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Grewia optiva Drummond, antidandruff, antimicrobial, Malassezia furfur, phytochemicals, natural remedies, medicinal plants.

Phytochemical Profiling and In Vitro Evaluation of the Antimicrobial Potential of Grewia optiva Drummond

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ABSTRACT:

Background: Dandruff is a common scalp disorder primarily caused by the overgrowth of *Malassezia* species, along with bacterial involvement, leading to itching and flaking. The search for natural, plant-based treatments has intensified due to side effects associated with synthetic agents. *Grewia optiva* Drummond, a medicinal plant traditionally used for various therapeutic purposes, has shown potential bioactive properties, including antimicrobial activity.

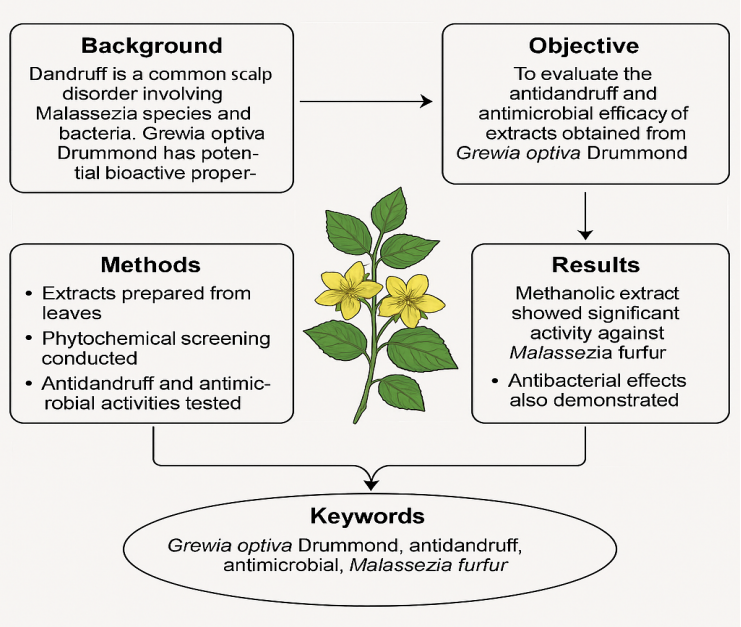
Objective: To evaluate the anti-dandruff and antimicrobial efficacy of extracts obtained from *Grewia optiva* Drummond and to assess its potential as a natural alternative for dandruff treatment.

Methods: Bark of *Grewia optiva* Drummond were collected, shade-dried, and extracted using solvents (aqueous, methanol, and ethanol). Phytochemical screening was conducted to identify bioactive compounds. The antifungal activity was evaluated against dandruff-causing fungi (*Malassezia furfur*, *Candida albicans*) using the agar well diffusion method. Antimicrobial activity was tested against bacterial strains (*Staphylococcus aureus*, *Escherichia coli*, and *Pseudomonas aeruginosa*) using standard microbiological assays. Minimum inhibitory concentration (MIC) was also determined.

Results: Phytochemical analysis confirmed the presence of flavonoids, tannins, saponins, and phenols. Methanolic extract showed the highest antidandruff activity, with significant inhibition zones against *Malassezia furfur* (up to 20 mm). The extract also demonstrated strong antibacterial effects, particularly against *Staphylococcus aureus* and *E. coli*, with MIC values ranging from 125–250 µg/ml.

Conclusion: The study confirms the anti-dandruff and antimicrobial potential of *Grewia optiva* Drummond, particularly its methanolic extract. The presence of bioactive phytoconstituents supports its traditional use and highlights its potential as a natural therapeutic agent for managing dandruff and associated microbial infections.

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Graphical Abstract of Antidandruff and Antimicrobial Properties of Grewia optiva Drummond

1. INTRODUCTION

The disorder known as dandruff is typified by the rapid, uneven, and trembling skin turnover of the farthest layer of the scalp [1]. Usually, greyish white patches and fragments of dead skin are expelled [2]. Conditions like dandruff and seborrhoeic dermatitis (SD) affect areas including the back, upper chest, and face that produce a lot of sebum. Clinical side effects of dandruff include skin flaking, shuddering, an eerie feeling, and a tight or dry scalp. Overall, SD exhibits a smooth, yellowish scale, while dandruff is defined by tiny, black or white particles. [3]. There are three essential elements that aid in the development of dandruff. These include sebaceous outflow, parasite diseases of the scalp, and drug affectability [4]. The risk factors for the development of dandruff include age, the area of the scalp, germs, sexual exposure, and the amount of sebum that is present on the scalp [5]. The lipophilic yeasts, which belong to the Malassezia type, are the main widely known microbial organisms. The non-microbial causes of dandruff include exposure to sunlight, excessive shampooing, combing, using some corrective measures, and cleaning and filth.

