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Original Article

Formulation and Evaluation of *Fumaria parviflora* Loaded Oil in Water Emulsion-Based Cream

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ABSTRACT

Background: *Fumaria parviflora* (FP) is a medicinal herb that is used in several traditional medicines to treat diseases like folliculitis, erysipelas. *Fumaria parviflora* Lam. belonging to the family Papaveraceae is used widely in traditional and folkloric medicine. It is known as 'Pittapapra' in Ayurveda, and 'Shahtaraa' in Unani is used to treat various ailments like indigestion, vomiting, fever, and fatigue. It is showing properties like anthelminthic, diuretic, diaphoretic, and blood-purifying properties. The present study is done to evaluate the antibacterial and antifungal properties of the extract. **Materials and Methods:** The plant extract was isolated by using a Soxhlet apparatus by using ethanol as the solvent. The extract was filtered using filter paper and heated in the oven to obtain the plant extract concentrate. The o/w emulsion-based cream was evaluated for pH, viscosity, thermal stability, spreadability, antibacterial (*S. aureus* and *E. coli*) and antifungal (*C. albicans* and *A. niger*) activity. **Results:** The o/w emulsion-based cream formulations were found to be stable, found to have pH compatible to human skin, no skin irritancy and also have good spreadability properties, and found to be effective against bacterial cells but no considerable effect on fungal cells. **Conclusion:** The o/w emulsion-based cream formulations were examined for both antibacterial and antifungal activities but from the results we concluded that *Fumaria parviflor*a Lam. is found to be effective against bacterial cells and useful in treating bacterial skin infections.

Keywords: *Fumaria parviflora*, Antibacterial, Antimicrobial, Cream.

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INTRODUCTION

A perennial plant with many branches, *Fumaria parviflora* is utilized extensively in both traditional Yunani medicine and Ayurvedic treatment throughout India. A species of flowering plant called *Fumaria parviflora* is sometimes referred to as fine-leaved fumitory, Indian fumitory, and fumitory with fine leaves. In the family Papaveraceae, the genus Fumaria contains roughly 60 species of annual flowering plants. It is an Ayurvedic plant with the Latin name *Fumaria parviflora* and the Sanskrit name parpat. In the Indian medical system, it is a well-liked therapeutic plant.[1] *Fumaria parviflora* is a plant used traditionally in Iranian medicine to treat liver illnesses, skin conditions including dermatitis and acne, and bronchitis. It is also used as an expectorant and a diuretic.[1,2] The whole herb is widely utilized in the Ayurvedic medicinal system as, cooling, bitter, constipating, cures biliousness, expectorant, promotes "vata" and fever, burning sensations throughout the body, exhaustion, mental drowsiness, intoxication, urine discharge, vomiting, thirst, blood enrichment, and is beneficial in leprosy.[1] The protective and antioxidative properties of *Fumaria parviflora* and other species of fumaria plants were demonstrated against the CCl_4 model of hepatotoxicity. For instance, *Fumaria parviflora* showed beneficial benefits on the toxicity of paracetamol to the liver. The *Fumaria parviflora* plant is given in Figure 1.[3]

The plant has a wide range of biological traits, including hepatoprotective, antifeedant, antiprotozoal, laxative, antioxidant, antimicrobial, antieczema, antipruritic, anthelmintic, antidiabetic, antinociceptive, antiparasitic, prokinetic, and spasmodic action. *Fumaria parviflora* Lam leaves extract shows equal effectiveness with silymarin at a dosage of 200 mg/kg and exhibits strong hepatoprotective action against INH (isoniazid) and RMP (rifampicin) caused hepatotoxicity.[5,4] Although the plant was not well studied, it has significant ethanopharmacological significance. They thus conducted their current research, which deals with critically significant data on the micromorphological traits of this medicinal plant, in order to give fundamental pharmacognostic criteria as well as aid in

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identification and authenticity. The development of the herbal pharmacopeia standards includes the use of pharmacognostic and phytochemical analysis, which is crucial for the identification and quality control of medicinal plants.[6]

Fumaria parviflora ethanolic extract has been shown by Gilani *et al*. to have anti-inflammatory, antinociceptive, and protective properties. Furthermore, it has been demonstrated that *Fumaria parviflora* has beneficial effects on the process of sperm generation in male rats. According to phytochemical analyses of various fumaria plants, *Fumaria parviflora* in particular, contains a variety of compounds including cryptopine, sinactine, protropine, parfumine, perfumidine, bicuculline, adlumine, stylopine, fumariline, fumarophycine, dihydrofumariline, dihydrosanguirine, and fumaritine. Using *in vivo* models of inflammation, the ethanolic and aqueous extract of *Fumaria parviflora* leaves shown considerable anti-inflammatory action. *Fumaria parviflora* leaves have anti-inflammatory properties because they suppress several cytokines, function as an antioxidant, and scavenge free radicals.[7] *Fumaria parviflora*'s hydroalcoholic extract demonstrated notable hepatoprotective efficacy against Carbon Tetrachloride (CCl_4), which severely damaged the liver. With levels more than 100 mg/kg, the plant extract stopped the liver damage caused by CCl_4. The findings of this investigation confirm conventional wisdom regarding the hepatoprotective properties of *Fumaria parviflora*. The plant's bioactivity has been linked to several biological effects, including antispasmodic, anti-inflammatory, bronchodilator, antidiarrheal, hypoglycemia, dermatological illnesses, hepatoprotective, laxative, anthelmintic, antiprotozoal, and antinociceptive impact.[8]

