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Formulation And Evaluation Of Garlic Extract Containing Anti-Dandruff Gel

Rudra R. Chandel

Department of Pharmacy

SHRADDHA INSTITUTE OF PHARMACY, WASHIM, MAHARASHTRA, INDIA

Aditi V. Tikait

Department of Pharmaceutics

SHRADDHA INSTITUTE OF PHARMACY, WASHIM, MAHARASHTRA, INDIA

Swati P. Deshmukh

Department of Pharmacology

SHRADDHA INSTITUTE OF PHARMACY, WASHIM, MAHARASHTRA, INDIA

ABSTRACT

Dandruff is a prevalent scalp disorder characterized by excessive flaking, itching, and inflammation, often caused by the overgrowth of *Malassezia* fungi. Conventional anti-dandruff treatments, though effective, can lead to side effects such as dryness, irritation, and microbial resistance with prolonged use. This study focuses on developing a natural, herbal alternative using garlic (*Allium sativum*) extract, renowned for its potent antifungal, antimicrobial, and anti-inflammatory properties. The objective was to formulate and evaluate an anti-dandruff gel containing garlic extract, aloe vera, and other excipients to enhance efficacy, stability, and cosmetic acceptability. Three gel formulations (F1, F2, and F3) were prepared with varying concentrations of garlic extract and evaluated for physicochemical properties such as pH, spreadability, texture, washability, and stability. Antifungal efficacy was assessed through microbial inhibition studies. The optimized formulation (F3) exhibited the best performance with a pH of 5.5, excellent spreadability, smooth consistency, and the highest zone of inhibition (21 mm) against *Malassezia furfur*. It was also non-irritant and easy to wash off, enhancing user compliance. The results demonstrate that garlic extract, when incorporated into a topical gel, offers an effective and safe herbal remedy for dandruff. This formulation

serves as a promising alternative to chemical-based treatments, providing both therapeutic and cosmetic benefits. Further clinical evaluation is recommended to support large-scale commercialization.

Keywords

Garlic extract, Anti-dandruff gel, *Malassezia furfur*, Herbal formulation, Allicin, Antifungal activity, Natural remedy, Scalp health, Carbopol 934, Aloe vera.

1. INTRODUCTION

Dandruff is a common scalp condition that affects a large proportion of the global population. It is characterized by the shedding of dead skin cells, resulting in visible white flakes on the scalp and shoulders, often accompanied by itching and irritation. The primary cause of dandruff is the overgrowth of the yeast-like fungus *Malassezia*, which thrives on the scalp's natural oils. Other factors, such as poor scalp hygiene, excess oil production, skin conditions like eczema, or stress, can also exacerbate dandruff. Conventional treatments typically involve the use of antifungal shampoos containing synthetic active ingredients such as ketoconazole, selenium sulfide, or zinc pyrithione. While these treatments may be effective, they can also have side effects, such as scalp irritation, dryness, or long-term sensitivity. [1]

In recent years, there has been increasing interest in natural alternatives for dandruff treatment, particularly those derived from plant-based ingredients. Garlic (*Allium sativum*) is one such natural remedy that has gained significant attention due to its potent antimicrobial, antifungal, and anti-inflammatory properties. Garlic contains allicin, a bioactive compound that has been shown to inhibit the growth of *Malassezia*, the fungus responsible for dandruff. Garlic also possesses antioxidant properties that help reduce inflammation and irritation on the scalp, further contributing to its effectiveness in managing dandruff. [2]

The formulation of a garlic extract-based anti-dandruff gel is a promising alternative to chemical treatments. The gel base provides several advantages, including easy application, non-greasy texture, and enhanced stability of active ingredients. Gel formulations also allow for the slow and controlled release of the active compounds, ensuring that they stay on the scalp for extended periods, which can enhance their effectiveness. Moreover, the gel format is typically more user-friendly, offering a more pleasant application experience than traditional shampoos or lotions.

A gel is a semisolid system consisting of a dispersion of small or large molecules in a liquid phase that is gelled using a gelling agent. In pharmaceutical and cosmetic applications, gels are commonly used for topical delivery of active ingredients.[3]

The preparation of the garlic extract for use in the gel is a critical step. Garlic can be extracted using various methods, such as methanolic, ethanolic, or aqueous extraction. Each method has its advantages, with methanol and ethanol providing higher yields of bioactive compounds. Once the garlic extract is prepared, it is incorporated into the gel matrix, which is typically composed of gelling agents such as carbopol, hydroxyethylcellulose, or xanthan gum. These gelling agents help form the desired gel consistency, ensuring the proper texture for easy application and spreading on the scalp. Other ingredients, such as humectants (e.g., glycerin) and emollients (e.g., dimethicone), are added to maintain moisture, improve the smoothness of the gel, and enhance its skin compatibility. [4]

1.1 Dandruff

Dandruff is a common scalp disorder characterized by excessive shedding of dead skin cells from the scalp. It is considered a non-inflammatory form of seborrheic dermatitis and is marked by symptoms such as itching, dryness, and the presence of white flakes. Although not life-threatening, dandruff can cause significant psychological and social distress, reducing the quality of life for affected individuals [5].