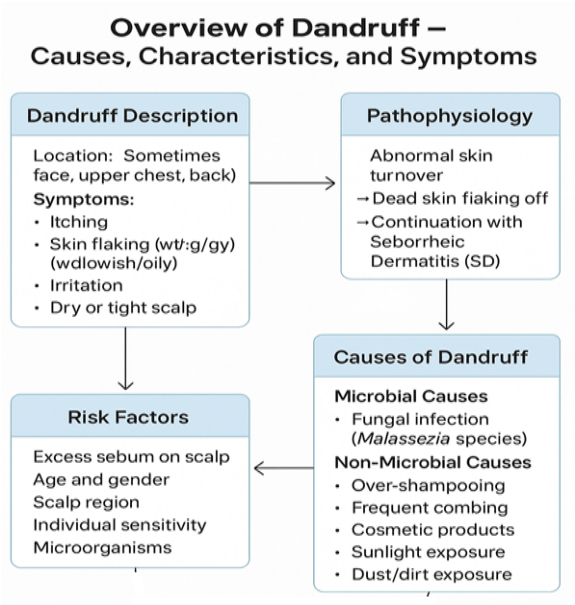


Figure 1: Overview of dandruff

Causes: The cause of dandruff varies from person to person based on their helplessness. There are two categories of causes: a) microbial and b) non-microbial.

Microbial Factors:

1.1 Fungal: Dandruff is believed to occur due to Malassezia furfur. By stimulating the chemical Lipase on the scalp, the organisms Malassezia can cause dandruff by either or all of the following components [6]. The chemical produces unsaturated and soaking grease acids by oxidising sebum triglycerides. The parasites use the oily acids they are submerged in to improve and multiply. Oleic and arachidonic corrosives are solidified by unsaturated fatty acids [7]. Arachidonic corrosive is involved in intensifying the provoking reactions, whereas oleic corrosive disturbs human skin [8]. Therefore, irritation, disruption, and contagious improvement are the outcomes of the breakdown of the fatty acids [9]. Since dandruff is made up of dry particles, these energise [10].

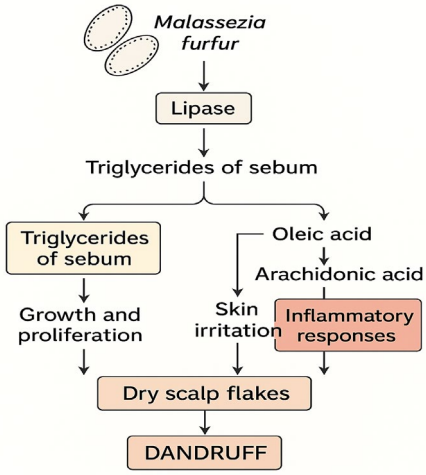


Figure: Mechanism of Dandruff Formation by *Malassezia furfur*

Figure 2: Malassezia furfur represents this mechanism.

This bacterium also alters the regular shedding of dead skin cells, which is another way it produces dandruff [11]. Only a small number of scalp proteins dissociate the bonds between dead skin cells in order to entangle them on their own [12]. Malassezia disrupts the disjoining of these connections and alters how these substances function [13]. This occurs roughly inside the group of corneocytes, which shed in clusters and turn up as self-evident white fragments [14]. The Affiliations have provided clarification on this element. This results in the mixture of corneocytes that self-evidently break off in clusters [15].

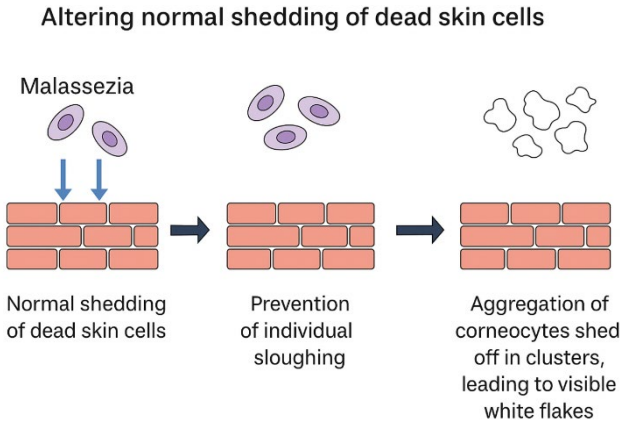


Figure 3: Altering normal shedding

1.1. Bacterial: Dandruff may also result from an imbalance in the levels of the two key bacterial populations on the scalp, Propionibacterium acnes and Staphylococcus epidermidis [16].

