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SHORT COMMUNICATION

Development and Evaluation of Natural Anti-dandruff Shampoo

Faruk Alam[1], Soma Das[2], Pallab Kalita[3], Bhaskar Jyoti Pathak[4], Moidul Islam Judder[4], Debaprotim Dasgupta[5] and Dhrubajyoti Sarkar[1]*

[1]Faculty of Pharmaceutical Science, Assam Down Town University, Sankar Madhab Path, Gandhinagar, Panikhaiti, Guwahati - 781026, Assam, India; dhrub.s@gmail.com

[2]Department of Pharmaceutical Sciences, School of Medical Sciences, Adamas University, Barrackpore-Barasat Road, Kolkata - 700126, West Bengal, India

[3]School of Pharmaceutical Sciences, University of Science and Technology Meghalaya, Baridua, Ri Bhoi - 793101, Meghalaya, India

[4]Royal School of Pharmacy, The Assam Royal Global University, Betkuchi, Guwahati - 781035, Assam, India

[5]NEF College of Pharmaceutical Education and Research, Nagaon - 782001, Assam, India

Abstract

The purpose of the study was to develop a pure herbal anti-dandruff shampoo and assess its efficacy and safety. The herbal shampoo was prepared by mixing various amounts of the following extracts into a 10% aqueous solution: Neem (*Azadirachta indica*), Lemongrass (*Cymbopogon citrates*), Reetha (*Sapindus mukorossi*), Sheekakai (*Sapindus indica*), Amla (Indian gooseberries), Bhringaraj (*Eclipta alba*), and Brahmi (*Bacopa monnieri*). The pH was changed, and methylparaben was added as a preservative in very minute amounts. To ascertain the physicochemical characteristics of the prepared shampoos, several tests including visual inspection, pH, wetting time, percentage of solid contents, foam volume and stability, surface tension, detergency, dirt dispersion, etc. were carried out. By giving 20 student volunteers a blind test, the conditioning performance of the herbal shampoo formulation was also assessed. The herbal shampoo was presented simply and appealingly. It demonstrated high detergency, good cleaning, and low surface tension. After 5 minutes, the shampoo's formulation provided good foam stability. It was discovered that the scores for the conditioning performance of the hair after using a herbal shampoo ranged from 1.75 to 3.4. The results revealed that the specifically formulated shampoo had outstanding conditioning performance, comparable to a shampoo that is easily found in markets. *Malassezia furfur* was used as a test subject for the efficiency of the multi-herbal anti-dandruff formulations. Formulation F4 demonstrated strong antifungal activity, as measured by the zone of inhibition and lowest inhibitory concentration. However, additional research and development are required to improve its quality and safety.

Keywords: Green Preparation, Herbal, *Malassezia furfur*, Shampoo

1. Introduction

Hair is a key component of human beauty. Throughout the beginning of time, people have used herbs for cleansing, beautifying, and controlling hair. The use of synthetic substances has increased over time, but people are now becoming more aware of their serious negative effects, including eye and scalp irritation, hair loss, and dryness of the hair. These areas drew people to use herbal products since they are safer, less expensive, and have few negative effects. This in turn increased customer demand. The most popular hair care product is shampoo. It can be used to clean the hair and scalp of dirt, dandruff, previously applied hair styling product residue, and environmental pollutants[1]. It comes in viscous liquid form. Hair cleansers, often known as shampoos, are used not only to clean