Anti-inflammatory activity

Using *in vivo* models of inflammation, the ethanolic and aqueous extract of *Fumaria parviflora* leaves showed considerable anti-inflammatory action. *Fumaria parviflora* leaves have anti-inflammatory properties because they suppress several cytokines, function as an antioxidant, and scavenge free radicals.[10,9]

Hepatoprotective activity

Fumaria parviflora Lam. Leaves extract shows equal effectiveness with silymarin at a dosage of 200 mg/kg and exhibits strong hepatoprotective action against INH (isoniazid) and RMP (rifampicin) caused hepatotoxicity. To guard against the hepatotoxicity of isoniazid and rifampicin, this plant extract is utilized as a food addition to antitubercular treatment. Rats' serum biochemical characteristics after receiving a long-term dose of *Fumaria parviflora* extract. This study's findings indicated that *Fumaria parviflora* has an impact on hepatic function, but they diverge somewhat from those of other studies.[12,11]

Alqasoumiet *et al*. examine the hepatoprotective properties of an ethanol extract of *Fumaria parviflora* aerial parts and Momordica balsamina leaves against experimentally induced liver damage in rats. Rats treated with two extracts had their livers examined histopathologically based on the findings of biochemical parameter measurements. Hepatocytes that appeared normally suggested that the extracts had effectively protected the liver from the hepatotoxic effects of carbon tetrachloride from *Fumaria parviflora. Fumaria parviflora* hydroalcoholic extract significantly reduced the severity of liver damage produced by carbon tetrachloride CCl_4 and showed hepatoprotective action. With levels more than 100 mg/kg, the plant extract stopped the liver damage caused by CCl_4. The findings are consistent with long-held notions about *Fumaria parviflora's* hepatoprotective properties.[14,13]

Anti-parasitic activity

Meloidogyne incognita root-knot nematode management the use of green manure and extracts from the plant *Fumaria parviflora* on tomato has shown nematicidal capabilities and is a possible new control agent for plant parasitic nematodes. *Fumaria parviflora's* roots exhibited greater nematicidal activity than the plant's tops did. According to these findings, *Fumaria parviflora* may be used alone or in conjunction with other pest control strategies to treat *M. incognita*.[15]

Anti-diabetic activity

Fumaria parviflora Lam powder's oral administration to streptozotocin-induced diabetic rats enhanced their blood levels of triglycerides, total cholesterol, and HDL, but had no appreciable impact on their levels of glucose or LDL. The effects of a methanolic extract of *Fumaria parviflora* on blood sugar levels in healthy and diabetic rats produced by streptozotocin. Only streptozotocin-induced diabetic rats with blood glucose levels below 100 mg/dl responded favourably to the administration of *Fumaria parviflora* extract (p 0.001) extracts.[16]

Anti-microbial activity

A single new antibacterial component, N-octacosan-7-ol, was discovered by Jameel *et al*. from a methanolic extract of the whole *Fumaria parviflora* Lam plant. Against *E. coli, S. epidermidis, A. niger, C. albicans*, and the isolated chemical demonstrated more effective antibacterial and antifungal activity. These findings suggested that the substance may have a practical use in the prevention and defence against bacterial (gramme+ and gramme-), leishmanial and fungal, diseases in both people and animals.[17]

Protective effect

The ability of an ethanol extract from the leaves of *Fumaria parviflora* to protect adult Wistar rats' testicles against lead-related injury. Following lead acetate treatment, there were substantial reductions in testis weight, blood testosterone level, epididymal sperm count, seminiferous tubule diameter, and

Glutathione Peroxidase (GPx) and Superoxide Dismutase (SOD) content. Additionally, it was shown that the lead-treated rats had considerably higher amounts of Malondialdehyde (MDA). However, co-administration of the extract showed that *Fumaria parviflora* significantly increases the selected reproductive indices in rats treated with lead. *Fumaria parviflora* plant leaves are extracted with ethanol to enhance male reproductive health and hence boost fertility. Seminal vesicle and ventral prostate weight did not differ significantly across experimental groups. In rats treated with the extract, there was a significant increase in the density of epididymal sperm and the percentage of morphologically normal sperm. Rats given extracts of *Fumaria parviflora* leaves at doses of 200 and 400 mg/kg/day had considerably greater serum testosterone levels.[18]

Gastrointestinal activity

Similar to loperamide and dicyclomine, the aqueous-methanol (30:70) extract of *Fumaria parviflora* prevented castor oil-induced diarrhea in rats and mice. *Fumaria parviflora*'s antidiarrheal and antispasmodic properties, which may be mediated by a dual blockade of muscarinic receptors and Ca^{2+}, provide it with a strong scientific foundation for its usage as a remedy for diarrhea and stomach cramps. The active ingredient in *Fumaria parviflora* plant extract demonstrated prokinetic, laxative, and spasmodic effects that were partially mediated through cholinergic pathways with species and tissue selectivity, and this supports the use of *Fumaria parviflora* as a medication for disorders of the gut motility such as constipation and indigestion.[19]