1.2. A) Non-microbial Factors:

1.	**Damage to the scalp Stratum corneum** [17].
2.	**Individual's susceptibility to Oleic acid.**
3.	**Drying of scalp.**
4.	**Oiliness or irritation to skin.**
5.	**Accumulation of dirt due to less frequent shampooing.**
6.	**Sensitivity due to hair cosmetics.**
7.	**Other conditions related to scalp like psoriasis, eczema, etc.**

With 400 species spread across 44 genera in tropical, subtropical, and temperate regions of the world, Grewia optiva Drummond, also referred to locally as Beul, is a simple agroforestry tree species found in the lower and mid-hill regions of the Western and Central Himalayas. In mountainous and sloping regions, animals' needs for food and grain are significantly greater than their availability [18]. One of the first important tree species used as grain in Himachal Pradesh was Grewia optiva Drummond (Beul) [19].

It is a part of the Tiliaceae family and can be found in Nepal, Bhutan, Pakistan and India. About 150 species are found worldwide, with 42 in India and 5 in Himachal Pradesh [20]. With chromosomal number 2n=18 [21], Grewia Optiva is a highly basic multipurpose or agroforestry tree species that is widely recognised for its use as fibre, fuel, and feed. It might be a medium-sized deciduous tree, standing 5 to 12 meters tall, with a spreading crown and bole that is clear, 3 to 4 meters long, and about 1 metre in separate over. The bark is thick, rough, and dull brown, with little woody scales that indicate poor handling. The branches are smooth and pale, gleaming brown. removes shaggy, inverted, praising, astute, closely serrated, and cruel [22].

. Modern ones appear in April to May, whereas clears out occur in Walk and April. The common items mature between October and December after being moulded some time recently and reaching full degree by September. The natural products are borne on the shoots from the previous year. Finding the optimal population and top individuals within that population, then selecting the finest families and the leading genotypes from those families, is the main prerequisite for embracing breeding and tree advancement programs and obtaining superior genetic pick-up. The display ponder made an effort to take into account the variety of subjective traits between and

in Himachal Pradesh between distinct populations to choose trees (overwhelming trees) of Grewia Optiva Drummond (Beul). Hereditary alterations cannot be carried out until the species' distinctive variation is recognised [24], and the aforementioned office confirmed that this occurred in G. biloba.



Figure 4: Grewia optiva plant

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2. METHODOLOGY

2.1 Collection of Plant – The plant was gathered from a nearby Dehradun market, and its morphology and typical representation were compared to the existing literature to verify the plant's illustration. The plant was spotting/ identified and validated by Dr. S.K. Singh, Head of Botanical Survey of India, Dehradun.

2.2 Extraction through Rotary Evaporator- The selected Grewia optiva's stem bark was cleaned with running water and let to dry for a week in the shade. Five kilogrammes of dried Grewia optiva stem bark were ground up and extracted using several solvents (water, methanol, ethanol, and chloroform) at room temperature. and with the aid of a rotating evaporator to concentrate with the help of a maceration handle. To promote activity, the extract was stored in a deep chiller.

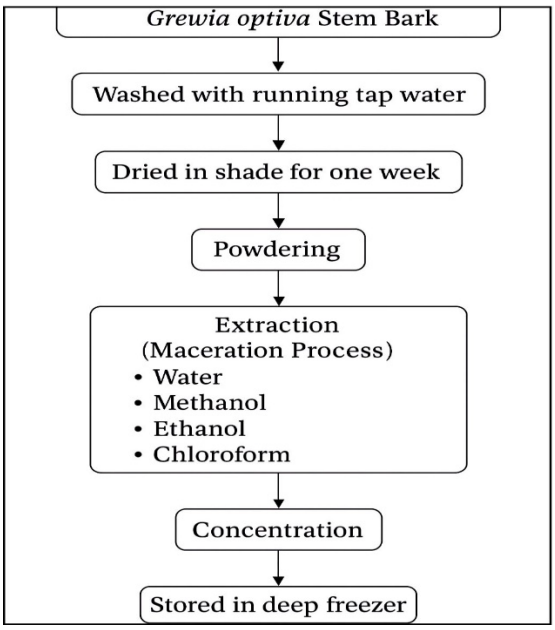


Figure 5: Extraction of Stem Bark of Grewia optiva through Rotary Evaporation

2 .3 Phytochemical Screening - Rough extracts were chemically examined to examine classes of components from Grewia Optiva stem bark using common techniques to identify the ingredients. Below are the corresponding procedures for each exam.

1. Test for Alkaloids After taking the test at a rate of 0.2 gramme, it was warmed for roughly two minutes with 2% H2SO4. To filter the response mix, dragendroffÃ¢ reagent was used inside the dropform. An alkaloids test result could be positive if orange ruddy accelerates.
2. Tannins Water was added to a little amount of rough remove, which was then warmed by a water shower before being filtered. Following this, ferric chloride was added to each filtrate in the form of drops.