*Author for correspondence

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the hair but also to add gloss, keep the hair manageable and oily, and occasionally get rid of dandruff[2]. The most prevalent dermatological skin concern relating to the scalp, dandruff is a non-inflammatory, chronic disorder that is evident by an enormous range of scalp tissue being impacted[3]. Although the primary cause of dandruff cannot be seen clearly, there are other contributing causes, including an oily scalp and poor hygiene that might result in a fungal infection and it appears more often if the hair is not washed for a week. Dandruff is known to be controlled by fungistatic ingredients in anti-dandruff shampoos. *Malassezia furfur* is a typical lipophilic, saprophytic yeast that grows on the face, scalp, and upper trunk of humans. The unicellular fungus known as tinea versicolor, seborrheic dermatitis, folliculitis, and atopic dermatitis is linked to several skin conditions that primarily affect the top layers of the skin[4]. A severe condition of the stratum corneum of the scalp, dandruff is characterized by hyperproliferative cells that cause swelling, itching, and redness. Seborrheic dermatitis has a similar clinical appearance and symptoms but is more severe. The lipophilic yeast *Malassezia furfur* absorbs Free Fatty Acids (FFAs) from sebaceous triglycerides, which causes the symptoms to appear. The stratum corneum is breached by the FFAs, which also cause trans-epidermal water loss that is ascribed to dandruff[5]. The use of topical antifungal medications or other items is a part of treating dandruff. Recurrences are common, thus prophylaxis with skin and hair treatments is necessary to maintain healthy skin and a youthful appearance. Today's market offers a variety of anti-dandruff shampoos, including synthetic, herbal, medicated, and non-medicated shampoos. The most well-known herbal anti-dandruff shampoos are those that give off the idea of being purer, safer, and more effective. Since no surfactants are used during the preparation of herbal anti-dandruff shampoos, they are free from side effects, have good stability, and are less toxic than synthetic shampoo[6]. Surfactants found in synthetic shampoo have the potential to cause major side effects like scalp itchiness, hair loss, drying of hair, greying of hair, split ends, and eye irritation. Due to their negligible negative effects and low cost, herbal cosmetics are attracting large populations for these reasons[7]. Herbal shampoo is viewed as an alternative to synthetic shampoo, however, creating cosmetics from entirely natural ingredients is challenging. The manufacture of shampoo frequently uses a variety of medicinal plants, many of which have been identified in the literature to have positive benefits on hair. These can be simple or plain shampoo, antibacterial or anti-dandruff shampoo, or nutritional shampoo including vitamins, amino acids, and proteins hydrolysate, depending on the nature of the contents[8]. Plant products can be employed in a variety of forms, including powdered form, crude form, refined extracts, or derivative forms[9]. Developing herbal anti-dandruff shampoo from a single natural component that is milder and safer than synthetic therapies while still competing favorably with their foaming, detergency, and solid content is rather difficult. To combat dandruff, wash our hair, and work as a conditioning agent without harming or damaging our hair, we thought about creating a pure herbal anti-dandruff shampoo[10].

2. Materials and Methods

2.1 Plants

The botany department of Assam Down Town University in Guwahati, India, validated the plants utilized in the current study after they were collected in and around Guwahati, Assam. Neem (*Azadirachta indica*) is a plant that is used to clean the scalp, unclog pores, and encourage the growth of hair. Neem is also used to treat dandruff, strengthen hair, and stop hair loss, and has antibacterial and therapeutic characteristics[11]. Neem's components nimbolide and nimmbidin have been reported to have antibacterial and antifungal effects. These elements destroy the cell walls of bacteria and fungi[12]. Neem leaf extracts have been proven to inhibit a variety of pathogens, including *C. albicans*, *C. tropicalis*, *Neisseria gonorrhoea*, and multi-drug-resistant *Staphylococcus aureus*[13]. *Cymbopogon citrates*, a key component of lemongrass, is Citral (3, 7-dimethyl-2, 6-octadienal) a compound that contains both geranial (*trans*-citral, or citral A), and neral (*cis*-citral, or citral B), two isomeric acyclic aldehydes. It has recently been demonstrated that citral can damage the integrity of the cell membrane. Citral may also act as an antifungal agent by preventing the production of ergosterol and mycelial proliferation. By disrupting oxidative phosphorylation and cell membranes through significant ROS buildup, citral prevents fungal development[14,15]. Extracts of the reetha plant (*Sapindus mukorossi*) effectively combatted *Malassezia furfur* fungus. To remove lice, it is also used to wash hair[16]. Shikakai (*Sapindus indica*) is a powerful cleanser, anti-dandruff agent, and regulator of hair development. Moreover, the high saponin content of reetha and shikakai causes them to form a rich lather when