The condition primarily affects the stratum corneum of the scalp, where abnormal keratinization and desquamation lead to visible flaking. The process is typically accelerated in dandruff patients, with skin turnover occurring in approximately 7–15 days instead of the usual 28-day cycle. As a result, immature corneocytes clump together and are shed as flakes.

Multiple factors contribute to dandruff, including increased sebum production, colonization by Malassezia species (particularly *Malassezia globosa* and *Malassezia restricta*), individual susceptibility, and environmental conditions such as humidity and temperature. Hormonal imbalances, poor hygiene, and the use of certain hair products may further aggravate the condition. [6]

Among these, the role of *Malassezia*, a lipophilic yeast naturally present on the scalp, is most well-documented. These fungi hydrolyze triglycerides in sebum to produce oleic acid, a known irritant that penetrates the stratum corneum and triggers abnormal skin responses in susceptible individuals. This contributes to increased cell turnover, barrier disruption, and inflammation, leading to characteristic flaking and itching. [7]

Conventional treatments for dandruff include the use of antifungal agents such as ketoconazole, selenium sulfide, and zinc pyrithione, along with keratolytics and corticosteroids. However, these synthetic agents may cause adverse effects with long-term use, such as irritation or resistance. Hence, the focus has shifted toward herbal remedies that are milder, safer, and possess multiple therapeutic properties.

In this context, garlic (Allium sativum) emerges as a potent natural agent due to its antifungal, antibacterial, antioxidant, and anti-inflammatory properties. Rich in compounds like allicin and ajoene, garlic has demonstrated strong inhibitory effects against *Malassezia* and other fungal pathogens, making it a promising candidate in the formulation of anti-dandruff treatments.

Dandruff is a widespread scalp disorder characterized by excessive shedding of dead skin cells, itching, and sometimes inflammation. It is primarily caused by the overgrowth of the yeast *Malassezia furfur*, which thrives in the oily environment of the scalp. Other contributing factors include poor hygiene, stress, hormonal imbalances, and underlying skin conditions such as seborrheic dermatitis. Conventional dandruff treatments often involve the use of medicated shampoos containing active ingredients like ketoconazole, zinc pyrithione, selenium sulfide, and salicylic acid. These agents work by reducing fungal growth, slowing down skin cell turnover, or removing flakes from the scalp.[8] While effective, prolonged use of synthetic products can lead to side effects such as dryness, irritation, or resistance. As a result, there is growing interest in natural and herbal alternatives. Remedies like garlic extract, tea tree oil, neem, and aloe vera have shown antifungal, antibacterial, and soothing properties. Among these, garlic (*Allium sativum*) is particularly notable for its active compound allicin, which exhibits strong antifungal effects against *Malassezia*. Herbal treatments are generally considered safer and more sustainable for long-term use.

Maintaining a healthy scalp through regular cleansing, a balanced diet, and stress management can further support dandruff control. Newer approaches, such as probiotic shampoos and plant-based antifungals, are also being explored for their potential to rebalance the scalp microbiome and provide lasting relief. [9]

1.2 Need for Herbal Formulations

In recent years, there has been a growing global inclination toward herbal and natural remedies in both the pharmaceutical and cosmetic industries, particularly for treating common dermatological issues such as dandruff. This trend is largely driven by concerns regarding the potential side effects, resistance, and environmental impact associated with synthetic chemical treatments. Conventional anti-dandruff products, including agents like ketoconazole, selenium sulfide, zinc pyrithione, and coal tar, though effective, can often lead to undesirable effects such as scalp dryness, irritation, hypersensitivity reactions, and damage to the scalp's natural microbiome. Furthermore, long-term use may cause resistance or dependency, leading to a recurrence of symptoms once treatment is stopped. [10]