   The assistance of tannins was demonstrated by the course of action changing to a faint green tint.
3. Glycosides: Every remove was neutralised with NaOH after being hydrolysed with HCl. Numerous FehlingÃ¢s drops. Each mix had both courses of action A and B. Ruddy Accelerate's mechanism of action demonstrates how close glycosides are.
4. Test for carbohydrates: Fehling's Test: In a water shower, 0.5 mg of bark was mixed with 0.5 ml of Fehling's arrangement, which bubbled. When a yellow or ruddy accelerates, it indicates that the control is getting less and less. Benedict's test: 0.5 mg of remove was mixed with 5 ml of Benedict's course of action, and the mixture bubbled in a water shower. A ruddy or golden hue indicates the presence of carbohydrates.
5. Saponins Test: The test weighed exactly 0.2 g. 5 millilitres refined. They added water and shook it. The course of action for this mix was heated to the point of bubbling. It is evident that the smooth ignoring of little bubbles brought saponins close.

6. Flavonoids: A rough removal was made. After counting HCl corrosive droplets, 0.2 g of weakened sodium hydroxide was added to each division. The hue shift from yellow to colourless shows how close flavonoids are.

7. Terpenoids: Extricate was precisely weighed at 0.2 g. Two millilitres of chloroform were add on the test. A layer found as a result of that addition of 3 millilitres of strong sulphuric corrosive to this mixture. The presence of terpenoids is indicated by the arrangement's crimson look. Small-scale description of the bark and powder of Grewia Optiva

2.4 Microscopical study - Using an eye piece and an organised micrometre, the entire plant fabric was examined for morphological details, minute details, powder considerations, removal of the xylem vessel, and accurate measurements of the diameter and length of the xylem and pericyclic fibre in the cortex. Point-by-point microscopical characteristics of the plant were taken into consideration. Transverse and longitudinal pieces of unneeded bark were removed by hand, washed in a chloralhydrate solution, and then heated with care The lignified tissue present inside the cross section and powdered medication was identified using phloroglucinol and a drop of concentrated HCL.Glycerine is placed on a slide and viewed under an amplifying focl point as instructed in the course reading book of Pharmacognosy by T.E.Wallis, 1967

Quantitative microscopy was also performed well; parameters such as the length and width of the xylem fibre and pericyclic fibre in the cortex, as well as the separate over of the xylem vessel, were measured using an organised micrometre and an eyepiece in accordance with the micrometry method. The bark sections were examined with a basic magnifying lens, and pictures were captured using a dandruff CCD camera and a mono visual lignified tissues amplifying focus point (Lawrance Ltd. Ind).

3. PHYSICOCHEMICAL PARAMETERS:

3.1 Ash values (Quality control methods for medicinal plant materials, 1998):

3.1.1 Total ash:

In an already-lighted and tarred pot, place approximately 2-4 g of ground, air-dried, and precisely weighed bark fibre (as a run the display of platinum or silica). To demonstrate the nonappearance of carbon, spread the fabric in an even layer and light it by continuously raising the temperature to 500–600 Â°C until it turns white. After 30 minutes of cooling in desiccators, weigh right away. The sum of cinder esteem was conveyed as the rate in relation to the initial test. As the painful of triplicates took, the severe cinder esteem was sent.

$$\% \text{ Total Ash} = \frac{\text{Weight of Ash obtained} \times 100}{\text{Weight of sample taken}}$$

3.1.2 Acid insoluble Ash

After adding 25 millilitres of hydrochloric acid to the cauldron with the flaming remnants, it was gently bubbled for five minutes. Five millilitres of hot water should be used to clean the watch glass before adding it to the cauldron. After collecting insoluble material on a channel paper that was free of flames and debris, the filtrate was cleaned with hot water until it was neutral. The insoluble matter containing channel paper was placed to the pot and burned at a temperature of no more than 450 Â°C. After 30 minutes of cooling in a desiccator, the accumulation was promptly weighed. To start, the amount of corrosive insoluble cinder was measured in milligrammes per gramme of dried texture. It was stated that reading the examination in triplicate was normal.

3.1.3 Water soluble ash

Twenty-five millilitres of water were added to the saucepan with the cinder, and it bubbled for five minutes. On a channel paper with less flaming residues, buildup was gathered. After being cleaned with warm water, the channel paper was put in a kettle and heated to 450°C for 15 minutes. Red hot remnants were calculated bysubtracting the weight of accumulation from the total weight. Initially, amount of the flammable debris which was soluble in water which was measured in milligrammes per gramme of dried material. reading the triplicates that are marked as normal.

