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A Review on Pharmacological and Phytochemical Profile of Calendula Officinalis

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ABSTRACT
Calendula officinalis, commonly known as pot marigold, is a medicinal herb with a longstanding history in traditional medicine across various cultures. Rich in phytochemicals such as carotenoids, flavonoids, terpenoids, and essential oils, it exhibits a wide range of pharmacological activities including antioxidant, anti-inflammatory, wound healing, anti-diabetic, anthelmintic, and cardioprotective effects. Detailed phytochemical analysis and in vitro and in vivo studies have validated many of its traditional uses. Its bioactive compounds contribute to its effectiveness in treating skin conditions, metabolic disorders, and cardiovascular issues. With the growing preference for plant-based and holistic treatments, Calendula officinalis holds promise as a natural therapeutic agent in modern medicine.

I. INTRODUCTION

Human beings have depended on nature for decades for medicines, shelters, food stuffs, fragrances, clothing, flavours, fertilizers and means of transportation throughout the ages. The traditional medicine practice is widespread in China, India, Japan, Pakistan, Sri Lanka and Thailand. About 40% of the total medicinal consumption is attributed to traditional tribal medicines alone by China. [1]Most of the important drugs of the past 50 years, which have revolutionized modern medicinal practice, have been isolated/derivatized from plants.[2]Medicinal plants are important for drug development. [3]Medicinal plants have emerged as a promising frontier in the search for innovative antiviral therapies. [4]

The field of herbal medicine is expanding quickly and has the potential to completely transform healthcare.[5] The field of herbal medicine is expanding quickly and has the potential to completely transform healthcare. Growing public discontent with the negative effects of traditional pharmaceuticals and a growing desire for natural and holistic approaches to health Studies by scientists verifying the effectiveness of herbal treatments.[6]

Calendula officinalis, commonly known as English marigold, pot marigold, Bride of the Sun, bull flower, and butterwort, is a well-known therapeutic herb that has been used for centuries. It is grown in sunny location and adapt to variety of soil types. Various parts of the plant, especially the leaves and flowers, contain a wide range of biologically active compounds, including carotenoids, flavonoids, saponins, sterols, phenolic acids, and lipids. [7]

Calendula officinalis has a rich history of traditional medicinal use, dating back to the 12th century, it was cultivated and utilizedby ancient civilizations including the Egyptians, Greeks, Hindus, and Arabs for its healing properties. The name Calendula is derived from the Latin word "calends", meaning the first day of every month, a reference to its prolonged and consistent flowering period throughout the year. [8] Historically, Calendula officinalis was used by soldiers during the American Civil War to stop bleeding and accelerate wound healing, also used as an effective remedy for a variety of skin conditions.[9] Itbelongs to the genus Calendula within the Asteraceae family, which comprises approximately 15 species and is gynomonoecious (both female and male bisexual flowers).[10] It was cultivated and utilized by ancient civilizations including the Egyptians, Greeks, Hindus, and Arabs for its healing properties.[11]

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SYNONYMS[12]

- Calendula aurantiaca kotschy ex Boiss
- Calendula eriocarpa DC
- Calendula hydruntina (Fiori) Lanza
- Caltha officinalis (L.) Moench

Fig 1: Plant of Calendula officinalis

VERNACULAR NAME[13]

TAXONOMICAL CLASSIFICATION[14]

Kingdom: Plantae
Subkingdom: Tracheobionta
Division: Magnoliophyta
Class: Magnoliopsidadis
Subclass: Asteridaean
Family: Asteraceae
Tribe: Calenduleae
Genus: Calendula
Species: Calendula officinalis

SLNO	LANGUAGE	VERNACULAR NAMES
1	Malayalam	Chendumalli
2	Tamil	Samanthi
3	English	Pot marigold, Garden marigold
4	Hindi	Genda
5	Kannada	Chenduhoovu
6	Kashmiri	Sadherga

Table 1: Vernacular names

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BOTANICAL DESCRIPTION[15]

Calendula officinalis is anaromatic annual plant. The leaves are simple, curved, oval and covered with fuzz on both sides. The leaves are thin, long, lower spatulate almost fuzzy and not jagged. The flowers are marginal from yellow to bright orange colour. Anomocytic stomata are present at the epical region of the outer epidermis. Inflorescence is also known as capitulum. Consist of ray florets and disc florets. Ray florets are deep orange in colour, sessile and zygomorphic while disc florets are isdeep-orange in colour, sessile, actinomorphic, hermaphrodite but sterile,tubular and epigynose, corolla absent, consists of 5 united petals, which are 5 lobed and tubular. Trichomes are covering and glandular. Fruits are also known as Aachen. Outer surface is rough and each grain weighs about 8 to 12 g. Seeds are typically curved like a boat.