Antioxidant activity

The ethanol (50%) extract of *Fumaria parviflora* significantly reduced the oxidative stress brought on by nimesulide. Reactive Oxygen Species (ROS) were produced quickly, glutathione was depleted, antioxidant genes were altered, and the mitochondrial membrane was severely depolarized, which led to death. The study comes to the conclusion that nimesulide induces hepatotoxicity in rats via involving mitochondria and that herbal supplements may be used to lessen the oxidative stress caused by drugs that are required to be taken in large dosages because of severe illness. In primary rat hepatocyte cultures, the aqueous-alcoholic extract of *Fumaria parviflora* prevented nimesulide-induced cell death. By modifying crucial apoptotic stages, *Fumaria parviflora* extract eliminated the harmful effects of nimesulide without affecting its therapeutic benefit.[20]

Anti-nociceptive activity

The antinociceptive activity of *Fumaria parviflora* Lam.'s methanolic extract is significantly affected. In the formalin test, particularly in the late phase and hot-plate test, the extracts of *Fumaria parviflora* had an impact that might not be mediated by opioid receptors. It is suggested that additional research into this plant, particularly in models of inflammation, is warranted.[21]

Antipruritic activity

A randomized, double-blind, and placebo-controlled experiment was conducted to determine the effects of *Fumaria parviflora* on Uremic Pruritus (UP) in Hemodialysis (HD) patients. *Fumaria parviflora* is risk-free and may lessen HD patients' UP symptoms. One interpretation of *Fumaria parviflora* is that it supports the immunohypothesis explanation for UP.[22]

Antifeedant activity

The effectiveness of the volatile oils from the Satureja hortensis and *Fumaria parviflora* Plodia plants were evaluated for their antifeedant action against the Plodia interpunctella Hubner, Indian meal moth. Results showed that Satureja hortensis oil considerably reduced the relative consumption rate and relative growth rate when compared to *Fumaria parviflora*. Compared to *Fumaria parviflora*, Satureja hortensis oil had a higher feeding deterrent index.[23]

Anthelmintic activity

The effectiveness of *Fumaria parviflora* Caesalpinia crista seeds and leaves vs oxyclozanide (a common medicine) against sheep fasciolosis. On the 18th day after therapy, oxyclozanide's effectiveness in lowering faecal egg count was determined to be 100%. On the 18^{th} and 28^{th} days following therapy, *Fumaria parviflora* and Caesalpinia crista, respectively, demonstrated 59.4%, 91.8% and 58.7%, 87.3% effectiveness at a dosage of 80 mg/kg. It was determined that *Fumaria parviflora* Caesalpinia crista had anthelmintic action against ovine fasciolosis that was substantial (p0.01) and equivalent to that of the common medication oxyclozanide.[24]

Antibacterial activity

The nonacosane-10-ol (alcohol), 23a-homostigmast-5-en-3-ol (homolog of -sterol), and cis- and trans-protopinium (alkaloid) of *Fumaria parviflora*, three previously identified recognised chemicals, have antibacterial action. *In vitro* testing was done on plant extracts and pure chemicals against seven clinical Gramme (-) and Gramme (+) bacterial species. At the maximum dosage of 300 g/mL, the cis- and trans-protopinium was the most effective antibacterial substance against all strains tested. The viable cell count experiments showed that all three substances were bactericidal. Extracts from *Fumaria parviflora* and phytochemicals, in particular the cis- and trans-protopinium, have antibacterial activities and might be exploited to create new chemotherapeutic drugs.[25]

MATERIALS AND METHODS

Determination of the phytochemicals present in the *Fumaria parviflora* extract

Gas chromatography and mass spectroscopy (GC-MS) method

A methanol solvent is used to dissolve a *Fumaria parviflora* extract before injecting it into the intake port. The heated intake causes the liquid sample to vaporize and turn into a gas. The sample is transported through the column by the mobile phase, which is an inert gas, such as helium. Depending on their chemistry, various components of the sample have various interactions with the stationary phase of the column. As a result, they move through the column at various speeds, which separates them. Following their sequential separation, the separated chemicals exit the column and enter a detector, such as a mass spectrometer (MS). The retention time of a compound is the length of time it takes for it to move through the column.

Preformulation methods

FT-IR

Fumaria parviflora

The FT-IR spectrum of *Fumaria parviflora* has been recorded with a Fourier-Transform IR spectrophotometer within the range 4000-400 cm^{-1} by utilizing the method of KBr pellet. In this method, a small amount of plant extract (approx. 1mg) was taken in a mortar, and KBr was added to it in the ratio of 1:10, followed by trituration with a pestle. Then the mixture was put in a die cavity and pressed with KBr press under a pressure of 4-5 tons, leading to a formation of a thin film. This film was placed in the sample compartment and the FTIR was performed in the mentioned range to obtain the spectrum of the drug.

Mixture

The FT-IR spectrum of *Fumaria parviflora* has been recorded with a Fourier-Transform IR spectrophotometer within the range 4000-400 cm^{-1} by utilizing the method of KBr pellet. In this method, a little amount of plant extract and all the chemicals which are used in the formulation were taken in a mortar, and KBr was added to it in the ratio of 1:10, followed by trituration with a pestle. Then the mixture was put in a die cavity and pressed with KBr press under a pressure of 4-5 tons, leading to the formation of a thin film. This film was placed in the sample compartment and the FT-IR was performed in the mentioned range to obtain the spectrum of the drug.

