Phytochemical analysis of *Inula Cappa*

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Abstract- *Inula cappa* is a medicinal shrub widely distributed across the Himalayan region and Southeast Asia. Used extensively in traditional systems of medicine, the plant is known for its pharmacological potential, particularly its antioxidant, and anti-inflammatory activities. This study provides a comprehensive evaluation of *Inula cappa*, focusing on its phytochemical constituents of the leaves and stems. The results validate the traditional use of *Inula cappa* and suggest its potential application in modern herbal medicine. The analysis of *Inula cappa* resulted in the identification of chemical constituents. These compounds were identified based on their respective retention indices.

Key words: Phytochemical, antioxidant and anti-inflammatory.

Introduction

Inula cappa (syn. *Duhaldea cappa*) is a medicinal plant belonging to the Asteraceae family and is naturally distributed in the high-altitude regions of the Himalayas. It grows commonly along forest edges, open grasslands, and mountain slopes between 1,500 and 3,000 meters. The plant is easily identified by its aromatic character, hairy leaves, and bright yellow, daisy-like flowers[1]. Although not widely known outside local communities, it holds a steady place in traditional herbal practices.

For generations, people living in the Himalayan regions of India, Nepal, Bhutan, and China have used *Inula cappa* as a home remedy for common ailments. Its leaves and stems are typically prepared as teas, decoctions, or pastes to treat cough, sore throat, chest congestion, diarrhoea, and minor skin infections. The plant is also applied externally to soothe wounds and reduce inflammation. In many areas, it is collected seasonally, dried, and stored for year-round use[2].

Studies suggest that extracts of the plant, especially methanolic and chloroform extracts, may support respiratory and digestive health, aligning with traditional claims.

Phytochemical investigations have revealed that *Inula cappa* contains several important secondary metabolites, including flavonoids, phenolic compounds, and terpenoids. The presence of such compounds

indicates that *Inula cappa* may possess significant therapeutic value and could serve as a source of new bioactive molecules[3].

With the increasing global interest in herbal medicines, proper scientific evaluation of plants like *Inula cappa* has become essential. Herbal drug evaluation ensures correct identification, assesses the safety of plant materials, and measures the consistency of active compounds[4]. This not only validates traditional knowledge but also supports the development of reliable, evidence-based herbal formulations and potential new therapeutic agents.

Figure- 1 *Inula cappa* **plant**

Morphology of *Inula cappa*

Inula cappa, a distinctive herb native to the Himalayan region, may seem modest in appearance, yet its structure reflects an elegant and well-adapted design shaped by its natural environment. This section provides a clear and simplified overview of the plant's morphology, describing the characteristics of its leaves, stems, flowers, and roots. Understanding these structural features not only helps in proper identification of the species but also highlights the biological adaptations that enable *Inula cappa* to thrive in high-altitude ecosystems.

Leaves- The leaves of *Inula cappa* are a vital part of its identity. They not only help the plant survive and thrive, but are also the parts most commonly used in traditional medicine[5]. They are arranged alternately on the stem, which means each leaf grows on its own at different levels rather than directly opposite another. The edges (margins) of the leaves are usually entire or slightly toothed, and the tip is pointed. The base is typically rounded or narrowed, attaching to a short leaf stalk (petiole) or sometimes directly to the stem (sessile).

Flowers- The part of *Inula cappa* that truly makes it stand out—its flowers[6]. These bright, yellow blossoms are not only beautiful but also carry much of the plant's medicinal potential. They are arranged in a capitulum (a dense flower head), which is typical of the Asteraceae family. Each head consists of many small florets packed together to look like one large flower. They are

usually bright yellow to golden-yellow, giving the plant a radiant and eye-catching look during its blooming season, which is typically from June to September.

Each flower head consists of two types of florets:

Ray florets: These are the long, strap-like petals around the edge that make the flower look daisy-like[7].

Disc florets: These are the small, tubular flowers in the centre. They may have a mild scent and are known to attract bees, butterflies, and other pollinators, making *Inula cappa* important not just for medicine, but for the environment as well.