TYPES AND VARIETIES[16]

1. Indian Prince
2. Apricort beauty
3. Pink surprise

Fig 2: Flower

Fig 3: Leaf

Fig 4: Root

MICROSCOPICAL STUDIES[17]

MICROSCOPY OF ROOT

The main root of 7-day-old seedlings has a uniseriate epidermis of tubular- shaped cells followed by a cortex of 7 to 9 layers of thin-walled irregular parenchyma cells of obvious intercellular spaces, the innermost layer of the cortex is endodermis. Its casparian strip is detected Vas dots in the transverse sections. The stele is composed of two phloem strands alternating with a similar number of exarch xylem ridges. Each xylem ridge comprises of 6 to 7 vessels.

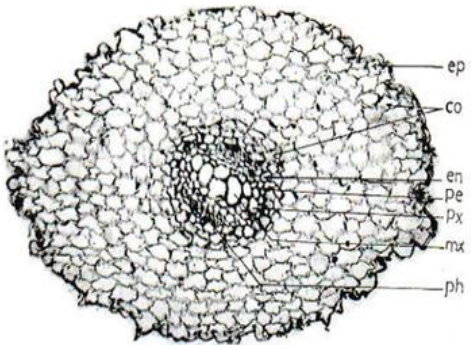

Fig 5: TS of root of Calendula officinalis

MICROSCOPY OF STEM

The shoot apex is dome shaped consist of two layered tunica overlying the corpus. The median portion of the main stem at flowering onset shows a transverse section of an epidermis composed of a single layer. The cortex consists of 10 to 15 layers, the outer 2 to 3 layers are collenchymatous underlying the epidermis. The innermost layer of the cortex, the starch sheath is hardly recognized. The bundles are endarch and collateral, forming a dictyostele. The fascicular cambium forms much secondary xylem and little secondary phloem. The interfascicular cambiumproduces new bundles. Thus, the stele consists of 35-40 bundles, each with about 10-l5 rows of vessels.

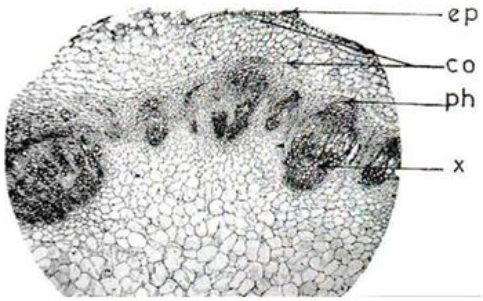

Fig 6: TS of stem of Calendula officinalis

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MICROSCOPY OF LEAF

The blade of the mature leaf is composed of epidermal layers (abaxial and adaxial), a mesophyll (palisade and sponge tissues), and a midrib which is the principle vascular vein. The epidermal cells are thin walled and covered with a thin cuticle. Both upper and lower epidermis cells appear tangentially elongated in shape. Stomata are more numerous on the lower epidermis than on the upper one and it is of anomocytic type (i.e) without subsidiary cells. At the midrib region, both upper and lower epidermis are convex, and the thickness at this region averages 1097 µ. While that of the mature blade averages 336µ.The palisade tissue consists of one layer of slender cells full of plastids occupying one-half of the whole thickness of the mesophyll. The spongy tissue is composed of 2 to 3 layers of chlorenchymatous loosely arranged cells with many wide intercellular spaces.

Fig 7: TS of leaf of Calendula officinalis

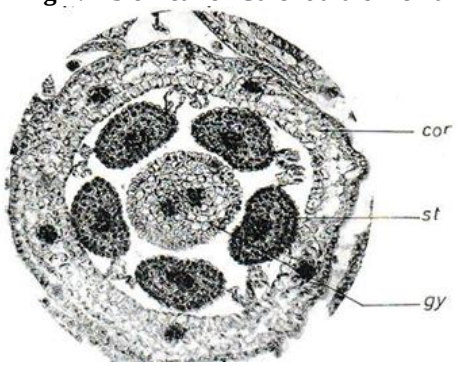

Fig 8: TS of flower bud of Calendula officinalis

MICROSCOPY OF RAY AND DISC FLORETS

The ray flowers are arranged on the margin of the flattened receptacle. They are located around the periphery. The calyx is absent. The corolla is found at the abaxial side and consists of 2 epidermal layers with 8-10 layers of rounded parenchymatous cells in between. There are 6-7 bundles extending through it. Stamens are absent.