Thermal analysis by DSC

DSC, a thermal analytical process, was employed to get the thermogram of *Fumaria parviflora* by using aluminum pans. In this technique, an accurate weight of the sample was taken in the aluminum pans and sealed tightly. To determine the thermal behavior of the plant extract, the aluminum pans containing the sample were heated at a temperature range of 40-300°C, with a scanning rate of 20°C/min. To provide an inert atmosphere nitrogen gas was purged continuously at a 40 mL/min flow rate.

Formulation methods

Extraction of Fumaria parviflora by using the soxhlet apparatus

Take the plant of *Fumaria parviflora* into the big-sized filter paper. Crush the dried obtained *Fumaria parviflora*. Pack the obtained crushed dried *Fumaria parviflora* into the filter paper so that it is secured without getting wasted. This package can be to be placed in the thimble, which is being used in the Soxhlet extraction method. In the extraction of *Fumaria parviflora*, methanol is used as the solvent which will be prefilled into the distillation flask. And after the experimental setup is ready, the Soxhlet apparatus is heated so that it will be able to heat the solvent (methanol) to the boiling temperature. The evaporated methanol is contained within the apparatus by the condenser unit. The solvent is heated to reflux. Solid material (*Fumaria parviflora*) in the chamber slowly fills warm solvent (methanol). The desired compound dissolves in the warm solvent. The warm solvent along with extract *Fumaria parviflora* can be then separated by evaporation method via heating. The solvent will be evaporated from the mixture leaving behind the extract *Fumaria parviflora* which was dried and can be used for further formulation.

Preparation of cream

Oil in water (o/w) emulsion-based cream was formulated. The *Fumaria parviflora* and other oil-soluble components were dissolved in the oil phase and heated to 75°C. After heating, the water phase was added slowly to the oil phase with continuous stirring until the cooling of the emulsion took place. Then, finally to the emulsified mixture, the glycerin is added, with continuous stirring. Then the prepared cream is transferred to the clean container. The oil and water phases and their quantities are given in Tables 1 and 2 simultaneously.

Evaluation of the Formulation

Physical properties(29)

Determination of organoleptic properties

The assessment of medications through the sense organs is known as organolepticity. It alludes to analytical techniques including colour, odour, taste, size, form, and unique characteristics like touch and texture. The cream's smell, colour, and look were scrutinized

pH of the cream

The pH range of 4-6 seen in creams is ideal for human skin. A digital pH meter was used to measure the pH of various

formulations. 1 g of cream and 100 mL of distilled water were weighed, mixed, and then chilled for 2 hr. The pH of each formulation was tested three times, and the average values were calculated.

Test for thermal stability

With the use of a spatula, the prepared cream was placed into a glass bottle and taped to sink to the bottom. Filled the bottle to its halfway point, put the plug in, and tightened the top. For 48 hr, the filled bottle was maintained upright at 41°C within the incubator. If the sample does not exhibit any oil separation or other phase separation after it is removed from the incubator, the test was successful.

Irritancy

It is possible to utilise irritation to anticipate a substance's potential for severe skin irritation. To find out whether a substance or chemical may produce local irritation in the skin, mucosa, or ocular tissues, an irritation test(s) might be employed. On the left-hand dorsal surface, test mark a square of 1 cm^2. The designated area was covered with cream, and the application time was recorded. Up to 30 min of irritation were monitored and reported.

Viscosity

A brook field viscometer operating at 50 rpm was used to measure the viscosity of the cream formulation. Due to the shear energy in a fluid process system, viscosity plays a significant role in determining the friction loss. Viscosity is a metric for a fluid's resistance to flow. The amount of energy needed to create a desired condition of flow increases with a liquid's viscosity. The determination of viscosity was done at room temperature.

Spreadability

It was measured in terms of how long it took for two slides, under a specific weight, to separate from cream that was positioned in between the slides. The spreadability increases as the time required to separate the two slides decreases. Glass slides with uniform dimensions were selected from two sets. On one of the slides, the herbal cream mixture was applied. The other slides were positioned on top of the formulation, sandwiching the cream between them. The weight of the higher slides caused the cream to be compressed uniformly to produce a thin layer. The extra formulation that was sticking to the slides was scraped off once the weight was removed. The power of the weight that was attached to the upper slide allowed for unfettered slipping down. It was noted how long the upper slide took.

$$\text{Spreadability} = m*l/t$$

Where, m=weight tied to the upper slide (30g).

l=length of a glass slide (5 cm).

t=time taken in seconds.

Phase separation

Phase separation is the process of separating a single homogenous mixture into two separate phases. Phase separation between two immiscible liquids, such as oil and water, is the most frequent form of phase separation. The prepared cream was stored undamaged at 25-300°C and away from light in a covered container. For 30 days, phase separation was closely monitored every 24 hr. Phase separation was evaluated for changes.

Characterization of the formulation

Antibacterial activity

Pathogenic cultures and growth condition

Staphylococcus aureus MTCC96 and *E. coli* MTCC118 pathogenic cultures were cultivated in Brain Heart Infusion (BHI) medium for 24 hr at 37°C while being constantly shaken (150 rpm).