shaken with water. Furthermore, they are recognised to benefit the skin and other organ systems[17]. Shikakai (*Sapindus indica*) also preserves the natural oil of hair and keeps it healthy and shiny. It lessens hair loss and gives the hair more volume. It has strong anti-dandruff properties and shields the scalp from infections. Indian gooseberries, or "amla", are a fruit that is abundant in vitamin C and is used in hair treatments as an anti-dandruff, hair growth, and hair-strengthening agent[18]. By utilising Nagarmotha, conditions of the scalp such as dandruff and hair loss have been reduced (*Cyperus rotundus*) and it stimulates hair follicles. To encourage the growth of new hair, it acts on the sebaceous gland. It is said to contain essential oils that, at varying amounts, are beneficial against different fungi strains[19]. Aloe vera has the highest antifungal action, as evidenced by the fact that fungi's mycelial growth was inhibited as concentrations rose and that it also thickens and nourishes hair[20]. Bhringaraj (*Eclipta alba*) is regenerating the scalp while keeping the hair's original black colour. The herb Brahmi (*Bacopa monnieri*) nourishes hair and calms the nerves, releases tension, and helps with healthier scalp circulation. Cocamono is a surfactant that makes preparation more viscous. One of the most often used parabens as an antifungal preservative that inhibits microbial development is methylparaben.

2.2 Preparation of Herbal Anti-dandruff Shampoo

Precisely 50 gms of raw drugs were obtained, and each was extracted with distilled water at a temperature of under 60°C. The ratios listed in Table 1 were used to weigh and combine the aqueous extracts of all the crude medicines. The shampoo was preserved in an appropriate container and utilized for additional investigation[21-23].

2.3 Evaluation of Antifungal Herbal Shampoo

2.3.1 Physical Appearance

The formulated shampoo was evaluated for its consistency, colour, clarity, and visual appearance, which were all reported in Table 2.

Table 1. Different formulations of herbal anti-dandruff shampoo

Ingredients	Properties	F1	F2	F3	F4	F5
Neem (ml)	Antibacterial agent	40	45	50	55	60
Lemongrass oil (ml)	Antibacterial agent	2.5	2	1.5	1	0.5
Reetha (ml)	Detergent and antidandruff	5	5	5	5	5
Shikakai (ml)	Detergent	0.5	0.5	0.5	0.5	0.5
Amla (ml)	Anti-dandruff agent	5	5	5	5	5
Nagarmotha (ml)	Scalp disorder	0.5	1	1.5	2	2.5
Brahmi (ml)	Hair tonic	5	5	5	5	5
Bhringaraj (ml)	Hair growth promoter	2.5	2	1.5	1	0.5
Aloe-vera gel(ml)	Moisturizing agent	1	1	1	1	1
Glycerine (ml)	*Reduces dryness and breakage*	5	5	5	5	5
Cocamono	*Surfactant*	4%	4%	4%	4%	4%
Methylparaben (ml)	Preservative	0.180	0.180	0.180	0.180	0.180
Perfume	Fragrance	q.s	q.s	q.s	q.s	q.s
Water		q.s	q.s	q.s	q.s	q.s
Total (ml)		100	100	100	100	100

Table 2. Contains the findings of the visual examination of a group of formulations (F1-F5)

Appearance	Colour	Transparency	Consistency	Fragrance
Viscous in nature	Brown	Non-transparent	Smooth	Characteristic

2.3.2 pH Determination

By combining 1 gm of shampoo with 100 ml of distilled water, the pH of the herbal anti-dandruff shampoo was measured using a pH meter. The pH value was recorded.

2.3.3 Measurement of Viscosity

The Brookfield Viscometer LVDV Prime-I was used to measure the viscosity of the shampoo. The viscosity of shampoo at room temperature was measured using a spindle speed range of 0.3 to 10 rpm, or 30±2 °C[24].

