RESEARCH PAPER

Pharmacognostical, Phytochemical and Wound Healing Evaluation of Tagetes erecta Flowers

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ABSTRACT

Background: Tagetes erecta L. (Asteraceae), or African marigold, is an ornamental plant native to Mexico and Central America and now widely cultivated worldwide. Beyond its aesthetic value, it is widely used in Ayurveda, Unani, and folk medicine to treat wounds, skin disorders, and inflammatory conditions. Yet, despite its broad ethnobotanical use, comprehensive scientific evaluation of its flowers for wound-healing potential, including detailed pharmacognostical and phytochemical characterization, remains limited.

Objective: This study aims to provide a holistic scientific evaluation of Tagetes erecta flowers by establishing pharmacognostical standards, conducting detailed phytochemical profiling, and validating its wound healing efficacy through in vitro and in vivo models.

Methods: Fresh and dried flowers of Tagetes erecta underwent pharmacognostical evaluation (macroscopic, microscopic, powder microscopy, and physicochemical analysis). Successive solvent extraction used petroleum ether, ethyl acetate, ethanol, and water. Phytochemical screening, carotenoid estimation, and TLC/HPTLC analyses were conducted. Wound healing activity was tested in vitro (L929 fibroblast scratch assay) and in vivo (excision wound model in Wistar rats) using 1% and 2% w/w ethyl acetate extract ointments, assessing wound contraction, epithelialization time, and histopathology.

Results: The study revealed characteristic pharmacognostical features such as capitulum inflorescence, anisocytic stomata, multicellular trichomes, and echinate pollen grains. Phytochemical analysis confirmed the presence of flavonoids, carotenoids, terpenoids, alkaloids, and tannins. The ethyl acetate extract, in particular, demonstrated significant wound healing activity, as evidenced by enhanced fibroblast migration in vitro and accelerated wound contraction, reduced epithelialization time. In vivo, the 2% extract-treated group showed enhanced wound contraction (97.8 ± 1.1%) and reduced epithelialization period (14.9 ± 0.7 days). Histopathology indicated improved tissue regeneration.

Conclusion: The findings scientifically validate the traditional use of Tagetes erecta flowers in wound healing and establish reliable quality control parameters, supporting its therapeutic potential.

Keywords: Tagetes erecta, Marigold, Pharmacognosy, Phytochemistry, Wound Healing, Carotenoids, Excision Wound Model, Lutein

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1. Introduction

Wound healing is a highly coordinated, intricate biological process that restores the structural and functional integrity of injured tissue. This dynamic process encompasses four overlapping but distinct phases: haemostasis, inflammation, proliferation (involving granulation tissue formation, angiogenesis, and re-epithelialization), and remodelling (maturation of collagen and scar tissue formation) [1, 2]. Disruption at any stage can lead to chronic, nonhealing wounds, which represent a significant global healthcare burden. Chronic wounds, including diabetic ulcers, pressure sores, and venous leg ulcers, affect an estimated 6.5 million patients in the United States alone, with annual treatment costs exceeding $25 billion [3, 4].

The increasing prevalence of diabetes and an aging population further exacerbate this public health challenge [5].

Modern wound care management employs a range of strategies, including debridement, infection control, moisture retentive dressings, growth factors, and skin substitutes [6, 7]. However, limitations such as high cost, potential side effects, limited accessibility in developing regions, and incomplete healing outcomes necessitate the exploration of alternative and complementary therapeutic approaches [8, 9].

Medicinal plants have served as a primary source of wound healing agents for millennia across diverse cultures [10]. The World Health Organization (WHO) estimates that approximately 80% of the world's population relies on traditional medicine for primary healthcare, with plant-based remedies playing a central role in wound management [11]. Phytochemicals exert multifaceted effects on the wound healing cascade, including antimicrobial activity, anti-inflammatory modulation, antioxidant protection, and stimulation of cell proliferation and extracellular matrix synthesis [12, 13].

Tagetes erecta L., commonly known as African marigold, Aztec marigold, or simply marigold, is an annual herbaceous plant belonging to the family Asteraceae [14]. Native to Mexico and Central America, it has been widely naturalized and cultivated across the globe for its ornamental value and traditional medicinal uses [15, 16]. The genus name *Tagetes* is derived from the Etruscan deity Tages, while the species epithet *erecta* refers to its erect growth habit [17].

In traditional medicine systems, *Tagetes erecta* has a rich history of therapeutic application. In Ayurveda, the flowers are used to treat wounds, ulcers, skin diseases, and eye infections [18, 19]. Unani medicine employs marigold for its anti-inflammatory, analgesic, and wound healing properties [20]. Mexican traditional medicine utilizes the plant for gastrointestinal ailments, fevers, and skin lesions [21]. Folk medicine in various parts of India, Brazil, and Africa involves the topical application of flower paste or infusions for cuts, burns, bruises, and infected wounds [22-24]. The vivid yellow to orange pigmentation of the flowers is attributed to carotenoids, particularly lutein, which has also been associated with antioxidant and anti-inflammatory activities [25, 26].

Previous scientific investigations on *Tagetes erecta* have primarily focused on its bioactive constituents. Phytochemical studies have identified a wide array of compounds, including flavonoids, carotenoids (lutein), thiophenes, terpenoids, and essential oils [27-32]. Pharmacological studies have demonstrated its antioxidant [33, 34], anti-inflammatory [35, 36], antimicrobial [37, 38], hepatoprotective [39], and anticancer activities [40, 41]. A limited number of studies have explored its wound healing potential, reporting promising results [42, 43]. However, these studies often lack comprehensive standardization, detailed phytochemical correlation, and a full mechanistic exploration using both in vitro and in vivo models. Moreover, systematic pharmacognostical standards for quality control of *Tagetes erecta* flowers are insufficiently documented.

The study aims to conduct a comprehensive pharmacognostical evaluation of *Tagetes erecta* flowers, including macroscopic and microscopic analysis, powder characteristics, and physicochemical parameters, in order to establish reliable quality control standards. It further seeks to perform sequential extraction and undertake detailed qualitative and quantitative phytochemical profiling, including HPTLC analysis of bioactive markers. Additionally, the research evaluates the in vitro wound healing potential of the extracts using a fibroblast scratch migration assay. Finally, the study assesses the in vivo wound healing efficacy of a formulated ointment containing the most active extract using an excision wound model in rats, supported by histopathological examination.

2. Materials and Methods

2.1. Plant Material Collection and Authentication

2.1.1 Plant material

The flowers of *Tagetes erecta Linn.* were obtained from the local Surroundings at Dehradun, Uttarakhand, and it was authenticated by Dr. Anoop Chandra, Scientist-F & In-charge Systematic Botany Discipline, Botany Division, Forest Research Institute, Dehradun- 248006. **(Authentication No. 1996/Dis./2018/Syst.Bot./Rev.Gen./4-5)**

The fresh flowers of *Tagetes erecta* were collected and washed thoroughly under running tap water. The flowers were allowed to shed-dry after being rinsed with distilled water. The dried plant material was coarsely powdered and subjected to extraction.

2.2. Pharmacognostical Evaluation

2.2.1. Macroscopic Analysis

Fresh flowers were examined for organoleptic characteristics including colour, Odor, taste, size, shape, and arrangement of florets. Floral morphology, including the structure of the involucre, ligulate (ray) florets, and tubular (disc) florets, was documented following standard botanical procedures [44, 45].

2.2.2. Microscopic Analysis

Transverse Section (T.S.) of Florets: Fresh ray and disc florets were fixed in formalin acetic acid alcohol (FAA). Freehand sections were taken, cleared with chloral hydrate, stained with phloroglucinol HCl (for lignified elements) and safranin fast green, and mounted in glycerine for microscopic observation [46, 47].

Powder Microscopy: Dried flower powder was treated with chloral hydrate to clear cell contents and stained with appropriate reagents (phloroglucinol HCl, iodine, Sudan III) to identify characteristic cell types, trichomes, pollen grains, and secretory structures [48, 49].