Assay protocol

A sterile petri dish was filled with BHI agar (1.5% w/v agar) that had been pre-inoculated with the bacterial pathogen (1% v/v) and allowed to harden. Using a sterile cork borer, 4 mm wells were created, and 80 L of the sample (stock: 100 mg/mL) was added. For appropriate diffusion, the plates were maintained at 4°C for 30 min. Plates were then incubated for 24 hr at 37°C and checked for the presence of an inhibitory zone (mm in diameter). Gentamycin (1 mg/mL), an antibiotic, served as a positive control.

Figure 1: *Fumaria parviflora*.

Table 1: The oil and water phases for the preparation of the cream.

Sl. No.	List of ingredients	
	Oil phase	Water phase
1	Steric acid	Fumaria parviflora
2	Olive oil	Triethanolamine
3	Cetyl alcohol	Water
4	Glycerine	
5	Benzyl alcohol	

Table 2: The oil and water phases and their quantities.

Sl. No.	Ingredients	Quantity for 10 g	Quantity for 100 g	Application
1	Steric acid	1 g	10 g	Used as lubricating agent Skin protectant.
2	Olive oil	0.6 mL	6 mL	Used as antioxidant and has moisturizing properties.
3	Cetyl alcohol	0.5 g	5 g	Used as an emulsifying agent.
4	Glycerine	0.5 mL	5 g	Used as moisturizing agent.
5	Triethanolamine	0.2 mL	2 mL	Used pH adjuster.
6	Benzyl alcohol	0.2 mL	2 mL	Used as preservative, solvent, viscosity decreasing agent.
7	Water	Qs.	Qs.	As solvent, conditioning agent, cleansing agent.

Table 3: Phyto-constitution present in the *Fumaria parviflora* identified by the GC-MS analysis.

Sl. No.	Phyto-constitution	Class	Retention time
1	Hexamethylcyclotrisiloxane	Polymeric organosilicon	2.5
2	Octamethyltetrasiloxane	Polymeric organosilicon	4.5
3	hexamethyl-3-[(trimethylsilyl)oxy] trisiloxane	Polymeric organosilicon	4.5
4	Benzyloxymethylimine	Phenethylamine	8.65
5	Amphetamine	Phenethylamine	8.66
6	2-Propanone, 1,1,1,3,3,3-hexafluoro-, o-(phenylmethyl)oxime		8.67
7	Dodecanal	Fatty aldehyde	12.75
8	3-Nonyn-2-ol	Phenolic compound	12.8
9	5-(2-Furyl)-4-methyl-2-(4-morpholinylmethyl)-2,4-dihydro-3H-1,2,4-triazole-3 -thione	Steroid	13.42
10	N-Methyladenosine	Steroid	13.45
11	N-(8-hydroxy-6-sulfamoylnaphthalen-2-yl) acetamide		13.56
12	3-Decyn-2-ol	Phenolic compound	14.31
13	(2Z,5Z)-2,5-Pentadecadien-1-ol	terpenoid	14.41
14	Benzyl linoleate	Fatty acid	14.59
15	Cyclobutanol	Fatty acid	17.0
16	Cyclopropyl carbinol	Fatty acid	17.21
17	2-Aminononadecane	Fatty acid	17.24
18	Octodrine	Fatty acid	17.5
19	2-Aminotridecane	Fatty acid	17.7

Table 4: FTIR spectra data with respective functional groups of *Fumaria parviflora* plant extract.

Peak (cm^{-1})	Bond nature
3642.73	N-H stretching
3642.72	O-H stretching
3180.15	C-H stretching
2922.25	C-H stretching
2725.51	C-H stretching
2675.36	C-H stretching
2382.88	C=C stretching
2036.90	Aromatics
1888.18	C=O stretching
1444.73	O-H bending
1375.29	O-H bending
1305.85	C-O stretching
1158.26	C-O stretching
1028.08	C-O stretching
986.37	C-N stretching
886.00	C-C stretching
846.78	N-H bending
725.26	N-H bending

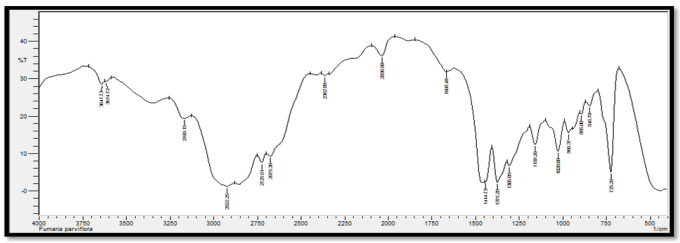

Figure 2: FT-IR of *Fumaria parviflora* plant extract.

Anti-fungal activity

Fungal cultures and growth condition

In potato dextrose broth, *Candida albicans* ATCC90028 and *Fusarium oxysporum* MTCC1755 were cultivated for three days at 30°C with continual shaking (150 rpm).

Assay protocol

PDA agar was put onto a clean petri plate and let to set. The test fungal culture was added to the medium using sterile swabs, and a Whatman filter paper disc measuring 4 mm was placed equally apart. 10 L of the sample extract (stock, 100 mg/mL) was put into the disc and allowed to soak. Plates were examined for the existence of an inhibitory zone (mm in diameter) after 2-3 days of incubation at 30°C. Fluconazole, an antibiotic, was used as a positive control (1 mg/mL).[26]

RESULTS

Determination of the phytochemicals present in the *Fumaria parviflora* extract.