The disc flowers are arranged in the centre of the flattened receptacle. Transverse section of the flower bud shows that the sepals are absent. The corolla tube consists of 2 epidermal layers with 4-5 layers of loosely arranged polygonal parenchymatous cells in between. There are 5 bundles extending through the tubular portion of the corolla.

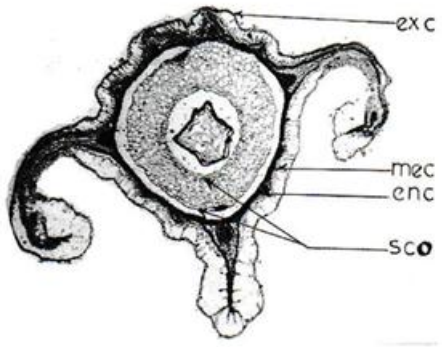

Fig 9: TS of mature fruit of Calendula officinalis

MISCROSCOPY OF FRUIT

The achene fruit develops from an inferior ovary. The fruits are polymorphic on the same inflorescence, namely, small incurvate, big incurvate and elongated. It is irregular in outline. The fruit coat consists of an outer layer (exocarp) of parenchyma cells varying in shape and size. The narrow-winged region of the fruit consists of epidermis and sub epidermis. The outer epidermis cells are nearly rounded in shape while cells of the inner layer are palisade-like. The subepidermal cells have an elongated or barrel shape. The seed coat consists of more or less spongy parenchymatous cells.

CHEMICAL CONSTITUENTS[18,19]

Calendula officinalis contains a wide range of bioactive compounds, including terpenoids, flavonoids, triterpenol esters, steroids, phenolic compounds, carotenes, triterpenoids, essential oils, quinones, fatty acids, minerals, saponins, carbohydrates, sterols, and tocopherols. Specific quinones such as ubiquinone, tocopherol, phylloquinone, and proto-quinone have been identified from various plant parts. Other notable constituents include paraffins, calendin, and calendulin.

Carotenoids:

The flowers of Calendula officinalis are rich in orange-colored carotenoids, primarily lycopene, β-carotene, lutein, flavoxanthin, and zeaxanthin. Additional carotenoids in the petals and pollen include luteoxanthin, neoxanthin,

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violaxanthin, 9Z-violaxanthin, 9Z-neoxanthin, auroxanthin, 9Z-antheraxanthin, mutatoxanthin, 13Z-lutein, cryptoxanthin and α, β-carotene.

Terpenoids:

These sesquiterpenoids, entailing ι-cadinol, α-cadinol, and ι-muurolol, bring out antioxidant action through a radical scavenging mechanism.

Flavonoids:

Flavonoid content in Calendula officinalis ranges from 0.21% to 0.68%. Major flavonoids include quercetin, isorhamnetin, quercitrin, isorhamnetin 3-glucoside, and narcissin. Three new flavonoids, calendoflaside, calendoflavoside, and calendoflavobioside have also been identified.

Lipids:

Calendic acid is the major fatty acid in the seed oil of Calendula officinalis, accounting for 38.9% to 58.4% across 17 studied species and reaching its peak concentration at seed maturity. A monohydroxy fatty acid, D-(+)-9-hydroxy-10,12-octadecadienoic acid, makes up about 5% of total seed oil fatty acids. Linoleic acid (39.45%) is predominant, followed by oleic acid (16.26%) and palmitic acid (14.96%)

PLANT PART	GROUP	ACTIVE INGREDIENTS
Flower	Terpenoids	Taraxasteol, Lupeol, Erythrodiol, Calenduloside, Calendula glycoside A and B, Cornulacicacidacetate.
	Flavonoids	Calendoflavoside, Isoquercetin, rutin, isorhamnetin, quercetin, Narcissin, Isorhamnetin-3-O—D glycoside
	Coumarins	Scopoletin, umbelliferone, EsculetinOplopanone, Cubenol, Methyllinoleate
	Volatile oils	Limonene, Nerolidol, Palustronp-cymene, Nonanal, Sabinene, Carvacrol, Pinene, t-muurolol, Geraniol
Leaves	Quinones	Tocopherol, Plastoquinone, Phylloquinone, Ubiquinon
Root	Terpenoid	Calenduloside B