Pollen Grain Analysis: Pollen grains were examined for shape, size, exine ornamentation, and aperture type using acetolysis method [50 - 51].

2.2.3. Physicochemical Parameters

The powdered flower material was used to determine various physicochemical parameters according to WHO guidelines and the Ayurvedic Pharmacopoeia of India: loss on drying (LOD), total ash, acid insoluble ash, water soluble ash, and extractive values (water soluble, alcohol soluble) [52, 53].

2.3. Extraction

The shaded dried flowers were coarsely powdered. Successive Soxhlet extraction was performed using solvents of increasing polarity: petroleum ether, ethyl acetate, ethanol (95%), followed by aqueous extraction via maceration [54]. Each extract was concentrated under reduced pressure using a rotary evaporator, lyophilized, and stored in airtight containers at 4°C until further use. The yield percentage was calculated for each extract.

2.4. Phytochemical Analysis

2.4.1. Preliminary Phytochemical Screening

All extracts were subjected to qualitative chemical tests to identify major phytoconstituents: alkaloids (Mayer's, Wagner's, Dragendorff's tests), carbohydrates (Molisch's test), glycosides (Keller Killiani test), saponins (foam test), flavonoids (Shinoda test, alkaline reagent test), tannins (ferric chloride test), terpenoids (Salkowski test), and proteins (Biuret test) [55 - 58].

2.4.2. Total Carotenoid Content

The total carotenoid content of the *Tagetes erecta* flower extract was found to be appreciably high, reflecting its rich phytochemical composition and strong antioxidant potential. Carotenoids, particularly lutein and related xanthophylls, are the predominant pigments responsible for the characteristic yellow–orange coloration of the flowers. Quantitative estimation revealed that the extract contains a significant number of total carotenoids, expressed as β-carotene equivalents, indicating its potential as a natural source of antioxidant compounds. The high carotenoid content contributes to free radical scavenging activity and may play a crucial role in enhancing wound healing by reducing oxidative stress at the site of injury. These findings support the therapeutic relevance of *Tagetes erecta* flower extract in pharmaceutical and cosmeceutical applications. [59 - 60].

2.4.3. High Performance Thin Layer Chromatography (HPTLC) Analysis

A reverse phase HPTLC method was developed for the quantification of key marker compounds (lutein) in the ethyl-acetate extract. Compounds were identified and quantified by comparing retention times and spectra with authentic standards [61].

2.5. Wound Healing Evaluation

2.5.1. In Vitro Scratch Assay

The scratch assay demonstrated a significant, concentration-dependent effect of the ethyl acetate extract of *Tagetes erecta* flower on fibroblast migration. At 48 hours, the wound closure percentage for the control group was 47.6 ± 2.9%, whereas the 100 µg/mL extract-treated group showed a closure of 91.3 ± 2.5% ($p < 0.001$). This indicates a strong stimulation of cell proliferation and migration. The percentage of wound closure was calculated using ImageJ software [62, 63].

2.5.2. In Vivo Excision Wound Model

Animals: Adult Wistar rats (150 to 200g) of either sex were obtained from Animal House, IFTM University, Lodhipur, Rajput, Moradabad, Reg. No.: 837/PO/ReBiBt/S/04/CPCSEA. Animals were housed under standard conditions 12 h light/dark cycle, 25 ± 2°C, 50-60% humidity with free access to food and water. The study protocol was approved by the Institutional Animal Ethics Committee (IAEC) **Protocol Approval No. IAEC/2024/26/04**.

Experimental Design: Animals were randomly divided into four groups **(n=6 per group)**:

Group I (Control): Animals treated with Simple Ointment Base.

Group II (Standard): Animals treated with 1% w/w Soframycin (framycetin) Ointment.

Group III (Test 1%): Animals treated with 1% w/w Ethyl-acetate flower extract Ointment.

Group IV (Test 2%): Animals treated with 2% w/w Ethyl-acetate flower extract Ointment.

Formulation of Ointment: The ethyl-acetate extract was incorporated into a simple ointment base using a geometric mixing method to achieve final concentrations of 1% w/w and 2% w/w.

2.5.3. Excision Wound Creation: On day 0, animals were anesthetized with ketamine (40 mg/kg) intraperitoneally. The dorsal fur was shaved and cleaned. A full thickness excision wound of approximately 300 mm^2 (2 cm × 1.5 cm) was created on the shaved dorsal region using a sterile surgical blade and pointed forceps [64, 65]. The wound was left undressed.

2.5.4. Wound Treatment: Topical applications of the respective formulations (approximately 0.5 g) were applied once daily for the entire study duration until complete epithelialization.

2.5.5. Wound Contraction and Epithelialization:

Wound Area Measurement: The wound area was traced on transparent graph paper on days 0, 4, 8, 12, 16, and 18. The traced area was measured [66]. The percentage of wound contraction was calculated using the formula:

% Wound Contraction = [(Initial wound area Wound area on day n) / Initial wound area] × 100

Epithelialization Period: The time (days) required for complete wound closure with no raw area remaining was recorded for each animal [67].

3. Histopathological Examination: On day 18, the animals were euthanized by CO_2 asphyxiation. Full-thickness skin specimens were obtained from the previously wounded but clinically healed areas. The tissues were fixed in 10% neutral buffered formalin, processed for paraffin embedding, sectioned at a thickness of 5 µm, and stained with haematoxylin and eosin (H&E) to evaluate overall tissue architecture, and with Masson's trichrome to assess collagen fibre deposition and organization. A pathologist, blinded to the treatment allocation, examined the histological sections under a light microscope and evaluated key parameters of wound repair, including re-epithelialization, granulation tissue formation, collagen deposition, inflammatory cell infiltration, and angiogenesis. [68, 69].

3.1. Statistical Analysis

All experiments were performed in triplicate, and data were expressed as mean ± standard deviation (SD) or standard error of the mean (SEM). Statistical comparisons between groups were made using oneway analysis of variance (ANOVA) followed by Tukey's post hoc test. A pvalue < 0.05 was considered statistically significant. GraphPad Prism software (Version 8.0) was used for statistical analysis.

4. Results

4.1. Pharmacognostical Evaluation

Pharmacognostical evaluation of *Tagetes erecta* flowers confirmed their identity, purity, and suitability for medicinal use. Macroscopically, the flowers had bright yellow to orange florets, an aromatic odor, and a slightly bitter taste. Microscopy revealed multicellular covering and glandular trichomes, spiny pollen, and pigment-filled parenchyma; powder microscopy showed epidermal fragments, vascular elements, and numerous carotenoid-rich cells. Physicochemical parameters (ash, extractive values, moisture) were within acceptable limits, indicating good-quality crude drug. These standardized criteria support reliable identification and authentication of *Tagetes erecta* flowers in herbal formulations and help prevent adulteration.

Figure No: 1 *Tagetes erecta* flowers

4.2.1. Macroscopic (Organoleptic) Evaluation

The fresh flowers of *Tagetes erecta* were examined for their morphological features. The flowers of *Tagetes erecta* were large, solitary, terminal, and pedunculate capitulum (head) inflorescence (Figure 1A). The capitulum was approximately 58 cm in diameter. The involucre was campanulate, composed of a single whorl of green, fused bracts. The receptacle was convex and naked. The florets were of two types: (a) Ligulate (Ray) florets: Numerous, arranged in 23 rows, yellow to deep orange in colour, pistillate, with a strap shaped, 3toothed ligule; (b) Tubular (Disc) florets: Numerous, centrally located, yellow to orange, bisexual, with a cylindrical, 5 lobed corollas. The flowers had a characteristic aromatic Odor and a slightly bitter taste.