Gas chromatography and mass spectroscopy (GC-MS) method

Fumaria parviflora extract is used in the GC-MS method and the found phytoconstituents are given in Table 3.

Preformulation method

FT-IR

Fumaria parviflora

The FT-IR spectrum of *Fumaria parviflora* plant extract is depicted in Figure 2. FT-IR spectra data with respective functional groups of *Fumaria parviflora* plant extract is given in Table 4. It was found that all the characteristic absorption peaks of *Fumaria parviflora* plant extract were observed in the FT-IR spectra and there was no disappearance or shift of functional peaks of *Fumaria parviflora* plant extract.

Mixture

The FT-IR spectrum of *Fumaria parviflora* plant extract and the chemicals used in the formulation are depicted in Figure 3. FT-IR spectra data of the mixture is given in Table 5. It was found that all the characteristic absorption peaks of *Fumaria parviflora* plant extract and chemicals used in the formulation were observed in the FTIR spectra and there was no disappearance or shift of functional peaks.

Thermal analysis by DSC

The thermogram of *Fumaria parviflora* extract from DSC thermal analysis showed a sharp endothermic peak at 149.08°C, depicted in Figure 4, which is the melting point of the extract.

Evaluation of the Formulation

Physical properties

Determination of organoleptic properties

The physical qualities of each cream formulation were assessed based on its appearance and aroma. It has a Normandy grey hue and no smell.

pH of the cream

The produced creams' pH results were determined to be in the range of 5.6, which is appropriate for topical use. Creams have a pH of 4-6, which is suitable for human skin.

Table 5: FT-IR spectra data of the mixture.

Peak (cm^{-1})	Bond nature
2920.32	O-H stretching
2850.88	C-H stretching
1705.13	C=O stretching
1485.95	C-H bending
1433.16	O-H bending
1301.99	O-H bending
1062.81	C=O stretching
937.44	C=C bending
723.33	C-H bending
686.68	C-H bending
547.80	Benzene derivative

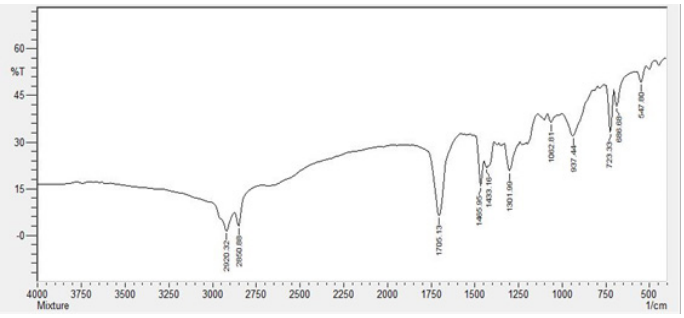

Figure 3: FT-IR of *Fumaria parviflora* plant extract and the chemicals used in the formulation.

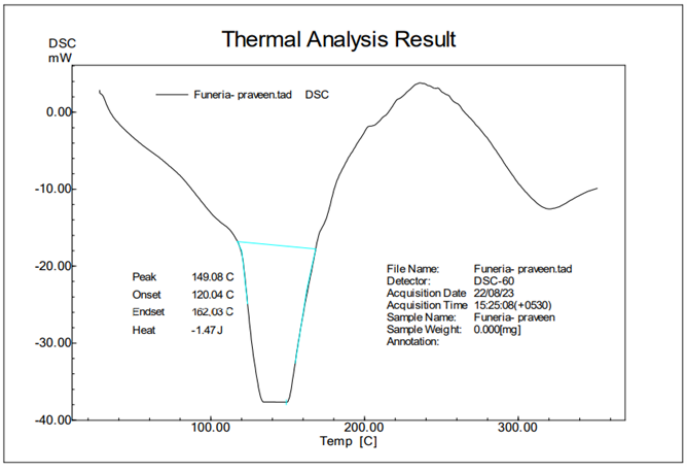

Figure 4: DSC of *Fumaria parviflora* plant extract.

Test for thermal stability

The humidity chamber, which was set at 60-70% RH and 37°C, was used to assess the formulation's thermal stability. No oil separation was noticed, and all of the formulations are stable.

Irritability

For a few min, a little amount of gel was applied externally to the skin's surface, and the skin's reaction was observed. It wasn't determined to be irritating.