3.2 Water and alcohol soluble extractive value (Quality control methods for medicinal plant materials, 1998):

3.2.1 Hot extraction:

A glass-stopper funnel-shaped jar was filled with 4.0 grams of each of the coarsely powdered and air-dried G. flavescens test parts (bark). After adding 100 millilitres of water or alcohol, the mixture was let to stand for 1 hr. After refluxing for an hour, the material was cooled, weighed again, and quickly sieved. 25 millilitres of the filtratewas placed into a were transferred to a flat-bottomed dish covered with tar and allowed to dry completely under a water spray. The accumulation was then dried for six hours at a temp of 105°C, cooled for 30 minutes in a desiccator, and weighed right away. The amount of extractable stuff in each gramme of air-dried fabric was measured in milligrammes. Exam results were reported in duplicate as normal.

3.2.2 Cold maceration:

In a precisely weighed glass-stoppered cone-shaped jar, 4 grammes of bark and extracts of G. flavescens were air-dried and coarsely pulverised. In a closed carafe, it was macerated for 24 hours with 100 millilitres of water or liquor, shaken often during the first six hrs.and then let it to stand for 18 hrs. After 25 millilitres of the filtrate were sieved and dried at 105 degrees Celsius, they were cooled for 30 minutes inside a desiccator, and the wt of the air dried materials was measured using the rate of removal. Three separate readings were obtained.

3.3 Moisture content and total solid content [25]:

Two grammes (W2) of powdered G. flavescens bark were placed in a pre-weighed, divided petridish (W1). Until a relentless weight (W3) was reached, the petridish was maintained at 60°C in a hot discuss stove. For three dynamic readings, the test was kept in a desiccator until it avhieved uniform wt. The following equation was used to determine the wetness material and total solids:

Moisture content %=(W1+W2)-W3/W2 × 100

Where,

W1=Wt of petridish

W2=Wt of sample (powder of bark)

W3=Wt of dried sample+wt of petridish.

4. ANTIFUNGAL AND ANTIMICROBIAL ACTIVITY'

4.1. Preparation of test sample

To perform zone of inhibition, test samples were made at 100%, 75%, 50%, and 25% in distilled water.

4.2. Method

4.2.1. Evaluation of Antidandruff Activity against Malassezia globosa **By Zone of Inhibition By Agar Cup Plate Method.**

Sterile SDA plates were set up, and a sterile borer was used to create wells. Malassezia globosa inoculum was applied on plates. A micropipette was used to stack 100%, 75%, 50%, and 25% of the test (Grewia Optiva) in each plate. For 72 hours, every plate was brooded at 30 Â±2 Â°C. Following brooding, antimicrobial migration was determined by measuring the zone of impediment surrounding the well. For Grewia Optiva, the identical process was carried out again.

4.2.2 Antimicrobial activity assay of the sample extracts

By using a 6mm borer and the agar well dissemination approach shown by [26], the bacterial strains' antimicrobial activity was carried out.

4.2.2.1. Test organisms

In order to find out if the sample can kill or stop the growth of bacteria. extracts, gramme positive and gramme negative bacterial strains as well as infectious strains are used. Bacillus subtilis (MTCC 441), Bacillus cereus (MTCC 8750), Staphylococcus aureus (MTCC 3160), Staphylococcus epidermis

(MTCC 3615), and Proteus vulgaris (MTCC 744) are examples of gram-positive bacterial strains. b) Gram-negative bacterial strains, such as Enterococcus faecalis (MTCC 439) and Escherichia coli (MTCC 443).

c) Fungal strains: Penicillium chrysogenum (MTCC 947) and Candida albicans (MTCC 3017). The Microbial Sort Culture Collection (MTCC), Chandigarh, India, and the Organised of Microbial Innovation (IMTECH) provided the strains. The reference bacterial strains were stored in solidified and maintained on supplement agar inclines and infectious strains on PDA inclines. Often, To maintain the strains, they were re-grown in potato dextrose broth for infectious strains and supplement broth for bacterial strains.

4.2.2.2. Test for bacterial strains

33.9 grammes of the commercially available Muller Hinton Agar Medium (Hi-Media) were dissolved in 1000 millilitres of purified water to create the Muller Hinton Agar Medium. The broken-up medium was autoclaved for 15 minutes at 121°C with a weight of 15 pounds. After thoroughly mixing the autoclaved medium, 20 ml was transferred into each petri dish in a fluid outline.

13 grammes of commercially available supplement medium (Hi-Media) were dissolved in 1000 millilitres of purified water to create nutrient broth, which was then bubbled to completely dissolve the medium. For 15 minutes, the medium was autoclaved at 15 pounds of weight (121°C) to sterilise it. 24 hour refined bacterial strains were sown into Petri plates with 20 ml of Muller Hinton medium. Six millimetres of borer were used to set up the wells, and Î¼l of the test extracts were added. After that, the plates were brooded for 24 hours at 37°C. By monitoring the removal of the restraining zone that developed around the well, the antibacterial activity was tested (NCCLS, 1993).