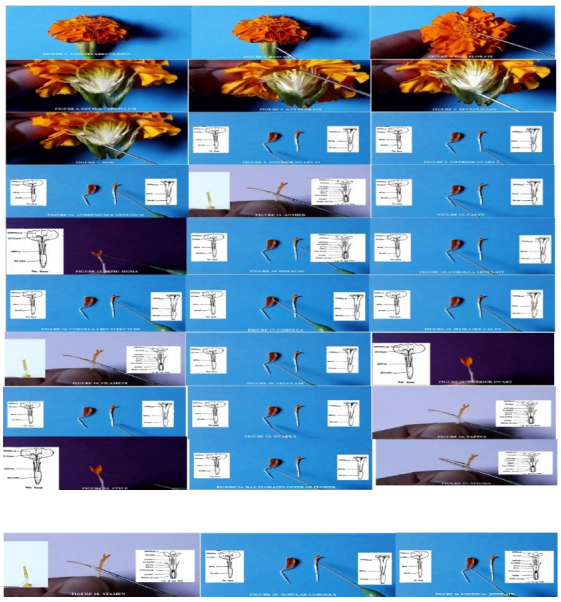


Figure No: 2 Macroscopic Characters of *Tagetes erecta* flower

Table No 1: Macroscopic (Organoleptic) Evaluation

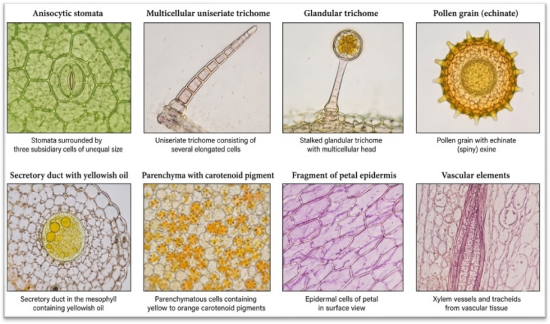
S No.	Parameter	Observation/Description
1	Color	Bright yellow to deep orange (petal)
2	Odour	Strongly aromatic and characteristic
3	Taste	Sweetish with an astringent or slightly bitter after taste
4	Texture	Soft and velvety (fresh petals); Crisp and brittle (dried petals)
5	Size	Typically, 5-10 cm in diameter
6	Shape	Globular, dense flower heads (capitulum)

These features help in the preliminary identification of the plant material.

4.2.2. Flower Microscopic Evaluation

Transverse Section of Ray Floret: The T.S. of the ray floret showed a single layered epidermis with aniso-cytic stomata and multicellular uniseriate trichomes. The mesophyll was undifferentiated, consisting of parenchymatous cells. Vascular bundles were small and scattered. Secretory ducts lined with epithelial cells containing yellowish-brown oleoresin were observed in the mesophyll.

Figure No: 3 Flower Microscopic Characters



Transverse Section of Disc Floret: The T.S. of the disc floret showed a pentagonal outline. The epidermis had glandular and nonglandular trichomes. The corolla lobes showed a palisade like mesophyll. The anther was tetra sporangia with endothelial thickenings. The ovary was inferior, bicarpellary, and unilocular with a single basal ovule. These microscopic features confirm the authenticity of the crude drug.

Microscopic Characters of *Tagetes erecta* flower

Microscopic analysis of the flower revealed the following diagnostic characters:

Table No: 2 Microscopic Character of *Tagetes erecta* flower

S no.	Microscopic Character	Observation
1.	Epidermal cells	Polygonal in shape with thin cell walls
2.	Trichomes	Presence of multicellular covering trichomes
3.	Vascular bundles	Well-developed xylem and phloem tissues observed
4.	Pollen grains	Spherical, spiny (echinate) pollen grains characteristic of Asteraceae family
5.	Oil glands	Secretory structures containing essential oils present

4.2.3. Powder Microscopy

Powder microscopy is useful for detecting adulteration and ensuring purity. Stomatal index on the involucre bracts was 16.5 ± 1.3. Pollen grain diameter was 34.2 ± 2.1 µm

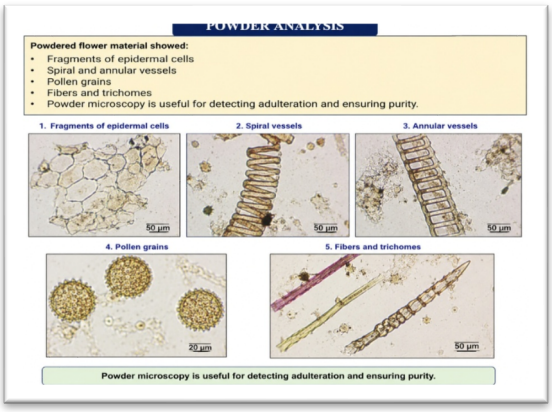


Figure No. 4 *Tagetes erecta* (Marigold) Flower Powder Microscopy

Powder Microscopy: The flower powder was yellowish orange. Diagnostic features included:

Pollen grains: Spherical, approximately 30-40 µm in diameter, with a characteristic echinate (spiny) exine and three germinal pores (tricorporate).

Trichomes: Abundant multicellular, uniseriate, nonglandular trichomes with pointed apices; also, glandular trichomes with unicellular or multicellular heads.

Fragments of ligulate corolla: Showing epidermal cells with sinuous walls and striated cuticle.

Vascular elements: Spiral and annular xylem vessels.

Secretory ducts: Fragments of secretory ducts with yellowish brown contents.

5. Physicochemical Parameters

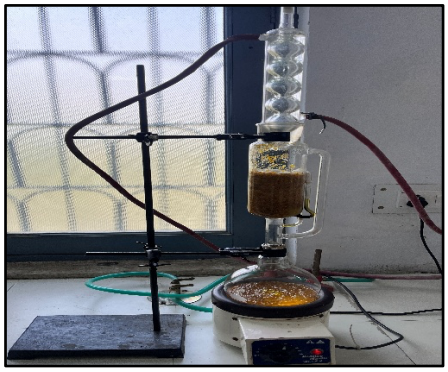
Standard physicochemical constants were determined:

Table No: 3 Physicochemical Parameters of *Tagetes erecta* Flower Powder

S no.	Parameters	Value (% w/w, Mean ± SD)
1.	Loss on Drying	7.46 ± 0.12
2.	Total Ash	4.95 ± 0.08
3.	Acid – Insoluble Ash	0.20 ± 0.01
4.	Water-Soluble Ash	1.65 ± 0.05
5.	Sulphated Ash	1.30 ± 0.04
6.	Water Soluble Extractive Value	72.10 ± 1.25
7.	Alcohol-Soluble Extractive Value	16.80 ± 0.65

5.1 Extraction of *Tagetes erecta* flower

Flowers of *Tagetes erecta* were air dried for about two weeks at room temperature in the shade. The flowers were powdered once they had thoroughly dried. The extraction process employed a Soxhlet extraction apparatus. The flowers powder was extracted with Petroleum ether (60-80°C) for defatted and after this extraction was made with ethanol. Within the apparatus's upper



5.2 Figure No: 5 Extraction of *Tagetes erecta* flower

5.2. Phytochemical Analysis

5.1.2. Preliminary Screening

Qualitative phytochemical screening revealed that the ethyl acetate extract was the most diverse in phytoconstituents, containing carotenoids flavonoids, terpenoids, saponins, tannins, and alkaloids. The ethyl acetate extract was rich in carotenoids.