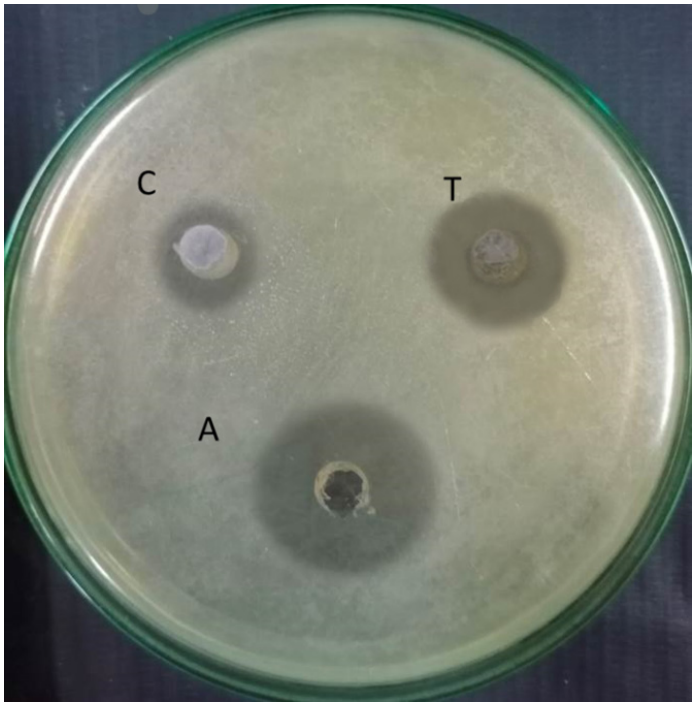

Figure 5: Antibacterial activity of given sample against *S. aureus*; A-Antibiotic gentamycin; C-Control; T-test.

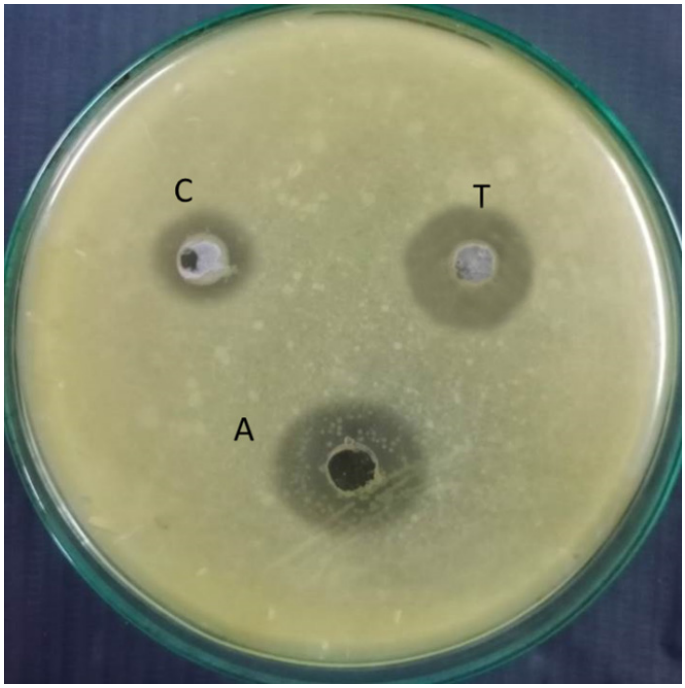

Figure 6: Antibacterial activity of given sample against *E. coli*; A-Antibiotic gentamycin; C-Control; T-test.

Viscosity

A brook field viscometer set to 50 rpm was used to measure the viscosity of the antibacterial cream formulation. The formulation's viscosity was determined to be between 1000 and 3000 cp, indicating that a little shear was all that was needed to spread the cream.

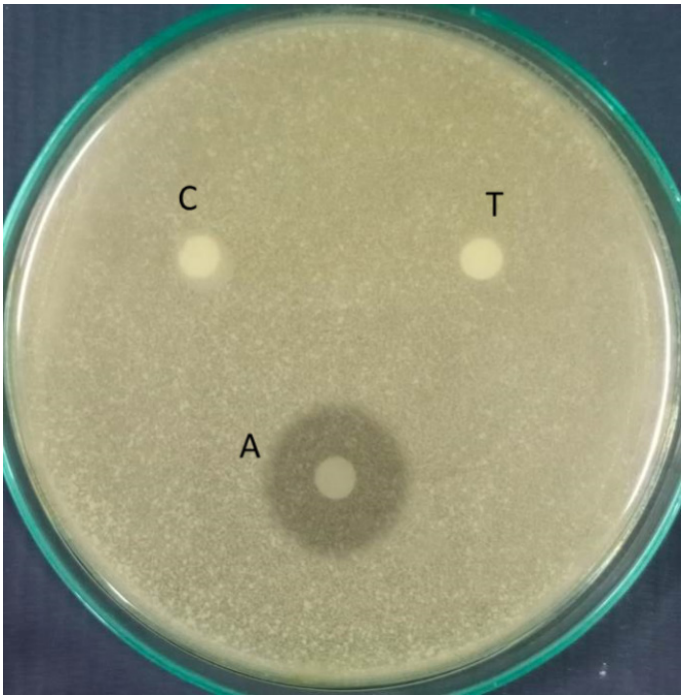

Figure 7: Antifungal activity of given leaf extracts against *Candida albicans*; A-Antibiotic Fucanozole; C-control; T-test.