In contrast, herbal formulations are widely considered safer, more biocompatible, and environmentally sustainable. Medicinal plants offer multiple pharmacological actions, including antifungal, antibacterial, anti-inflammatory, and antioxidant properties. These multifaceted benefits make them ideal for addressing the complex pathology of dandruff, which involves microbial overgrowth, excessive sebum secretion, barrier dysfunction, and skin cell hyper proliferation. For example, herbs like neem, tulsi, aloe vera, and garlic have demonstrated significant efficacy against *Malassezia* the yeast most commonly associated with dandruff. [11]

The incorporation of garlic (*Allium sativum*) into topical anti-dandruff formulations is particularly promising. Garlic is rich in bioactive compounds such as allicin and ajoene, which exhibit strong antimicrobial properties. Studies have shown that allicin, a sulfur-containing compound produced when garlic is crushed, can inhibit fungal growth by disrupting the integrity of fungal cell membranes, preventing replication and colonization. These properties, along with garlic's natural anti-inflammatory and antioxidant effects, contribute to its effectiveness in treating dandruff and other scalp infections.

Furthermore, the rising consumer preference for natural and chemical-free personal care products has led to a surge in demand for herbal-based shampoos, creams, gels, and conditioners. Products that are free from synthetic surfactants like sodium lauryl sulfate (SLS), parabens, and synthetic fragrances are now preferred due to their minimal toxicity and perceived health benefits. The sensory appeal, cultural familiarity, and perceived safety of herbal products make them particularly popular among consumers looking for gentle, yet effective alternatives.[12]

1.3 Role of Garlic in Antimicrobial and Antifungal Treatments

Garlic (*Allium sativum*), a member of the *Liliaceae* family, has been used for centuries in traditional medicine across cultures for its broad spectrum of therapeutic properties. Among its many health benefits, garlic is especially renowned for its antimicrobial and antifungal activity, making it a valuable natural remedy in the treatment of infections. The key bioactive component responsible for garlic's antimicrobial potency is allicin, a sulfur-containing compound produced when garlic is crushed or chopped. Allicin

exhibits a broad-spectrum inhibitory effect against a variety of pathogenic microorganisms, including bacteria, fungi, viruses, and some protozoa.[13]

Numerous studies have confirmed garlic's efficacy against Gram-positive and Gram-negative bacteria such as *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa*, and *Helicobacter pylori*. Allicin is believed to exert its antibacterial effects by interfering with microbial enzyme systems, particularly by inhibiting thiol-containing enzymes that are essential for microbial metabolism. This mode of action reduces the risk of resistance development, a growing problem with many conventional antibiotics. Furthermore, garlic has been found to exhibit synergistic effects when used in combination with certain antibiotics, enhancing their efficacy and overcoming microbial resistance. [14]

Garlic's antifungal properties are equally significant. Several studies have reported its strong inhibitory activity against fungi, particularly the *Candida* and *Malassezia* species, both of which are commonly associated with skin and scalp conditions. In the context of dandruff, *Malasseziaglobosa* and *Malasseziarestricta* play a central role in pathogenesis, and garlic has demonstrated effective inhibition of these lipophilic yeasts. The mechanism is thought to involve allicin's ability to disrupt fungal cell membranes, inhibit ergosterol biosynthesis, and interfere with the production of fungal toxins. In addition to allicin, other compounds in garlic such as ajoene and diallyldisulfide also contribute to its antifungal action, offering a multi-pronged approach to controlling fungal infections.[15]

Another significant benefit of garlic in antimicrobial therapy is its anti-biofilm activity. Biofilms are structured communities of microorganisms that are highly resistant to antibiotics. Garlic extract has been shown to prevent the formation of biofilms and also to disrupt pre-formed biofilms, which is especially useful in chronic and recurrent infections. This property makes garlic a promising alternative or adjunct to synthetic antifungal agents, especially for topical applications like dandruff treatments. [16]

2. Materials and Methods

2.1 Materials

Table No.1 Materials

Sr. No.	Name of Material	Manufacturer
1	Garlic Extract (*Allium sativum*)	The Garlic Company (USA),LLC
2	Aloe Vera Gel	AOS Products Pvt. Ltd..
3	Carbopol 934	Lubrizol Corporation (USA).Ltd.,
4	Glycerine	Wilmar International (Singapore)
5	Sodium Hydroxide	Dow Chemical Company (USA) Pvt. Ltd..
6	Sodium Benzoate	Eastman Chemical Company (USA) Pvt. Ltd..
7	Lavender Oil	Falcon Essential Oils (India) Pvt. Ltd..