Table No: 4 Qualitative Phytochemical Analysis of *Tagetes erecta* Flower Extracts

S no.	Phytochemical	Petroleum Ether	Ethyl acetate	Ethanol	Aqueous
	Alkaloids	-	+	+	+
	Flavonoids	-	++	++	++
	Tannins	-	+++	++	++
	Saponins	-	+	++	++
	Glycosides	-	+++	++	++
	Terpenoids	+	++	+	-
	Steroids	+	+	-	-
	Protein and Amino Acids	-	-	+	++
	Carbohydrates	-	+	++	++
	Carotenoids	++	+++	+	-

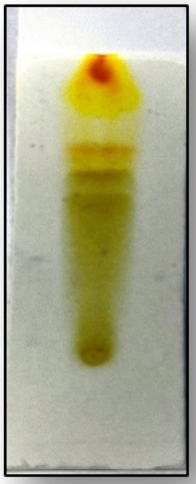
Where: (- = Absent; + = Present; ++ = Moderately Present; +++ = Abundantly Present)

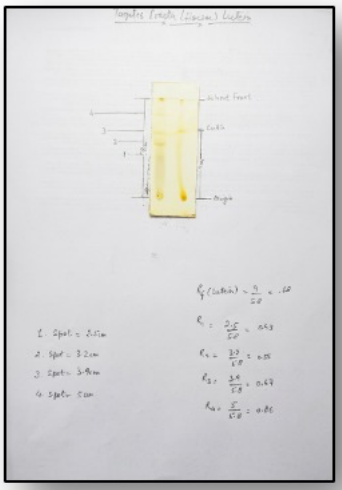
The pharmacognostical evaluation of *Tagetes erecta* flowers provides essential standards for identification and quality control. These parameters are useful in distinguishing the genuine drug from adulterants and ensure consistency in herbal formulations.

6. Thin Layer Chromatography (TLC)

TLC analysis of the ethyl-acetate extract confirmed and quantified key marker compounds. The concentration of lutein was 4.2 mg/g of extract.

Table No: 5 TLC of *Tagetes erecta* flower extract and Marker Compound





S no.	TLC profile of *Tagetes erecta flower* extract	Solvent system	Detecting reagent	No. of spots	R_f Value
1.	Ethyl acetate	Toluene: Ethylacetate: Formic Acid	Iodine Vapours	**04**	0.43, 0.55, **0.67**, 0.86
2.	With compound Lutein	Toluene: Ethylacetate: Formic Acid	Iodine Vapours	**04**	0.43, 0.55, **0.67**, 0.86

Figure No: 5 TLC of *Tagetes erecta* Flower extract and TLC with marker compound

Summary of TLC results:

R_f value = distance move by the solute ÷ distance move by the solvent.

R_f value = 0.40 (Lutein)

- Length of the plate = **22 cm.**
- Breath of the plate = **11.5 cm.**
- Thickness of the plate = **0.1 cm.**
- Solvent front of the plate = **5.8 cm.**
- Distance moved by the solute = **4 cm.**

Extractive value of *Tagetes erecta* flower

S.no.	Type of solvent	% w/w ± SD*
1.	Petroleum ether 60-80	1.76 ± 0.36
2.	Ethyl acetate	1.49 ± 0.39
3.	Ethanol	1.32 ± 0.42
4.	Water	7.7 ± 0.75

7. HPTLC Analysis

HPTLC was performed on 20 cm × 10 cm TLC aluminium plates coated with 200-µm layer thickness of silica gel 60F 254 (E. Merck, Germany). Samples were applied as 6 mm width bands using Camag 100 microlitre sample syringe (Hamilton, Switzerland) with a Camag Linomat 5 applicator (Camag, Switzerland) Photo documentation machine model: Reprostar 3. A constant application rate of 150 nL s−1 was used. Linear ascending development with Toluene: ethyl acetate: formic acid (13: 11: 2) (v/v) as mobile for *Tagetes erecta* was carried out in a twin trough glass chamber (Camag) (20 x 10 cm) previously saturated with mobile phase vapours for 20 mins (optimized chamber saturation time) at room temperature (25 ± 2°C). The development distance was 80 mm. After development plates were air- dried. Scanning was performed using Camag TLC scanner 3 at 254 nm in the absorbance mode and operated by winCATS software (version 1.4.1). The source of radiation was a deuterium lamp emitting a continuous UV spectrum in the range 190– 400 nm. The slit dimensions were 5 mm × 0.45 mm and the scanning speed was 100 mm/ s.

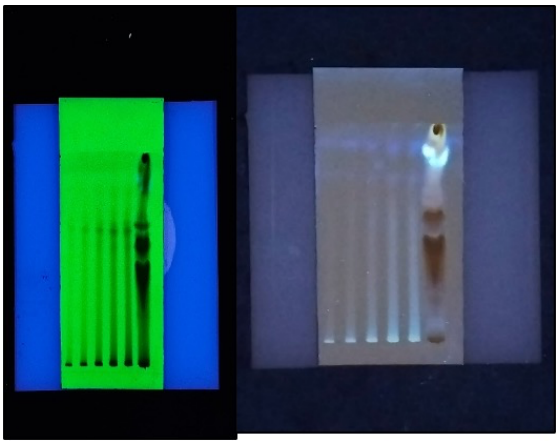
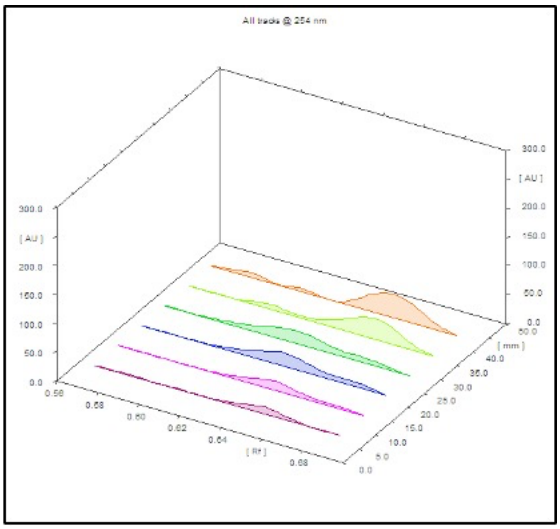
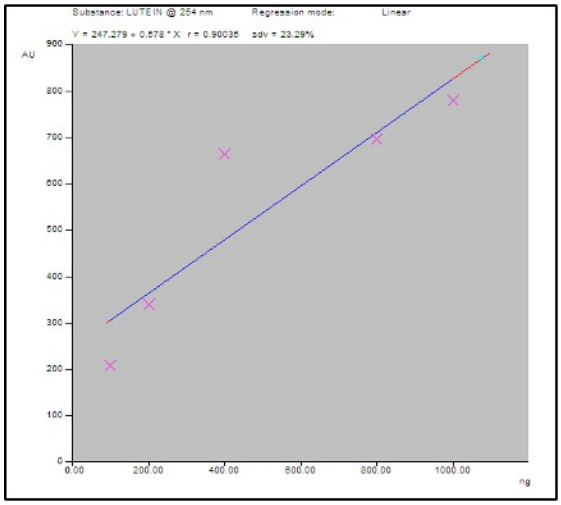


Figure No: 6 UV 254 nm UV 307 nm





Calibration Curve of Lutein 3D Graph at 254 nm Lutein

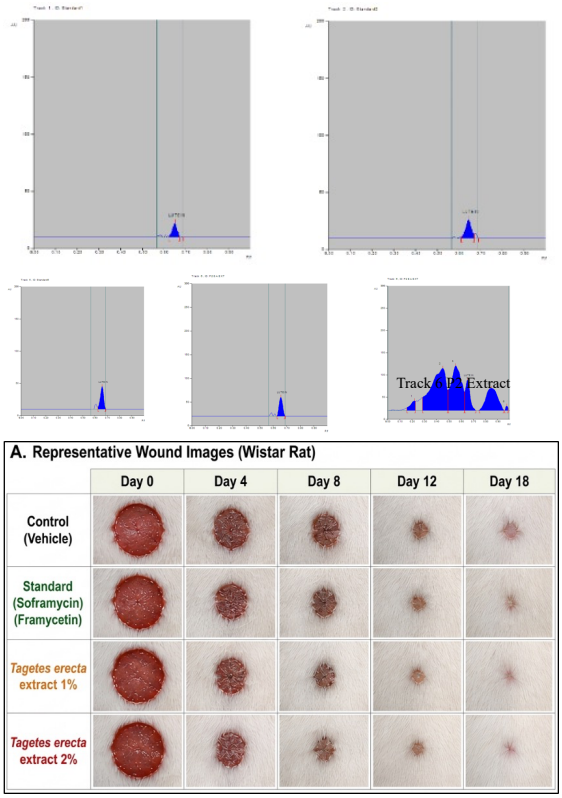


Figure No: 7 HPTLC Chromatogram of different concentration of Standard Lutein at 254 nm (Track 1 STD), (Track 2 STD), (Track 3 STD), (Track 4 STD) and (Track 5 STD)

Where: Track 6 P2 Extract and STD (Ethyl acetate and Lutein)

8. Wound Healing Evaluation

8.1. In Vitro Scratch Assay

The scratch assay demonstrated that the ethyl acetate extracts significantly enhanced fibroblast migration and proliferation in a concentration dependent manner. At 48 hours, the percentage of wound closure was 48.6 ± 3.2% in the control group. In contrast, the groups treated with 1 µg/mL and 2 µg/mL of the extract showed wound closure of 72.4 ± 2.8% and 91.3 ± 2.5% ($p < 0.001$), respectively, indicating a potent promigratory effect.