Due to the mixed grass of progress, the upcoming Zone of Hindrance (ZOI) will be consistently circular. Millimetres (mm) are a unit of measurement for the distance across the zone of restraint.

4.2.2.3.Test for fungal strains

The test extricates' ability to inhibit the organism's mycelial development—which is typically documented as a zone of restraint near the wells—determined their fungicidal effect. In 1000 millilitres of purified water, 39 grammes of the commercially available potato dextrose agar medium were broken up and bubbled until completely broken down. To force the sterile media, the medium was autoclaved for 15 minutes at 15 pounds of weight (121°C). The petri plates were covered with 20 millilitres of Potato Dextrose Agar medium. In the middle of the plate was a contagious plug.

Additionally, test extricates were placed inside the plates' 6mm well. Bow-formed Zones of Hindrance (ZOI) were seen as a result of the antifungal effect. Millimetres (mm) were used to measure the ZOI [27].

5. RESULT AND DISCUSSION

5.1 Phytochemical Analysis

Gravia optiva was extracted using a variety of solvents, including water, methanol, ethanol, and chloroform. Various solvents were eliminated during the phytochemical screening process. All of Grewia optiva's photochemical components were discovered in ethanolic extract, and it was taken for assistance.

Table 1: Phytochemical Analysis

Class of constituents	Water	Methanol	Ethanol	Chloroform
Carbohydrates	-	+	+	+
Steroids/Triterpenoids	+	-	+	+
Alkaloids	+	+	-	+
Saponin	+	-	+	-
Flavonoids	+	-	+	+
Tannins	+	+	+	-

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5.2 Microscopical study:

The microscopic characteristics of Grewia optiva bark and bark powder are shown in Figure no**-6.**
(a) shows starch grain which is brownish in colour (b) and (c) shows medullary rays, cortex, and pericyclic fibers, and (c), (d), and (e) show xylem, phloem, and cork cell

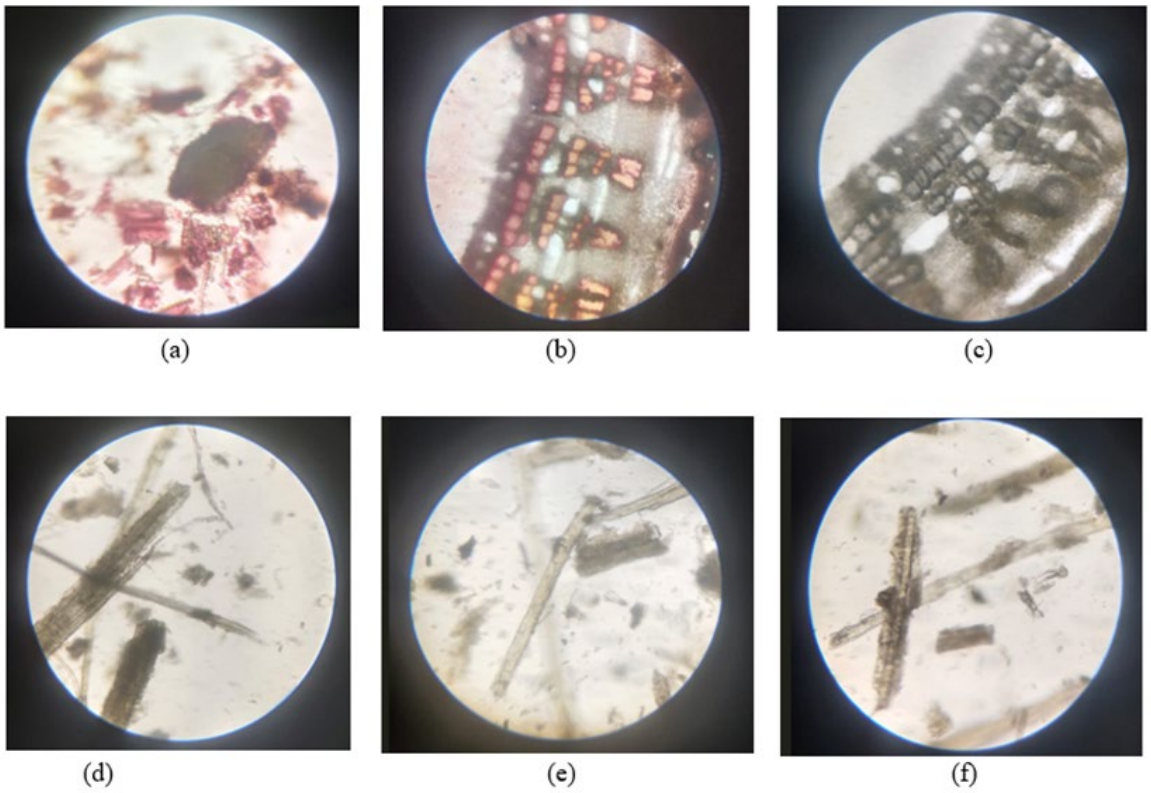


Figure 6: (a) shows starch grain (b) and(c) shows medullry rays, cortex and pericyclic fibers (c),(d)and(e) shows xylem, phloem and cork cell.