2.2 Equipments

Table No.2 Equipments

Sr. No.	Name of Equipment	Manufacturer
1	Weighing Balance	Ohaus (USA) Pvt. Ltd..
2	Mechanical Stirring	Fisherbrand (USA) Pvt. Ltd..
3	pH Meter	Thermo Fisher Scientific (USA) Pvt. Ltd..
4	Hot Plate	VWR International (USA) Pvt. Ltd..
5	Water Bath	Julabo (Germany) Pvt. Ltd..

2.3 Formulation Table

Table No. 3 Formulation Table

Sr. No.	Name of Material	F1	F2	F3
1	Garlic Extract (*Allium sativum*)	0.75ml	0.75 ml	1.05 ml
2	Aloe Vera Gel	1.5ml	1.2ml	1.5ml
3	Carbopol 934	0.075gm	0.09 gm	0.105 gm
4	Glycerine	0.105ml	0.12ml	0.105ml
5	Sodium Hydroxide	0.2 gm	0.2 gm	0.2 gm
6	Sodium Benzoate	0.015	0.015	0.015
7	Lavender Oil	0.03 ml	0.03 ml	0.045 ml
8	Distilled Water	12.525 ml	12.795 ml	12.18 ml
	Total amount	15 ml	15ml	15ml

3. METHOD & EVALUATION

3.1 Method of Preparation

3.1.1 Preparation of Garlic Extract

- ✓ Fresh garlic cloves were peeled, washed, and crushed using a mortar and pestle.
- ✓ The crushed garlic was macerated with distilled water or ethanol (depending on the extraction method) for 24–48 hours.
- ✓ The mixture was filtered using filter paper or muslin cloth to obtain a clear garlic extract.
  The extract was stored in a cool, dry place for further use.

3.1.2 Formulation of Anti-Dandruff Gel

- ✓ The gelling agent is dispersed in water, followed by the addition of humectants and preservatives.
- ✓ The mixture is heated and stirred to ensure uniform consistency.[46]
- ✓ Once the gel base is prepared, garlic extract is added slowly to avoid degradation of active compounds due to heat.
- ✓ The final gel formulation is adjusted to the desired pH and thoroughly mixed to ensure uniformity.
- ✓ After that added the Lavender oil 1-2 drops[47]

✓ After that packed in the container and label them

3.1.3 Packaging

The formulated anti-dandruff gel was packaged in:

✓ Clean, sterilized, opaque plastic jars or tubes to prevent exposure to light, air, and moisture.

✓ Air-tight containers were used to protect the gel from contamination and evaporation of volatile components like essential oils. [48]

✓ Polypropylene or high-density polyethylene (HDPE) containers were preferred due to their chemical resistance and non-reactivity with the formulation ingredients.[48]

3.1.4 Storage

The gel was stored at room temperature (25 ± 2°C) in a cool, dry place, away from direct sunlight and heat sources. Samples were also kept at refrigerated conditions (4–8°C) to monitor physical stability over time. Regular observation was done to check for: Changes in colour, odour, or consistence

3.2 Evaluation of Anti-Dandruff Gel

3.2.1 pH test

The pH paper test is used to determine the acidity or alkalinity of the anti-dandruff gel. A small amount of gel is dissolved in distilled water and a pH strip is dipped into the solution. The resulting colour change on the strip is compared with a standard pH chart to determine the pH value. An ideal pH for topical gels is typically between **4 and 6**, which is compatible with the natural pH of the scalp..[50]

Fig No.1 pH Test.

3.2.2 Spreadability

Spreadability was measured by placing a small amount of gel between two glass slides and applying a weight. The distance covered by the upper slide indicated the ease with which the gel could be spread over the scalp. The optimized formulation showed good spreadability, which is important for user comfort and even application.[51]

Fig No.2 Spreadability Test

3.2.3 Stability Studies

To evaluate the shelf-life and robustness of the gel, it was subjected to **accel**erated stability testing under different storage conditions:

- Room temperature (25°C)
- Elevated temperature (40°C)[52]

3.2.4 Irritancy

It was laid on the layer of skin and allow to absorb. An hour was used for examining the skin for any Symptoms of inflammation, redness, itching, or Discomfort.