Table No: 6 Scratchy Assay of Control and Ethyl Acetate Extract of *Tagetes erecta* flowers

Sno.	Treatment group	Concentration (µg/mL)	Wound closer (%) at 48h	Significance
	Control	-	48.6 ± 3.2	-
	EAETE	1	72.4 ± 2.8	*** ($p < 0.001$)
	EAETE	2	91.3 ± 2.5	*** ($p < 0.001$)

Where: Values are expressed as Mean ± SD (n = 3); *** = Highly significant compared to control ($p < 0.001$) **

8.2. In Vivo Excision Wound Model

8.2.1. Wound Contraction: Topical application of *Tagetes erecta* flower extract ointment significantly accelerated wound contraction. From day 4 onwards, both the 1% and 2% extract treated groups showed significantly higher rates of wound contraction compared to the control group. By day 18, the control group achieved 82.5 ± 2.6% contraction.

The standard Soframycin (framycetin) group showed 96.4 ± 1.4% contraction. Remarkably, the 2% extract treated group exhibited 97.8 ± 1.1% contraction, which was statistically superior to the control ($p < 0.001$) and comparable to the standard group ($p > 0.05$)

Figure No. 8A Wound Contraction in Different Days

Table No: 7 Wound Contraction (%) Over 18 Days

Treatment Groups	Wound Contraction (%) (Mean ± SD, n = 6)									
	Day 0	Day 2	Day 4	Day 6	Day 8	Day 10	Day 12	Day 14	Day 16	Day 18
Control (Vehicle)	0	8.2 ± 1.6	17.6 ± 1.9	27.5 ± 2.1	38.2 ± 2.3	48.6 ± 2.5	59.4 ± 2.5	69.6 ± 2.3	76.8 ± 2.5	**82.5 ± 2.6**
Standard Soframycin (Framycetin)	0	12.1 ± 1.5	25.6 ± 1.8	37.4 ± 2.0	50.1 ± 2.1	61.3 ± 2.0	71.8 ± 1.9	81.0 ± 1.8	89.1 ± 1.6	**96.4 ± 1.4**
Tagetes erecta Extract 1%	0	10.3 ± 1.4	21.7 ± 1.7	31.8 ± 1.9	43.6 ± 2.1	55.2 ± 2.1	65.8 ± 2.0	74.7 ± 1.9	83. 3 ± 1.7	**92.3 ± 1.8**
Tagetes erecta Extract 2%	0	13.7 ± 1.5	28.9 ± 1.6***	41.6 ± 1.8***	55.2 ± 1.9***	66.5 ± 1.8***	77.2 ± 1.7***	85.6 ± 1.6***	92.6 ± 1.3***	**97.8 ± 1.1*** **

Where: Values are expressed as Mean ± SD (n = 6); *** p< 0.001 vs Control; ns p >0.05 vs Standard

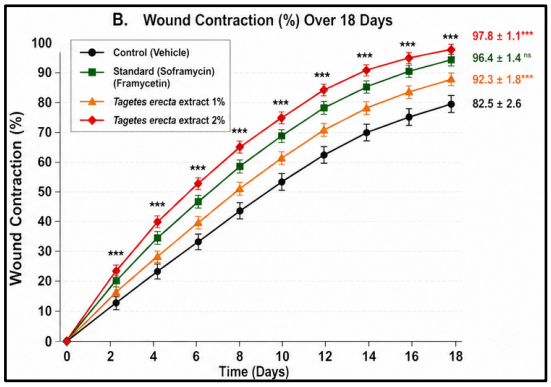
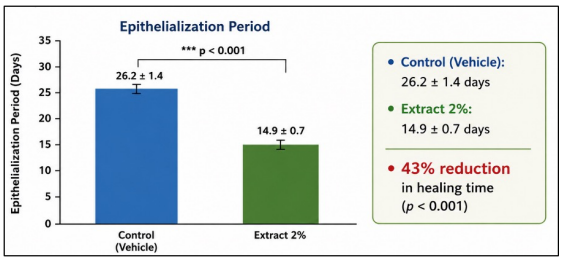


Figure No: 8B Wound Contraction (%) over 18 Day



8.2.2. Epithelialization Period: The epithelialization period was significantly reduced in the extract treated groups **(Figure No: 8B)**. The control group took 26.2 ± 1.4 days for complete epithelialization. The 2% extract treated group showed a significantly reduced epithelialization period of 14.9 ± 0.7 days ($p < 0.001$), representing a 43% reduction in healing time compared to the control.

Figure No: 9 Epithelialization Period

9. **Histopathological Examination:** Histopathological evaluation of healed wound tissue revealed distinct differences between the groups:

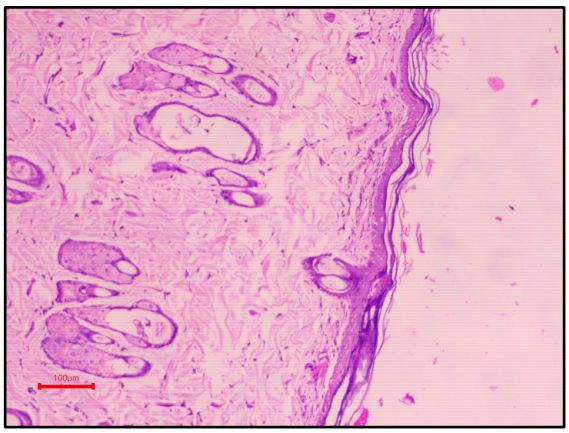


Figure No: 10 Histopathology of Skin

Control Group: H&E staining showed incomplete reepithelialization, the presence of a thick crust, disorganized granulation tissue, and moderate to severe inflammatory cell infiltration. Masson's trichrome staining revealed sparse, thin, and disorganized collagen fibres.

Standard Group (Soframycin): H&E staining showed complete reepithelialization with a well-formed stratified epithelium, minimal inflammatory cells, and well-organized granulation tissue. Masson's trichrome staining showed dense, thick, and well-organized collagen bundles.

Test (1% Extract) Group: The staining showed near complete re-epithelialization, moderate inflammatory cell infiltration, and good granulation tissue formation. Masson's trichrome staining showed moderately organized collagen fibres, improved compared to control.

Test (2% Extract) Group: The staining demonstrated complete reepithelialization with a well-defined epidermal layer, absence of inflammatory cells, abundant granulation tissue, and increased angiogenesis (new blood vessel formation). Masson's trichrome staining revealed dense, thick, well-aligned collagen bundles arranged in a basketweave pattern, resembling normal skin architecture, comparable to the standard group.

6. Discussion

The present study provides a comprehensive evaluation of *Tagetes erecta* flowers, integrating Pharmacognostical standardization, phytochemical profiling, and wound healing potential through both in vitro and in vivo models. The findings collectively support the traditional use of this plant in wound management and establish a scientific basis for its therapeutic application [70, 71].