Table 2: Chemical constituents

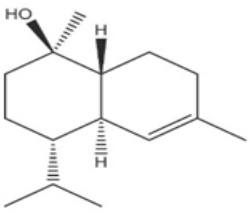

Fig 10: α-Cadinol

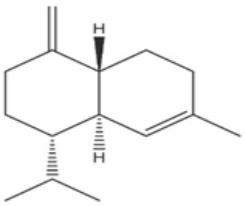

Fig 11: γ-Cadinene

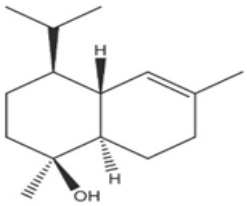

Fig 12: τ-Cadinol

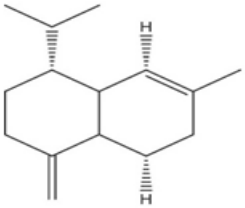

Fig 13: γ-Muurolene

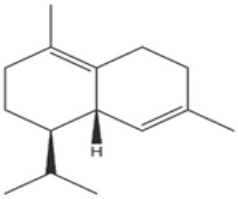

Fig 14: δ-Cadinene

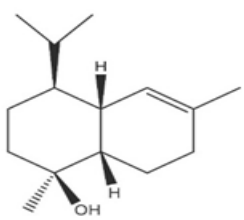

Fig 15: τ-Muurolol

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TRADITIONAL IMPORTANCE[20]

Anti diabetic agent, anti-oxidant agent, anti-inflammatory agent, analgesic,ant-bacterial agent, anti-fungal agent, anti-cancer agent, cardio-protective agent, anti-ulcer agent.

PHYTOCHEMICAL STUDIES[21,22,23]

Different methods such as extraction, fractionation, percolation, HPLCetc are used for the extraction of phytoconstituents. HPLC was developed in the early 1960's. Today it has grown into an essential tool for the modern analytical laboratory and it has replaced gas chromatography for a variety of analyses. For analysis of Calendula officinalis extract a PFP column (100 × 4.6 mm, Phenomenex) was used with a Shimadzu HPLC system and UV detection at 254 nm. The mobile phase consisted of acetonitrile and 2% aqueous acetic acid (15:85), with a flow rate of 0.5 mL/min and injection volume of 0.5 µL. Separation was achieved within 15 minutes for chlorogenic acid (3.30 min), caffeic acid (4.45 min), and rutin (7.55 min). The HPLC method showed linearity from 0.05–2 mg/ml for the compounds.

PHYTOCHEMICAL SCREENING [12,24]

The collected flowers are washed with distilled water and dried in shade for 4-6 days. They were then coarsely powdered and extracted completely by cold maceration. The solvents used for maceration were petroleum ether, methanol and Ethanol(95%).

The flower extracts (petroleum ether, methanol and ethanol) were subjected to preliminary phytochemical studies to qualitatively analyze the active components present in them.

Preliminary phytochemical screening of methanolic extract of Calendula officinalis was done by the analysis of their chemical constituents. Alkaloids, carbohydrate, proteins, terpenoids and flavonoids were identified in the methanolic extract Calendula officinalis.

Sl No	Phyto chemicals	Petroleum ether	Methanol	Ethanol
1	Carbohydrates	-	+	+
2	Saponins	+	+	+
3	Alkaloids	-	+	+
4	Cardiac glycosides	-	-	+
5	Amino acids and proteins	-	-	-
6	Gums and mucilage	-	-	-
7	Terpenoids	+	+	+
8	Flavonoids	+	+	+
9	Steroids	+	+	+

Table 1: Phytochemical screening
'+' indicates presence '-' indicates absence

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PHARMACOLOGICAL ACTIVITY

SECOND DEGREE WOUND HEALING ACTIVITY

Soraya Rezai et al. (2023)conducted a triple bond clinical study on 60 patients with second degree wound healing properties of oral calendula officinalis. The patients, aged between 18 and 55 years and with burn coverage ranging from 15% to 50% of total body surface area, were randomly divided into intervention and control groups. The intervention group received capsules containing 2 grams of dried Calendula officinalis, while the control group was given a placebo. The patient who received oral calendula officinalis showed better result as compared to placebo.[25]