Figure- 2 Leaves of *Inula cappa*

Figure- 3 Flowers of *Inula cappa*

Fruits and Seeds- After the blooming season, the flowers of *Inula cappa* mature into small fruits, which contain the seeds—nature's way of ensuring the plant's slopes where the wind is strong[8]. This helps it colonize new spaces naturally.

Roots- The root system of *Inula cappa* plays a major role in anchoring the plant and helping it absorb nutrients. They develops a taproot system, meaning it has one main central root that grows deep into the soil, with several smaller side roots branching from it. The roots are usually thick, fibrous, and slightly woody, especially in older plants.

They penetrate well into the ground, which helps the plant survive in dry, rocky soils.
In traditional medicine, not just the leaves and flowers, but also the roots are sometimes used for their therapeutic properties. They are believed to help with inflammatory issues, coughs, and digestive problems.

They are traditionally harvested for medicinal use and are known to contain:

i. Sesquiterpene lactones
ii. Terpenoids
iii. Alkaloids

Decoctions made from the roots are used to treat **liver ailments, rheumatism, sore throats**, and various forms of **inflame-mation**. The root system also plays a crucial role in anchoring the plant in its mountainous terrain and storing bioactive compounds during adverse seasonal conditions.

Pharmacological Activity of *Inula cappa*

Inula cappa has long been valued in traditional medicinal systems for its effectiveness against various health

conditions. Emerging scientific studies now support many of these traditional uses by identifying several important bioactive compounds, including flavonoids, phenolic acids, terpenoids, and sesquiterpene lactones, which are responsible for its medicinal properties[9]. This research provides an overview of the pharmacological activities of *Inula cappa.*

Phytochemical Constituents of *Inula cappa*

Inula cappa is known for its diverse array of secondary metabolites, which play a key role in its therapeutic properties. Phytochemical analyses indicate that the plant's leaves, stems, and roots contain substantial amounts of flavonoids, phenolic acids, sesquiterpene lactones, essential oils, alkaloids, tannins, and various other biologically active compounds. The specific composition and concentration of these constituents can differ based on the plant part examined and the extraction solvent used[10].

Flavonoids

Flavonoids represent one of the most abundant groups of phytochemicals present in Inula cappa. These polyphenolic compounds are well recognised for their strong antioxidant, anti-inflammatory, and liver-protective activities. Studies have shown that the methanolic extracts of the plant's leaves and stems contain particularly high levels of flavonoids. Several key flavonoids, including quercetin, kaempferol, luteolin, and apigenin, have been identified in Inula cappa[11]. These bioactive molecules play a crucial role in neutralising free radicals, preventing lipid peroxidation, and regulating pro-inflammatory cytokines, thereby contributing to the overall therapeutic potential of the plant.

Phenolic Compounds

Phenolic compounds present in *Inula cappa* are well known for their strong antioxidant, antimicrobial, and anti-aging effects. These bioactive molecules play a key role in defending the body against oxidative stress by neutralising harmful free radicals and limiting cellular damage caused by environmental pollutants, aging processes, and chronic inflammation[12]. Because phenolics dissolve more readily in polar solvents like methanol and ethanol, these solvents are commonly used to obtain phenolic-rich extracts from the plant. Among the major phenolic acids identified in *Inula cappa* are chlorogenic acid, caffeic acid, and gallic acid. These compounds not only demonstrate powerful antioxidant activity but also show therapeutic potential in reducing the risk of cancer, cardiovascular diseases, and neurodegenerative disorders. Their protective effects against oxidative injury further justify the plant's traditional use in various medicinal preparations.