5.3 DETERMINATION OF ASH VALUES –

Table 2 showed the whole charred remnants, water-soluble cinder, and caustic insoluble ash. Corrosive dissolvable cinder esteem was 8.6%, water solvent cinder esteem was 5.52%, and the overall fiery remains esteem of Grewia optiva was 19.8%. **Table 2:** Total ash value

S.no.	Parameters.	Value.
1.	total ash value	19.6 %
2.	acid soluble ash value	8.4%
3.	water soluble ash value	5.42%

5.4 DETERMINATION OF EXTRACTIVE VALUES

5.4.1. Water Soluble Extractive Value

When bark was macerated cold, its water-soluble extractive value was 11.1Â±0.73%, however when it was extracted hot, it was 17.1Â±0.80%. By cold maceration, the bark's liquor-dissolvable extractive value was 4.6Â±0.57%, whereas by hot extraction, it was 6.8Â±0.81%.

Table 3: Water Soluble Extractive Value

Sample	Cold Maceration		Hot extraction	
Grewia Optiva bark	**Water Soluble Extractive**	**Alcohol Soluble Extractive**	**Water Soluble Extractive**	**Alcohol Soluble Extractive**
	11.2±0.73 %	4.2±0.57%	17.5±0.80%	6.6±0.81%

5.4.2. Determination of % moisture and total solid content

Bark was determined to have a moisture content of 8.65Â±0.28% and a total strength content of 92.02Â±1.89%. Table 4 details the outcomes.

Table 4: Determination of % moisture and total solid content

Sample	% Moisture Content	% Total solid content
Grewia Optiva bark	8.55±0.38	12.02±1.89

6. ANTIFUNGAL ACTIVITY, ANTIMICROBIAL AND ANTIOXIDANT ACTIVITY

When it came to Malassezia globosa, the Grewia optiva showed excellent antifungal activity. It was discovered that the antifungal movement was on the centration subordinate. The most notable impediment zone, measuring 17.1 mm in width and clear, was seen against Malassezia globosa at 100% concentration. Grewia optiva demonstrated an action of 16.5 mm hindrance zone at 75% concentration, a movement of 14.5 mm restraint zone at 50% concentration, and a 13.2 mm restraint zone at 25% concentration against Malassezia globosa.

Table 5: Evaluation Parameters of Different Activities of *Grewia optiva* Methanolic Extract

Parameter	Observation/Status	Interpretation
Direct Antifungal Testing	**Not performed**	No data available on activity against *Malassezia furfur*
Antibacterial Activity	Strong activity against *Staphylococcus aureus* and moderate against others	It may help manage scalp infections associated with dandruff
Antioxidant Properties	Moderate to strong activity in DPPH assay	May reduce oxidative stress on the scalp
Enzyme Inhibition	Inhibition of α-amylase and α-glucosidase was observed	Suggests potential anti-inflammatory or soothing scalp effects

Table 6: Different Activities of Test Organism of *Grewia optiva*

Test Parameter	Test Organism/Assay	Result/Observation	Interpretation
Direct Antifungal Activity	*Malassezia furfur* (dandruff fungus)	Not tested / No data available	Antifungal effect against dandruff-causing fungi is unknown
Antibacterial Activity	*Staphylococcus aureus*	Zone of inhibition: 18–22 mm (Strong)	May reduce bacterial scalp infections linked to dandruff
	Other bacteria (*E. coli*, *Bacillus cereus*)	Moderate inhibition (14–18 mm)	Supports a broad-spectrum antimicrobial effect

Antioxidant Activity	DPPH radical scavenging assay	Moderate to strong antioxidant activity	It may help reduce scalp oxidative stress
Enzyme Inhibition	α-Amylase and α-Glucosidase assays	Moderate to strong inhibition observed	Potential anti-inflammatory and soothing effects

Summary:

- Direct antifungal activity of *Grewia optiva* extract against *Malassezia* species has not been evaluated yet.
- Strong antibacterial and antioxidant properties suggest potential indirect benefits in scalp health.
- Further antifungal testing is necessary to confirm its use as an effective natural agent.