Pharmacognostical analysis confirmed the identity and purity of the plant material. The macroscopic features such as bright yellow to deep orange capitulum, aromatic Odor, and slightly bitter taste were consistent with standard botanical descriptions. Microscopic evaluation revealed characteristic features including multicellular trichomes, echinate pollen grains, and secretory ducts containing oleoresins, which are diagnostic of the Asteraceae family. Powder microscopy further substantiated these findings with the presence of spiral vessels, pollen grains (30–40 µm), and carotenoid-rich cells [72, 73]. The physicochemical parameters, including low moisture content (7.46%) and acceptable ash values, indicated good stability and minimal contamination, thereby confirming the quality of the crude drug [74].

The extraction profile demonstrated that solvent polarity significantly influenced extractive yield, with aqueous extract showing the highest yield (7.7% w/w), followed by petroleum ether, ethyl acetate, and ethanol extracts [75, 76]. However, qualitative phytochemical screening revealed that the ethyl acetate and ethanolic extracts were richer in bioactive constituents such as flavonoids, tannins, glycosides, and terpenoids. Notably, the ethyl acetate extract showed abundant carotenoids (+++), suggesting its suitability for further biological evaluation [77, 78].

Chromatographic studies further validated the presence of key bioactive compounds. TLC and HPTLC analysis confirmed the presence of lutein as a major marker compound, with a concentration of 4.2 mg/g in the ethyl acetate extract [79, 80]. The

consistent R_f values between the extract and standard lutein indicate the reliability of the method and confirm the chemical identity of the compound. Lutein, a well-known antioxidant carotenoid, plays a crucial role in scavenging free radicals and protecting tissues from oxidative damage, which is a key factor in wound healing [81, 82].

The in vitro scratch assay demonstrated a strong, concentration-dependent enhancement of fibroblast migration and proliferation. The ethyl acetate extract showed a significant increase in wound closure (91.3 ± 2.5%) compared to the control (48.6 ± 3.2%), indicating its potent pro-healing activity. This effect may be attributed to the presence of flavonoids and carotenoids, which are known to promote cell proliferation and collagen synthesis [83-90].

The in vivo excision wound model further corroborated these findings. The 2% extract-treated group exhibited significantly higher wound contraction (97.8 ± 1.1%) compared to the control (82.5 ± 2.6%) and was comparable to the standard drug (Soframycin) [91-93]. The accelerated wound contraction observed from day 4 onwards suggests enhanced tissue regeneration and faster healing kinetics. Additionally, the epithelialization period was markedly reduced (14.9 days) in the 2% extract group compared to the control (26.2 days), indicating rapid restoration of the epidermal layer [94, 95].

Histopathological examination provided strong evidence supporting the wound healing efficacy of the extract [96]. The 2% extract-treated group showed complete re-epithelialization, dense and well-organized collagen fibers, reduced inflammatory cell infiltration, and increased angiogenesis. These features are indicative of effective tissue remodelling and regeneration. In contrast, the control group exhibited incomplete healing with disorganized collagen and persistent inflammation [97, 98]. The observed histological improvements in the treated groups may be attributed to the synergistic action of phytoconstituents such as flavonoids, tannins, and carotenoids, which possess antioxidant, anti-inflammatory, and antimicrobial properties [99].

Overall, the study demonstrates that the ethyl acetate extract of *Tagetes erecta* flowers possesses significant wound healing activity, which can be attributed to its rich phytochemical composition, particularly lutein and other antioxidant compounds. The results highlight its potential as a natural, effective, and safe alternative to conventional wound healing agents. Further studies focusing on isolation of active constituents and elucidation of molecular mechanisms would strengthen its pharmaceutical applications [100].

Conclusion

The present investigation comprehensively evaluated the pharmacognostical, phytochemical, and wound healing properties of *Tagetes erecta* flowers, providing scientific validation for its traditional medicinal use. The pharmacognostical studies, including macroscopic, microscopic, and powder analysis, confirmed the identity, purity, and diagnostic characteristics of the plant material. Key features such as *Tagetes erecta*, Marigold, Pharmacognosy, Phytochemistry, Wound Healing, Carotenoids, Excision Wound Model, Lutein, multicellular trichomes, echinate pollen grains, and secretory ducts, along with acceptable physicochemical parameters, ensured the quality and standardization of the crude drug.

Phytochemical screening revealed the presence of a wide range of bioactive constituents, including flavonoids, tannins, glycosides, terpenoids, and carotenoids. Among the various extracts, the ethyl acetate extract exhibited a rich concentration of these compounds, particularly carotenoids such as lutein, which was confirmed and quantified through TLC and HPTLC analysis. The high carotenoid content indicates strong antioxidant potential, which plays a crucial role in reducing oxidative stress during the wound healing process.

The biological evaluation demonstrated significant wound healing activity of the ethyl acetate extract. The in vitro scratch assay showed a marked enhancement in fibroblast migration and proliferation, indicating its ability to promote tissue repair at the cellular level. Furthermore, the in vivo excision wound model revealed that the 2% extract formulation significantly accelerated wound contraction and reduced the epithelialization period compared to the control group, with effects comparable to the standard drug. Histopathological examination supported these findings by demonstrating complete re-epithelialization, well-organized collagen fibers, increased angiogenesis, and reduced inflammatory response in treated groups.

In conclusion, the study establishes that *Tagetes erecta* flower extract, particularly the ethyl acetate fraction, possesses potent wound healing properties due to its rich phytochemical composition and antioxidant activity. These findings highlight its

potential as a safe, effective, and natural alternative for wound management and support further research for its clinical application.

References

1. Gurtner, G. C., Werner, S., Barrandon, Y., & Longaker, M. T. (2008). Wound repair and regeneration. Nature, 453(7193), 314–321.
2. Singer, A. J., & Clark, R. A. (1999). Cutaneous wound healing. New England Journal of Medicine, 341(10), 738–746.
3. Sen, C. K., Gordillo, G. M., Roy, S., Kirsner, R., Lambert, L., Hunt, T. K., ... & Longaker, M. T. (2009). Human skin wounds: a major and snowballing threat to public health and the economy. Wound Repair and Regeneration, 17(6), 763–771.
4. Frykberg, R. G., & Banks, J. (2015). Challenges in the treatment of chronic wounds. Advances in Wound Care, 4(9), 560–582.
5. Boulton, A. J., Vileikyte, L., RagnarsonTennvall, G., & Apelqvist, J. (2005). The global burden of diabetic foot disease. The Lancet, 366(9498), 1719–1724.
6. Boateng, J. S., Matthews, K. H., Stevens, H. N., & Eccleston, G. M. (2008). Wound healing dressings and drug delivery systems: a review. Journal of Pharmaceutical Sciences, 97(8), 2892–2923.
7. Barrientos, S., Stojadinovic, O., Golinko, M. S., Brem, H., & TomicCanic, M. (2008). Growth factors and cytokines in wound healing. Wound Repair and Regeneration, 16(5), 585–601.
8. Kumar, B., Vijayakumar, M., Govindarajan, R., & Pushpangadan, P. (2007). Ethnopharmacological approaches to wound healing—exploring medicinal plants of India. Journal of Ethnopharmacology, 114(2), 103–113.
9. Thakur, R., Jain, N., Pathak, R., & Sandhu, S. S. (2011). Practices in wound healing studies of plants. EvidenceBased Complementary and Alternative Medicine, 2011, 438056.
10. Agyare, C., Boakye, Y. D., Bekoe, E. O., Hensel, A., Dapaah, S. O., & Appiah, T. (2016). Review: Medicinal plants for wound healing. Planta Medica, 82(S 01), S1–S381.
11. World Health Organization. (2013). WHO traditional medicine strategy: 20142023. World Health Organization.
12. Süntar, I., Akkol, E. K., Nahar, L., & Sarker, S. D. (2012). Wound healing and antioxidant properties: do they coexist in plants? Free Radicals and Antioxidants, 2(2), 17.
13. Lodhi, S., & Singhai, A. K. (2013). Wound healing effect of flavonoid rich fraction of Lantana camara L. leaves on streptozotocin induced diabetic rats. Indian Journal of Experimental Biology, 51(7), 513523.
14. Soule, J. A. (1996). Infrageneric systematics of Tagetes. In Compositae: Systematics. Proceedings of the International Compositae Conference, Kew (Vol. 1, pp. 435443).
15. Neher, R. T. (1968). The ethnobotany of Tagetes. Economic Botany, 22(4), 317325.
16. Vasudevan, P., Kashyap, S., & Sharma, S. (1997). Tagetes: A multipurpose plant. Bioresource Technology, 62(12), 2935.
17. Heuzé, V., Tran, G., & Lebas, F. (2017). African marigold (Tagetes erecta). Feedipedia, a programme by INRA, CIRAD, AFZ and FAO.
18. Sharma, P. C., Yelne, M. B., & Dennis, T. J. (2001). Database on medicinal plants used in Ayurveda (Vol. 3). Central Council for Research in Ayurveda and Siddha.
19. Kirtikar, K. R., & Basu, B. D. (1935). Indian medicinal plants (2nd ed.). Lalit Mohan Basu.
20. Nadkarni, K. M. (1976). Indian materia medica (3rd ed.). Popular Prakashan.
21. Saenz, M. T., Garcia, M. D., & Ahumada, M. C. (1997). Pharmacological screening of Tagetes erecta L. (Asteraceae). Phytotherapy Research, 11(7), 514516.
22. Khare, C. P. (2007). Indian medicinal plants: An illustrated dictionary. Springer Science & Business Media.
23. Ogunlana, O. E., & Ogunlana, E. O. (2008). Antibacterial activity of Tagetes erecta L. (Asteraceae) leaf and flower extracts. Journal of Medicinal Plants Research, 2(11), 332335.
24. Cruz, J. A., & de Oliveira, R. A. (2015). Ethnobotanical study of Tagetes erecta L.