Tannins

Tannins found in *Inula cappa* are naturally occurring polyphenolic compounds recognised for their astringent, antimicrobial, and wound-healing properties. These compounds are predominantly present in the leaf extracts and contribute significantly to the plant's therapeutic value. Owing to their ability to precipitate proteins, tannins create a protective layer over mucosal tissues, which helps reduce irritation and inflammation. This mechanism makes them particularly useful in managing gastrointestinal disorders such as diarrhoea by decreasing fluid loss and supporting

the repair of intestinal lining. Their antimicrobial effects also aid in preventing infections in wounds and skin lesions. These beneficial properties correspond well with the traditional use of *Inula cappa* leaves in treating diarrhoea, minor wounds, and various skin infections.

Alkaloids

Although present in relatively low concentrations, alkaloids in *Inula cappa* are thought to contribute to the plant's analgesic and antibacterial properties. Alkaloids are nitrogen-containing compounds widely distributed in medicinal plants and are known for their broad range of pharmacological effects. In the case of Inula cappa, the specific alkaloid types and their exact quantities are still being explored through ongoing research. Early findings indicate that these compounds may help relieve pain by influencing neural pathways involved in pain perception[13]. Their antibacterial activity is believed to result from their ability to disrupt the integrity of microbial cell membranes, thereby inhibiting bacterial growth.

Material and Methods

Plant collection and preparation for extraction

Proper collection and preparation of plant material is essential in herbal research to ensure that the resulting extracts are pure, effective and suitable for laboratory analysis. Fresh leaves and stems of *Inula cappa* were gathered from a high-altitude region of Uttarakhand during the non-flowering season. After confirming the plant's identity, the required parts were collected using clean, sterilized tools such as gloves and scissors to maintain hygiene and prevent contamination. Only mature, healthy, and undamaged samples were selected, while any discoloured, infected, or wilted parts were excluded. To avoid environmental contaminants, plants growing near roadsides, industrial sites, or polluted areas were not selected for sampling.

Collection was carried out early in the morning, shortly after the dew had dried, to preserve the plant's active constituents, particularly those sensitive to heat or moisture. The collected material was immediately cleaned to remove soil, insects, and other impurities. Initially, the samples were rinsed under running tap water to remove visible debris, followed by a final wash with distilled water to ensure purity. Care was taken to avoid excessive handling or bruising, as damage to tissues may affect the stability of phytochemicals.

Drying the plant material is a crucial step, as it prevents microbial growth and preserves the therapeutic compounds. Shade drying was chosen because it is gentle and helps retain the natural colour, aroma, and bioactive components of Inula cappa. The cleaned leaves and stems were spread in a thin, even layer on clean papers or mesh trays and kept in a cool, dry, and well-ventilated area, away from direct sunlight. Exposure to sunlight was avoided to prevent degradation of sensitive phytochemicals. The shade-drying process lasted for approximately 10–15 days, allowing gradual and uniform removal of moisture.

Once completely dried, the plant material was ground into a fine powder using a mechanical grinder. Powdering increases the surface area of the material, thereby improving extraction efficiency and enabling accurate weighing for experimental use. The powdered material was sieved to obtain a uniform particle

size and then stored in airtight containers, preferably glass or food-grade plastic. These containers were kept in a cool, dry, and dark place to prevent moisture absorption, oxidation, or loss of phytochemical activity.

Before extraction, the powdered material was inspected for quality. This included checking for signs of fungal contamination, residual moisture, or abnormal odours. Only samples that were thoroughly dried, clean, and well preserved were used for extraction to ensure the reliability and accuracy of subsequent experimental results.

Figure- 4 Dried leaves of *Inula cappa*

Figure- 5 Dried stems of *Inula cappa*

Extraction Procedure

Approximately 100 grams of powdered leaves and stems were subjected to **successive solvent extraction** using the following solvents in increasing polarity:

- **Hexane** (non-polar)
- **Chloroform** (moderately polar)
- **Methanol** (polar)

Preliminary Phytochemical Screening

Standard qualitative tests were performed to detect the presence of major phyto-chemical groups in all three extracts (hexane, chloroform and methanol). The following tests were employed:

Chemical tests performed on plant extracts using solvents like methanol, ethanol, chloroform, or water—to detect the presence of important bioactive compounds.

