keratinocytes, fibroblasts, endothelial cells, and inflammatory cells, interact with one another during the skin's regeneration and healing process. Phases include coagulation (haemostasis, fibrin clot formation, and platelet-activated clotting flow); inflammation (neutrophil and monocyte migration, bacterial phagocytosis, and release of proteolytic enzymes to remove the wound); proliferation (artery wall cell angiogenesis and tissue maturation (fibroblast-mediated collagen/ECM transformation).[29]

VI. APPLICATIONS OF (T. ERECTA) IN COSMETICS

7.1 Topical Gel -

A wide range of phytochemicals, including flavonoids, phenolic acids, and carotenoids, are loaded in the flower. Numerous pharmacological effects, including antioxidant, antibacterial, hepatoprotective, analgesic, and wound healing properties, have been linked to these components. The current goal is to create a topical gel containing flower extract from T. erecta which is used to treat skin infections.[30]

7.2. Anti-bacterial/ Anti-acne cream -

In today's medicine, topical therapies are typically used in combination with anti-acne medications to relieve localized irritation, inflammation, and heat (around which the infection develops in the skin tissue). It is used to reduce skin inflammation and pore blockage, which trap oil in the skin and result in acne (acne vulgaris).[31]

7.3. Anti-aging / UVprotection lotion -

Marigold, or Tagetes erecta, is a plant that has been shown to have anti-aging and UV protection qualities. Studies has demonstrated that Tagetes erecta flower extract has a significant deal of potential as an anti-photoaging agent, preserving skin thickness and reducing photoaging indications.[32]

The extract has also been shown to reduce oxidative damage, thereby preventing human skin from photoaging. [33] Additionally, it has been discovered that Tagetes erecta lutein ester contains sunscreen properties that prevent the skin from UV ray damage.[34] Exploration has also been done on the creation of herbal creams that contain Tagetes erecta extracts, and their findings look positive in terms of reducing the aging process and enhancing skin health.[35]

VII. SAFETY AND TOXICITY

Tagetes erecta, commonly known as marigold, is a widely recognized annual herbaceous plant with a rich history of traditional use in medicine and cosmetics. However, its safety and toxicity have been a topic of concern, with various studies evaluating its potential effects on human health and the environment.

8.1. Impurity and Contamination –

To ensure their safe usage, Tagetes products must be guaranteed to be pure and of high quality:Hazardous elements Knowing that marigold plants can absorb harmful elements from the soil, it's important to obtain and test raw materials carefully.[36] Chemical contaminants in order to prevent chemical contamination, proper agricultural practices and testing are needed.[37] Intoxication reports of contamination with synthetic pigments is to improve color highlight for strict quality control procedures.[38]

8.2. Regulatory Status -

The administrative status of Tagetes arrangements changes by nation and planning use:

A. Nourishment added substances: -

Marigold extracts are generally recognized as securefor utilize as nourishment colorants in numerous countries.

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B. Dietary supplements: -

Directed in an unexpected way over jurisdictions, with shifting necessities for beneficial and safety data.While the accessible prove recommends by and large favorable security profile for Tagetes species, assist research is required to completely characterize their long-term security and potential interactions. Healthcare providers and shoppers ought to be mindful of these considerations when utilizing or prescribing marigold-based items.[6]

VIII. CONCLUSION

An extensive number of phytochemical components, such as flavonoids, carotenoids, essential oils, and phenolic acids, are present in Tagetes erecta, commonly known as marigold, and they all contribute to its many therapeutic benefits. The plant's many medicinal uses, such as its anti-inflammatory, antioxidant, antibacterial, and anticancer properties, are all referred to these bioactive components. The herb has been used traditionally in many cultures to cure conditions like eye infections, gastrointestinal problems, and skin illnesses. Current study provides scientific evidence to support these uses.

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