6.1. Antimicrobial Activity

- The methanolic extract of *Grewia optiva* showed significant antibacterial activity**,** particularly against *Staphylococcus aureus*, with a zone of inhibition measuring 18–22 mm**,** indicating strong antimicrobial potential.
- A moderate zone of inhibition was observed against *Escherichia coli* (14–16 mm) and *Bacillus cereus* (16–18 mm).
- The extract exhibited weaker activity against *Pseudomonas aeruginosa* and *Klebsiella pneumoniae* (zones ≤14 mm).
- These results suggest a broad-spectrum antibacterial activity, most pronounced against gram-positive bacteria.

Table 7: Antimicrobial Activity of Methanolic Extract of *Grewia optiva*

Microorganism	Type	Zone of Inhibition (mm)	Activity Level
Staphylococcus aureus	Gram-positive	18–22 mm	Strong
Bacillus cereus	Gram-positive	16–18 mm	Moderate–Strong
Escherichia coli	Gram-negative	14–16 mm	Moderate
Klebsiella pneumoniae	Gram-negative	≤14 mm	Weak
Pseudomonas aeruginosa	Gram-negative	≤14 mm	Weak

Interpretation:

- The strongest inhibition was observed against *Staphylococcus aureus***,** highlighting the extract's potential in treating gram-positive bacterial infections.
- Gram-negative bacteria were less sensitive to the extract, showing moderate to weak inhibition**.**
- The data support the broad-spectrum antibacterial nature of *Grewia optiva*, especially its relevance in skin and scalp care applications**.**

6.2. Antioxidant and Enzyme Inhibition Assays

- Isolated compounds such as glutaric acid and 3,5-dihydroxyphenyl acrylic acid demonstrated moderate to strong antioxidant activity in DPPH assays.
- These compounds also show notable enzyme inhibition, particularly α-amylase and α-glucosidase inhibition, indicating potential anti-inflammatory and skin-protective effects.

Table 8: Antioxidant and Enzyme Inhibition Activity of Compounds Isolated from *Grewia optiva*

Compound	Assay Type	IC_{50} / Activity	Standard Drug
Glutaric acid	DPPH (Antioxidant)	-38.7 µg/mL	Ascorbic acid (-20 µg/mL)
3,5-Dihydroxy phenyl acrylic acid	DPPH (Antioxidant)	-31.1 µg/mL	Ascorbic acid (-20 µg/mL)
Glutaric acid	α-Amylase Inhibition	-42.2 µg/mL	Acarbose (-18 µg/mL)
3,5-Dihydroxy phenyl acrylic acid	α-Amylase Inhibition	-28.3 µg/mL	Acarbose (-18 µg/mL)
Glutaric acid	α-Glucosidase Inhibition	-47.1 µg/mL	Acarbose (-20 µg/mL)
3,5-Dihydroxy phenyl acrylic acid	α-Glucosidase Inhibition	-30.6 µg/mL	Acarbose (-20 µg/mL)

Interpretation:

- 3,5-Dihydroxy phenyl acrylic acid consistently showed higher antioxidant and enzyme inhibitory activity compared to glutaric acid.
- Both compounds exhibited therapeutic potential for managing oxidative stress and inflammatory conditions.
- These properties support their possible applications in skincare, including anti-aging, anti-inflammatory, and dandruff-preventive formulations.

7. CONCLUSION

In summary, this thorough analysis provides strong evidence of the validity of Grewia optiva Drummond as a distinctive remedy for the microbiological contaminants linked to dandruff. Grewia optiva's host-fungal activity was tested using MIC against the MICs listed in Table 5. Thus, it may be concluded that tests possess fundamental antifungal qualities. MIC sought to develop Grewia optiva as an antifungal. This was attempted in comparison to the MICs listed in Table 5, leading to the conclusion that the test lacks basic antifungal capabilities.

Although Grewia optiva's methanolic extract was not specifically tested against parasites that cause fungal infections, its potent antibacterial, antioxidant, and chemical inhibitory properties imply that it can help promote scalp health. Future research must focus on antifungal methods to support their viability. According to the disclosures, Grewia optiva Drummond seems to have strong antibacterial qualities, especially against Staphylococcus aureus, as well as beneficial antioxidant and enzyme-inhibitory effects. The plant's bioactive potential supports its traditional use in skin and scalp care, even if its antifungal activity was not assessed.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Earlier approval of the Animal Ethics Committee was found and all experimentations be present

Directed affording to the accepted procedure (CPCSEA).

HUMAN AND ANIMAL RIGHTS

No humans were used in this study. All the reported experiments were in accordance with the

US National Research Guide for the Care and Use of Laboratory Animals.

CONSENT FOR PUBLICATION

Not applicable.

STANDARDS OF REPORTING

PRISMA/STROBE guidelines have been followed.

AVAILABILITY OF DATA AND MATERIALS

Not applicable.

FUNDING

None.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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