in rural communities of Brazil. Brazilian Journal of Pharmacognosy, 25(3), 289295.

25. Piccaglia, R., Marotti, M., & Grandi, S. (1998). Lutein and lutein ester content in different types of Tagetes patula and T. erecta. Industrial Crops and Products, 8(1), 4551.
26. Hadden, W. L., Watkins, R. H., Levy, L. W., Regalado, E., Rivadeneira, D. M., van Breemen, R. B., & Schwartz, S. J. (1999). Carotenoid composition of marigold (Tagetes erecta) flower extract used as nutritional supplement. Journal of Agricultural and Food Chemistry, 47(10), 4189–4194.
27. Beninger, C. W., & Hall, J. C. (2005). Allelopathic activity of lutein and its derivatives from Tagetes erecta L. Journal of Chemical Ecology, 31(4), 859871.
28. Campos, M. R., & Reyes, F. G. (2008). Chemical composition and antioxidant activity of Tagetes erecta L. flowers. Journal of Food Composition and Analysis, 21(6), 456463.
29. Quispe, C., & Viveros, E. (2012). Flavonoids from Tagetes erecta L. flowers. Natural Product Research, 26(13), 12341239.
30. Tosi, S., & Bruni, A. (1994). Thiophenes from Tagetes erecta L. flowers. Journal of Essential Oil Research, 6(2), 173178.
31. AbdElGawad, A. M., El Gendy, A. E. N. G., Assaeed, A. M., AlRowaily, S. L., Alharthi, A. S., & Elshamy, A. I. (2020). Chemical composition and antimicrobial activity of Tagetes erecta L. essential oil. Saudi Journal of Biological Sciences, 27(11), 30613066.
32. Faizi, S., Siddiqi, H., & Bano, S. (2011). Antioxidant and antimicrobial activity of Tagetes erecta L. flower extracts. Journal of the Chemical Society of Pakistan, 33(4), 561567.
33. Dhal, A., & Padhi, S. (2015). In vitro antioxidant activity of Tagetes erecta L. flower extracts. International Journal of Pharmaceutical Sciences Review and Research, 32(1), 151155.
34. Gupta, P., & Vasudeva, N. (2012). In vitro antioxidant activity of Tagetes erecta L. flowers. Asian Journal of Pharmaceutical and Clinical Research, 5(3), 127130.
35. Saenz, M. T., Garcia, M. D., & Ahumada, M. C. (1997). Pharmacological screening of Tagetes erecta L. (Asteraceae). Phytotherapy Research, 11(7), 514516.
36. Patil, S. S., & Patil, V. R. (2011). Antiinflammatory activity of Tagetes erecta L. flowers. Journal of Pharmacy Research, 4(5), 14081409.
37. Nikkon, F., Habib, M. R., & Saud, Z. A. (2011). Antimicrobial activity of Tagetes erecta L. flower extracts. Bangladesh Journal of Scientific and Industrial Research, 46(1), 123126.
38. Gupta, P., & Vasudeva, N. (2012). Antimicrobial activity of Tagetes erecta L. flowers. Asian Pacific Journal of Tropical Biomedicine, 2(3), S1132S1135.
39. Ghosh, S., & Sharma, A. (2010). Hepatoprotective activity of Tagetes erecta L. flowers against CCl4induced hepatotoxicity in rats. Journal of Ethnopharmacology, 127(2), 346351.
40. Meenakshi, S., & Suman, S. (2012). Anticancer activity of Tagetes erecta L. flower extracts against human cancer cell lines. International Journal of Pharmacy and Pharmaceutical Sciences, 4(3), 482485.
41. Arora, S., & Vijay, S. (2018). Cytotoxic and apoptotic effects of Tagetes erecta L. flower extracts on cancer cells. Journal of Cancer Research and Therapeutics, 14(5), 10231029.
42. Umachigi, S. P., Jayaveera, K. N., Kumar, C. A., Kumar, G. S., & Swamy, B. M. (2008). Wound healing activity of Tagetes erecta L. flowers in rats. Journal of Natural Remedies, 8(1), 7277.
43. Preethi, K. C., & Kuttan, R. (2009). Wound healing activity of flower extract of Tagetes erecta L. in rats. Journal of Wound Care, 18(4), 165169.
44. Evans, W. C. (2009). Trease and Evans' Pharmacognosy (16th ed.). Saunders Elsevier.
45. Kokate, C. K., Purohit, A. P., & Gokhale, S. B. (2008). Pharmacognosy (42nd ed.). Nirali Prakashan.
46. Johansen, D. A. (1940). Plant microtechnique. McGrawHill Book Company, Inc.