ANTHELMENTIC ACTIVITY

Alam et al. (2021) investigates the anthelmintic activity of Calendula officinalis flower extract by testing it on adult Indian earthworms (Pheretimaposthuma), which are physiologically similar to human intestinal parasites; nine groups of worms were treated with varying concentrations of the extract (10–35 mg/mL), while piperazine citrate and albendazole (10 mg/mL) were used as standard reference drugs, and the experiment measured the time to paralysis and death over a two-hour period, revealing a dose-dependent anthelmintic effect with higher concentrations (25–35 mg/mL) showing comparable efficacy to the standard drugs, suggesting that Calendula officinalis may serve as a natural alternative to synthetic anthelmintics and warrants further exploration of its active constituents.[26]

ANTI-DIABETIC ACTIVITY

Chakraborthy et al. (2011) induced diabetes in rats through a single intraperitoneal injection of alloxan at a dose of 150 mg/kg body weight, which significantly elevated blood glucose and urine sugar levels compared to normal rats; however, oral administration of hydroalcoholic extract of Calendula officinalis at doses of 25 and 50 mg/kg body weight in diabetic rats significantly reduced these levels when compared to the untreated diabetic group, and the extract at a dose of 100 mg/kg body weight was found to be highly effective, restoring blood glucose, urine sugar, and serum lipid levels to near-normal values, along with increasing total haemoglobin levels, with effects comparable to insulin, thereby clearly indicating that the hydroalcoholic extract of Calendula officinalis possesses both anti-diabetic and anti-hyperlipidemic properties.[27]

ANGIOGENIC ACTIVITY

Parente et al. (2011) evaluated the angiogenic and healing activities of Calendula officinalis ethanolic extract and its dichloromethane and hexane fractions using two models-36 rats with induced skin wounds and 90 embryonated eggs utilizing the chorioallantoic membrane assay; the effect on vascular proliferation was assessed by examining the expression intensity of vascular endothelial growth factor (VEGF) in wounds of rats, and morphometric analysis showed an increase in vascular area in CAMs treated with 1% ethanolic extract, 1% dichloromethane fraction, 1% hexane fraction, and the positive control (1% 17β-estradiol), compared to the solvent control (70% ethanol), which revealed a significant increase in the number of blood vessels relative to the solvent control, indicating strong angiogenic potential of the plant extracts and fractions.[28]

CARDIO-PROTECTIVE ACTIVITY

Ray et al. (2010)suggests that Calendula officinalis may offer cardioprotective effects against ischemic heart disease, as demonstrated in an experiment using two groups of isolated rat hearts, where the treated group was perfused with a Calendula officinalis solution at 50 mM in Krebs-Henseleit buffer for 15 minutes prior to inducing ischemia, while the control group received only the buffer, the results showed that Calendula treatment enhanced left ventricular developed pressure and aortic flow, reduced myocardial infarct size and cardiomyocyte apoptosis, and appeared to exert cardioprotective effects through modulation of antioxidant and anti-inflammatory pathways, as indicated by suppression of TNFα, thereby reinforcing the potential of natural products like Calendula officinalis in managing degenerative diseases such as ischemic heart disease.[29]

ANTI OXIDANT AND ANTI-INFLAMMATORY ACTIVITY

Prabhu Venkatesh et al. (2023) conducted an in vitro study to investigate a simple herbal tea formulation made from marigold (Calendula officinalis) flower petals, aiming to assess its anti-inflammatory and antioxidant properties. The anti-inflammatory effects were evaluated using albumin denaturation and anti-proteinase activity assays, while the antioxidant capacity was assessed through the DPPH radical scavenging assay at various concentrations (10–50 µl). Significant anti-inflammatory and antioxidant activity was observed, especially at lower concentrations of 10–20 µl, when compared to

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standard controls such as diclofenac and ascorbic acid. These findings suggest that marigold tea holds promise for managing oral lesions and conditions related to oxidative stress.[30]

II. CONCLUSION

Calendula officinalis, commonly known as pot marigold, is a highly versatile medicinal plant with a rich history of traditional use and increasing scientific validation, owing to its diverse phytochemical composition that includes alkaloids, carbohydrates, proteins, terpenoids, flavonoids, carotenoids, essential oils, and various other bioactive compounds, which collectively contribute to its wide-ranging pharmacological activities; the plant exhibits notable antioxidant, anti-inflammatory, wound-healing, anti-diabetic, and hepatoprotective properties, positioning it as a valuable resource in both traditional medicine and modern pharmaceutical development, and as advancements in phytochemical research and evidence from in vitro and in vivo studies continue to grow, Calendula officinalis is increasingly recognized as a promising natural remedy with multifaceted therapeutic potential, whose integration into contemporary healthcare supported by scientific rigor and sustainable cultivation may offer safer, more holistic treatment alternatives in the future.

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