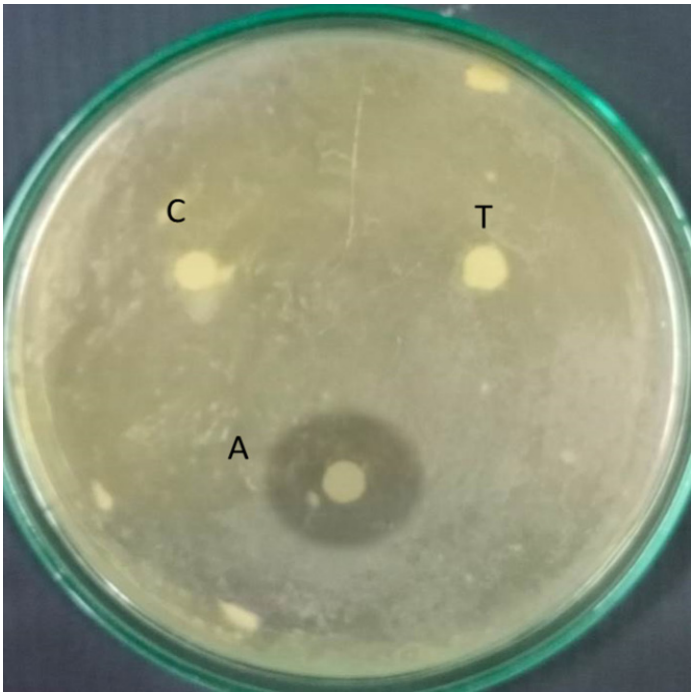

Figure 8: Antifungal activity of given leaf extracts against *Fusarium oxysporum*; A-Antibiotic Fucanozole; C-control; T-test.

Table 6: Pathogens used in the antibacterial studies.

Pathogens	Zone of inhibition (mm in diameter)		
	Control	Test	Antibiotic
S. aureus	10	14	20
E. coli	10	14	20

Table 7: Pathogens used in the antifungal studies.

Pathogens	Zone of inhibition (mm in diameter)		
	Control	Test	Antibiotic
C. albicans	-	-	16±0.00
A. niger	-	-	16±0.00

Spreadability

Spreadability of cream formulations, or a cream's capacity to cover the skin uniformly, is a crucial factor. The cream's formulation exhibits good spreadability.

Phase separation

The formulation is observed for 30 days and this hasn't showed any phase separation.

Characterization of the formulation

Antibacterial activity

The pathogenic culture *Staphylococcus aureus* MTCC96, and *E. coli* MTCC118, are used to determine the anti-bacterial activity which is given in the Table 6. The prepared formulation showed the zone of inhibition for the *Staphylococcus aureus* (Figure 5) and the *E. coli* (Figure 6).

Antifungal activity

Candida albicans ATCC90028 and *Fusarium oxysporum* MTCC1755 are used to determine the anti-fungal activity which is given in the Table 7. The prepared formulation has not shown the zone of inhibition for the *Candida albicans* (Figure 7) and the *Fusarium oxysporum* (Figure 8).

DISCUSSION

An antibacterial cream called *Fumaria parviflora* is used to treat a variety of bacterial illnesses. It is provided in the form of topical cream medication delivery systems for convenience of use. They are multicomponent systems that include co-surfactant and

non-polar aqueous surfactant components. Surfactant molecules can localise at the interface and reduce the surface tension there when they are present in an immiscible combination of oil and water. The majority of hydrophobic medications cannot be added directly to cream bases because their solubility serves as a barrier and causes issues with the medication's release. At 65-750C, the formulation that comprises the oil component was gradually mixed into the aqueous phase.

CONCLUSION

The created o/w emulsion-based cream was evaluated for microbiological growth against *C. albicans* and Fusarium oxysporum as well as antibacterial activity against *S. aureus* and *E. coli*. The hydrophobic medication is first incorporated into the oil phase, after which it is uniformly and finely dispersed in the aqueous phase using a combination of surfactant and co-surfactant that lowers the interfacial tension and enhances the miscibility of the two liquid phases. The cream method makes sense for topical medication administration over other forms due to its relative stability and simplicity of application and removal. The formulation of an o/w emulsion-based *Fumaria parviflora* cream for the treatment of bacterial infections was the primary goal of the current work. The *Fumaria parviflora* o/w emulsion-based cream's therapeutic effectiveness was increased by increasing its permeability and solubility, which also increased its bioavailability.

The pH of the *Fumaria parviflora* o/w emulsion-based cream was determined to be 5.6, and all of the o/w emulsion-based cream was confirmed to be stable in a humidity chamber at 60 to 70% relative humidity and 37°C. A brookfield viscometer was used to measure the viscosity of an antibacterial cream formulation and discovered that it ranged from 1000 to 3000 cp, indicating that only light shear was required to distribute the cream. The cream formulation has good spreadability, and after 30 days of observation, there hasn't been any evidence of phase separation. When compared to other commercially available creams used to treat bacterial infections, we discovered that o/w emulsion-based cream boosted skin penetration and deposition. According to the results of the testing, the cream has a pH that is suitable for human skin, is easily dispersed, and has strong antibacterial properties. One of the potential methods to decrease dosage frequency and extend the duration of medication concentration at the target location is this antibacterial cream. Finally, it may be inferred from the findings of the present investigation that the cream has improved the bioavailability of the medication *Fumaria parviflora*, which is weakly water-soluble. Our research has so demonstrated that *Fumaria parviflora* cream formulation may be used topically to treat bacterial infections.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

ABBREVIATIONS

FP: *Fumaria parviflora*; **INH:** Isoniazid; **RMP:** Rifampicin; **CCl_4:** Carbon tetrachloride; **GPx:** Glutathione peroxidase; **MDA:** Malondialdehyde; **UP:** Uremic pruritus; **HD:** Hemodialysis; **MS:** Mass spectrometer.

ETHICAL STATEMENT

This research has not involved studies such as human participants, human data, or human tissues.

PATIENT CONSENT

The authors took the consent for the publication.

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