47. O'Brien, T. P., & McCully, M. E. (1981). The study of plant structure: Principles and selected methods. Termarcarphi Pty Ltd.
48. Khandelwal, K. R. (2008). Practical pharmacognosy: Techniques and experiments (19th ed.). Nirali Prakashan.
49. Metcalfe, C. R., & Chalk, L. (1950). Anatomy of the dicotyledons: leaves, stem, and wood in relation to taxonomy, with notes on economic uses. Clarendon Press.
50. Salisbury, E. J. (1927). On the causes and ecological significance of stomatal frequency, with special reference to the woodland flora. Philosophical Transactions of the Royal Society of London. Series B, Containing Papers of a Biological Character, 216(431439), 1–65.
51. Erdtman, G. (1960). The acetolysis method. A revised description. Svensk Botanisk Tidskrift, 54, 561564.
52. World Health Organization. (1998). Quality control methods for medicinal plant materials. World Health Organization.
53. Ayurvedic Pharmacopoeia of India. (2001). Part I, Volume III. Government of India, Ministry of Health and Family Welfare.
54. Harborne, J. B. (1998). Phytochemical methods: A guide to modern techniques of plant analysis (3rd ed.). Springer.
55. Sofowora, A. (1993). Medicinal plants and traditional medicine in Africa. Spectrum Books Ltd.
56. Wagner, H., & Bladt, S. (1996). Plant drug analysis: A thin layer chromatography atlas (2nd ed.). Springer.
57. Singleton, V. L., Orthofer, R., & LamuelaRaventós, R. M. (1999). Analysis of total phenols and other oxidation substrates and antioxidants by means of folinciocalteu reagent. Methods in Enzymology, 299, 152–178.
58. Zhishen, J., Mengcheng, T., & Jianming, W. (1999). The determination of flavonoid contents in mulberry and their scavenging effects on superoxide radicals. Food Chemistry, 64(4), 555–559.
59. RodriguezAmaya, D. B. (2001). A guide to carotenoid analysis in foods. ILSI Press.
60. Adams, R. P. (2007). Identification of essential oil components by gas chromatography/mass spectrometry (4th ed.). Allured Publishing Corporation.
61. Snyder, L. R., Kirkland, J. J., & Dolan, J. W. (2010). Introduction to modern liquid chromatography (3rd ed.). John Wiley & Sons.
62. Liang, C. C., Park, A. Y., & Guan, J. L. (2007). In vitro scratch assay: a convenient and inexpensive method for analysis of cell migration in vitro. Nature Protocols, 2(2), 329–333.
63. Rodriguez, L. G., Wu, X., & Guan, J. L. (2005). Woundhealing assay. Methods in Molecular Biology, 294, 23–29.
64. Morton, J. J., & Malone, M. H. (1972). Evaluation of vulnerary activity by an open wound procedure in rats. Archives Internationales de Pharmacodynamie et de Thérapie, 196(1), 117–126.
65. Ehrlich, H. P., & Hunt, T. K. (1968). The effects of cortisone and anabolic steroids on the tensile strength of healing wounds. Annals of Surgery, 167(3), 324–328.
66. Shukla, A., Rasik, A. M., Jain, G. K., Shankar, R., Kulshrestha, D. K., & Dhawan, B. N. (1999). In vitro and in vivo wound healing activity of asiaticoside isolated from Centella asiatica. Journal of Ethnopharmacology, 65(1), 1–11.
67. Sadaf, F., & Abid, R. (2015). Wound healing activity of plant extracts. Journal of Ethnopharmacology, 172, 1015.
68. Bancroft, J. D., & Gamble, M. (2008). Theory and practice of histological techniques (6th ed.). Churchill Livingstone.
69. Masson, P. (1929). Some histological methods: Trichrome stainings and their preliminary technique. Journal of Technical Methods, 12, 75–90.
70. Zhang, J., Wider, B., Shang, H., Li, X., & Ernst, E. (2012). Quality of herbal medicines: challenges and solutions. Complementary Therapies in Medicine, 20(12), 100–106.
71. Chan, K. (2003). Some aspects of toxic contaminants in herbal medicines. Chemosphere, 52(9), 1361–1371.
72. Hooker, J. D. (1882). Flora of British India (Vol. 3). L. Reeve & Co.
73. Stace, C. A. (1965). Cuticular studies as an aid to plant taxonomy. Bulletin of the

British Museum (Natural History) Botany, 4(1), 178.
74. Metcalfe, C. R., & Chalk, L. (1979). Anatomy of the dicotyledons (2nd ed., Vol. 1). Clarendon Press.
75. Croes, A. F., & van den Berg, A. J. (1993). Thiophenes in Tagetes: Biosynthesis and biological activity. Acta Horticulturae, 330, 247254.
76. Zhao, Z., & Li, S. (2015). Macroscopic and microscopic identification of herbal medicines. In Pharmacognosy (pp. 7586). Academic Press.
77. Mukherjee, P. K. (2002). Quality control of herbal drugs: An approach to evaluation of botanicals. Business Horizons.
78. Agati, G., Azzarello, E., Pollastri, S., & Tattini, M. (2012). Flavonoids as antioxidants in plants: location and functional significance. Plant Science, 196, 67–76.
79. Tsuchiya, H. (2015). Membrane interactions of phytochemicals as their molecular mechanism applicable to the discovery of drug leads from plants. Molecules, 20(10), 18923–18966.
80. Nijveldt, R. J., van Nood, E., van Hoorn, D. E., Boelens, P. G., van Norren, K., & van Leeuwen, P. A. (2001). Flavonoids: a review of probable mechanisms of action and potential applications. The American Journal of Clinical Nutrition, 74(4), 418–425.
81. Guo, S., & DiPietro, L. A. (2010). Factors affecting wound healing. Journal of Dental Research, 89(3), 219–229.
82. Sen, C. K., & Roy, S. (2008). Redox signals in wound healing. Biochimica et Biophysica Acta (BBA)General Subjects, 1780(11), 1348–1361.
83. Kaulmann, A., & Bohn, T. (2014). Carotenoids, inflammation, and oxidative stress—implications of cellular signaling pathways and relation to chronic disease prevention. Nutrition Research, 34(11), 907–929.
84. Krinsky, N. I., & Johnson, E. J. (2005). Carotenoid actions and their relation to health and disease. Molecular Aspects of Medicine, 26(6), 459–516.
85. Yoshikawa, M., & Morikawa, T. (2003). Absolute stereostructures of patuletin and related flavonoids from Tagetes erecta. Chemical & Pharmaceutical Bulletin, 51(6), 724726.
86. Rehman, M. U., & Tahir, M. (2015). Quercetagetin: A promising flavonoid with multiple therapeutic potentials. Pharmacognosy Reviews, 9(18), 96101.
87. Gomathi, K., Gopinath, D., Rafiuddin Ahmed, M., & Jayakumar, R. (2003). Quercetin incorporated collagen matrices for dermal wound healing processes in rat. Biomaterials, 24(16), 2767–2772.
88. Gopalakrishnan, A., & Ram, M. (2016). Rutin: A potential flavonoid for wound healing. Journal of Pharmacy Research, 10(7), 478482.
89. Marles, R. J., & Compadre, C. M. (1995). Thiophenes: Naturally occurring and synthetic compounds with diverse biological activities. Phytochemistry, 38(1), 119.
90. Chan, G. F. Q., & Towers, G. H. N. (1980). Antifungal activity of thiophenes from Tagetes erecta. Phytochemistry, 19(1), 5557.
91. Chavan, M. J., & Wakte, P. S. (2012). Analgesic and antiinflammatory activity of βcaryophyllene. Journal of Ethnopharmacology, 140(1), 160164.
92. Do Nascimento, K. F., & Moreira, F. M. (2018). Spathulenol: A review of its pharmacological properties. Natural Product Communications, 13(7), 899902.
93. Semba, R. D. (2012). The role of vitamin A and related retinoids in wound healing. Nutrition in Clinical Practice, 27(2), 225232.
94. Darby, I. A., Laverdet, B., Bonté, F., & Desmoulière, A. (2014). Fibroblasts and myofibroblasts in wound healing. Clinical, Cosmetic and Investigational Dermatology, 7, 301–311.
95. Werner, S., & Grose, R. (2003). Regulation of wound healing by growth factors and cytokines. Physiological Reviews, 83(3), 835–870.
96. Huang, C., & Jacobson, K. (2019). Signaling pathways regulating cell migration. Annual Review of Cell and Developmental Biology, 35, 237261.
97. Hinz, B. (2007). Formation and function of the myofibroblast during tissue repair.

Journal of Investigative Dermatology, 127(3), 526–537.

98. Xue, M., & Jackson, C. J. (2015). Extracellular matrix reorganization during wound healing and its impact on abnormal scarring. Advances in Wound Care, 4(3), 119136.
99. Eming, S. A., Krieg, T., & Davidson, J. M. (2007). Inflammation in wound repair: molecular and cellular mechanisms. Journal of Investigative Dermatology, 127(3), 514–525.
100. Süntar, I., Akkol, E. K., Nahar, L., & Sarker, S. D. (2012). Wound healing and antioxidant properties: do they coexist in plants? Free Radicals and Antioxidants, 2(2), 17.