Fig No.3 Irritancy Test

3.2.5 Washability Test

The washability test is performed to assess how easily the formulated gel can be removed from the skin or scalp surface using water. This test is important to ensure that the gel does not leave behind any undesirable residue after use, which could potentially cause build up, irritation, or interfere with the scalp's natural function.[53]

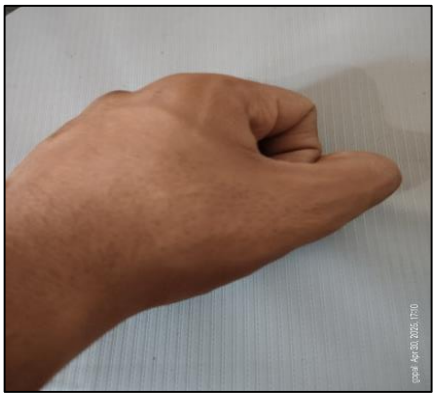

Fig No.4 Washablity Test Before

Fig No.5 Washablity Test After

4. RESULT AND DISCUSSION

4.1 Result

Table No. 4- Result

Sr. No.	Parameters	Formulation 1	Formulation 2	Formulation 3
1.	Colour	Light Gray	Gray	Light Gray
2.	Odour	Mild Garlic	Stronger Lavender Fragrance	Mild Lavender Fragrance
3.	Surface Texture	Normal Runny	Less Runny	More Runny
4.	Ph	5.5	5.5	5.5
5.	Appearance	Consistent Appearance	More Stable	Thickest Consistency
6.	Spreadability	Slightly Less Smooth	Ease Of Application	Uniform Layer With Minimal Pressure
7.	Irritation Test	No Irritation Occurs	No Irritation Occurs	No Irritation Occurs
8.	Washability Test	Good Washability	Very Good Washability	Excellent Washability
9.	Microbial Test	Moderate Inhibition	Exhibited Improved	Largest Zone Of Inhibition

4.2 Discussion

The formulation of an anti-dandruff gel containing garlic extract and other active ingredients was prepared with three variations (F1, F2, and F3) in order to evaluate the effect of ingredient concentration on gel properties, performance, and efficacy. The primary aim of the formulation was to develop a gel that could treat dandruff while being gentle on the scalp, effective against dandruff-causing fungi, and easy to apply. The following results and discussions provide insight into the gel's formulation, stability, and the impact of ingredient variations.

1. Appearance and Texture

- F1: The gel formed with a 0.5% Carbopol concentration provided a medium-thick consistency. It was slightly runny, but overall, the gel had a smooth and consistent texture.
- F2: The gel with 0.6% Carbopol was slightly thicker than F1, providing a more stable and less runny texture while maintaining good spreadability on the scalp.
- F3**:** The gel with 0.7% Carbopol had the thickest consistency. It exhibited good viscosity and remained stable even under storage. The texture was perfect for a gel product, easily adhering to the scalp without dripping.

2. pH Level

- All three formulations were adjusted to a pH of approximately 5.5 using Sodium Hydroxide, which is ideal for scalp and skin applications. The pH was maintained within a safe and effective range, which ensures that the gel will not cause irritation to the scalp and will be compatible with skin’s natural pH.

3. Homogeneity

- All formulations were found to be homogeneous with no separation of ingredients upon storage. There was no sign of phase separation, and the gels remained consistent in texture over time.

4. Spreadability

- F1 (with 0.5% Carbopol) had good spreadability, though it was slightly less smooth than the other two formulations.
- F2 and F3 exhibited excellent spreadability. F2 was particularly effective in spreading evenly without excessive pressure, while F3 had the best spreadability, making it easy to apply a thin layer on the scalp.

5. Viscosity

- F1 exhibited a medium viscosity, suitable for easy application but less stable under warmer conditions.
- F2 showed an improved viscosity over F1, enhancing its ability to stay on the scalp.
- F3, with the highest Carbopol concentration (0.7%), showed the highest viscosity, which allowed for a thicker, more stable gel. This formulation was expected to have better adhesion to the scalp and longer-lasting effects.

5. CONCLUSION

From the present study, it can be concluded that the formulated herbal anti-dandruff gel containing garlic extract is an effective, safe, and stable topical preparation for the treatment of dandruff. Garlic, owing to its high content of allicin and other sulfur-containing compounds, exhibited potent antifungal activity against *Malassezia furfur*, the primary organism responsible for dandruff. Among the three formulations developed, Formulation F3 showed the best results in terms of consistency, spreadability, pH, stability, and antifungal efficacy. The results also indicated that incorporating natural ingredients such as aloe vera and lavender oil further enhanced the therapeutic and cosmetic properties of the gel. The formulation was easy to apply, well-tolerated on the scalp, and easily washable, making it suitable for regular use. It remained physically and chemically stable under different storage conditions. The study supports the use of garlic-based herbal gels as an effective alternative to chemical anti-dandruff treatments. However, further studies including clinical trials and consumer evaluations are recommended to confirm its long-term efficacy and market potential.

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