Test for Alkaloids

Reagents Used: Mayer's, Dragendorff's, and Wagner's reagents.

Procedure: A few drops of reagent are added to the extract.

Positive Result: Formation of a **white or reddish-brown precipitate** indicates the presence of alkaloids.

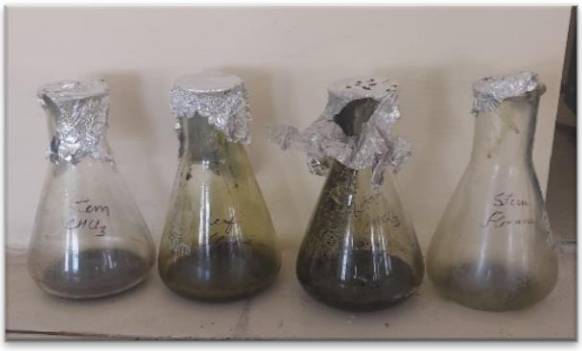


Figure-6 Various Extractions

Test for Flavonoids

Reagents Used: Magnesium ribbon and concentrated HCl (Shinoda test).

Procedure: Add magnesium and HCl to the extract.

Positive Result: A **pink, orange, or red coloration** indicates the presence of flavonoids.

Test for Tannins

Reagent Used: Ferric chloride solution.

Procedure: Add ferric chloride to the extract.

Positive Result: A **blue-black or greenish-black colour** confirms the presence of tannins.

Test for Phenolic Compounds

Reagent Used: Ferric chloride.

Positive Result: Formation of **deep blue or green colour** indicates phenols.

Test for Saponins

Foam Test: Shake the extract with water.

Positive Result: Persistent froth or foam indicates saponins.

Test for Terpenoids

Salkowski Test: Mix extract with chloroform and add concentrated sulphuric acid.

Positive Result: A **reddish-brown interface** shows terpenoids.

Test for Steroids

Liebermann-Burchard Test: Mix extract with acetic anhydride and sulfuric acid.

Positive Result: A **green or blue coloration** confirms steroids.

Test for Glycosides

Keller-Killiani Test:

Procedure: Mix the extract with glacial acetic acid containing a trace of ferric chloride. Carefully add concentrated sulfuric acid along the side of the test tube to form two layers.

Positive Result: A **blue or bluish-green ring** appears at the **interface**, indicating the presence of **cardiac glycosides** (deoxy sugar).

Table- 1 Test for phytochemical group

Phytochemical Group	Test Used	Indicator
Alkaloids	Mayer's, Wagner's, Dragendorff's	Cream/orange precipitate
Flavonoids	Shinoda Test	Pink/red coloration
Phenolic Compounds	Ferric Chloride Test	Deep blue/green colour
Tannins	Gelatin Test	White precipitate
Terpenoids	Salkowski's Test	Reddish-brown interface
Steroids	Liebermann–Burchard Test	Green/blue ring
Saponins	Foam Test	Persistent foam
Glycosides	Legal's Test	Pink to red colour
Proteins	Biuret Test	Violet colour

Results and Discussion

Phytochemical Screening Results

The preliminary phytochemical screening of *Inula cappa* extracts confirmed the presence of a wide array of secondary metabolites. The methanolic extract demonstrated the richest phytochemical profile, showing positive tests for **flavonoids, phenolics, tannins, alkaloids saponins, steroids, terpenoids, and glycosides**.

Chloroform extract also showed moderate results, while the hexane extract exhibited limited constituents, primarily **terpenoids and essential oils**.

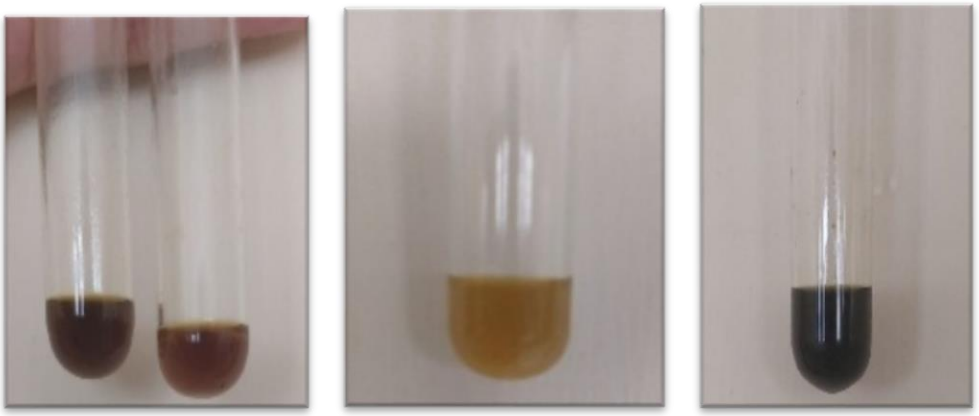
These findings suggest that polar solvents like methanol are more effective in extracting diverse phytoconstituents from *Inula cappa*, consistent with the solubility of phenolics and flavonoids in polar media.

Table – 2 Phytochemical properties from various extract of *Inula cappa*

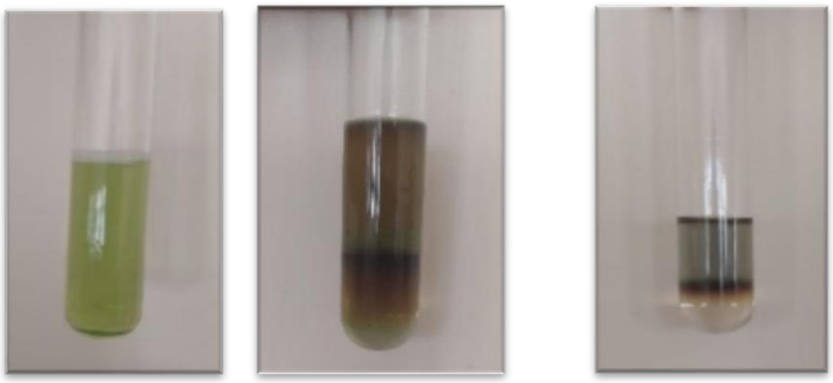
Phytochemical Group	Hexane Extract	Chloroform Extract	Methanol Extract
Alkaloids	–	+	+
Flavonoids	–	+	+++
Tannins	–	–	++
Phenolic Compounds	–	+	+++
Saponins	–	–	+
Terpenoids	++	+	+
Steroids	++	++	+
Glycosides	–	+	++
Essential Oils	++	+	–

Notes:

- (+++) = Strong presence
- (++) = Moderate presence
- (+) = Mild presence
- (–) = Absent or negligible



a) Alkaloids b) flavonoids c) tannins/phenolic compounds



d) Saponins e) glycosides f) terpenoids/ steroids

Figure- 7(a-f) Phytochemical Tests of various phytochemical constituent

Traditional uses of *Inula cappa*

Traditional uses of *Inula cappa*—for fever, joint pain, sore throat, and liver conditions—align with its **validated anti-inflammatory, antioxidant, and hepatoprotective activities**. The presence of specific phytochemicals (e.g., luteolin, quercetin, chlorogenic acid) provides a mechanistic basis for its ethnomedicinal value[15]. The findings also suggest its potential in developing herbal formulations, Neutraceuticals, or lead compounds for future drug discovery.

Conclusion

The results of preliminary phytochemical screening revealed that *Inula cappa* contains a broad spectrum of secondary metabolites, including **flavonoids, phenolic compounds, tannins, alkaloids, saponins, steroids, glycosides,** and **terpenoids.** These compounds are known for their wide-ranging biological activities, including antioxidant, antimicrobial, antiinflammatory, and hepatoprotective effects. Notably, the **methanolic extract** showed the highest presence of these phyto-chemicals, indicating the effectiveness of polar solvents in extracting bioactive constituents.

Disclaimer Statement

Authors declare that no competing interest exists. The products used for this research are commonly used products in research. There is no conflict of interest between authors and producers of the product.

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