2.4 Surface Tension Measurement

Shampoo should be diluted with distilled water to a concentration of 10%. A stalagmometer was used to take measurements. When the level reaches the mark, dip the flat end of the stalagmometer into the beaker containing the generated shampoo sample. Having corrected that, let the sample progressively egress from the mark. Count the number of drips produced as the liquid level changes from A to B. Perform the test using distilled water this time. The following equation was used to calculate the data:

$$R2 = \frac{(W3-W1)\ N1\ X\ R1}{(W2-W1)N2}$$

W1 stands for the weight of an empty beaker, W2 for the weight of distilled water, and W3 for the weight of a shampoo solution. N1 denotes the quantity of distilled water, while N2 denotes the quantity of shampoo solution. R2 is the surface tension of the shampoo solution, and R1 is the surface tension of distilled water at room temperature.

2.5 Percentage of Solid Content

Weighing 4 gms of shampoo in an evaporating disc allowed us to calculate the % solid content. By putting the liquid portion of shampoo in a heating mantle and keeping it for evaporation. To dry shampoo completely, the weight and percentage of solid content were calculated by using the following equation:

% Solid content = (Weight of solid after drying)/ (Weight of sample taken)

2.6 Cleaning Action

In a round bottom flask with 200 ml of water and 1 gms of shampoo, 5 gms of wool yarn was added. The flask's contents were kept at a constant temperature of 30±2 °C. 50 shakes per minute were applied to the flask for 4 minutes. The sample was taken out of the solution, dried, and weighed. The amount of grease removed was calculated by using the following equation:

DP = 100(1-T/C)

Where, DP = percentage of detergency power, C = weight of sebum in the control sample, and T = weight of sebum in the test sample.

2.7 Dirt Dispersion Test

In a test tube, 10 ml of distilled water was added to 2 drops of shampoo. One drop of the water-soluble dye Ponceau 4R was added to this solution, and the test tube's contents were shaken ten times. By using categories like none, light, moderate, and heavy, the amount of ink in the foam was indicated[25].

2.8 Wetting Time Test

The filter paper was cut into 1-inch-diameter discs with an average weight of 0.58 gm. The smooth disc surface was placed on the 1% v/v shampoo solution surface, and then the timer was set to begin. The time required for the disc to begin plunging wetting duration established[26,27].

2.9 Foaming Ability and Foam Stability

By ten times shaking 20 ml of 1% shampoo solution in a test tube, the foaming ability was assessed. The entire volume of the foam content was measured after shaking for one minute. Foam stability was evaluated by measuring the foam volume after shake tests lasting one minute and four minutes[28,29].

2.10 Conditioning Performance

An Asian woman's hair was collected from a nearby salon. It was cut into four pieces, each of which was 10 cm long and weighed 5 gms. A swatch was utilized without washing as a control The five other shampoo formulations (F1-F5) were used to wash the remaining five tresses identically. During each cycle, a conical flask holding a

combination of 10 g of a sample and 15 ml of water was used to shake each tree for two minutes. This was followed by a 50 ml water rinse. Each tree was then given time to dry in the open air at room temperature. The hair was subjected to a maximum of 10 washing cycles. Twenty randomly chosen student volunteers were given a blind touch test to assess the shampoos' conditioning abilities, including their smoothness and softness[29,30]. While wearing blindfolds, it was directed to rate the four tresses' conditioning performance on a scale of 1 to 4 (1 being the worst; 2 being adequate; 3 decent; and 4 exceptional).

2.11 Skin Irritation Test

The skin was covered with a 1% v/v shampoo solution made in distilled water. The applicant was given a two-hour contact window.

2.12 Anti-fungal Activity

2.12.1 Zone of Inhibition

Using the cup plate method, the *in-vitro* anti-fungal activity of all the formulations (F1-F5) against *Malassezia furfur* was assessed. The conical flask containing the inoculation media was cooled to 46°C and infected with the test organism before 30 ml of the medium was distributed into Petri dishes (20 ml of subculture medium/100 ml of the assay medium). A sterile cork borer was used to create four cups (6 mm in diameter) for each plate. The entire procedure was completed aseptically while using laminar flow. Under aseptic conditions, each cup was filled with 0.1 ml of the test solution, 0.1 ml of the standard solution (100 µg/ml, 250 µg/ml), and 0.1 ml of the solvent dimethylformamide (control). The medication is then evenly dissolved into the agar medium in Petri dishes. Afterwards, for 48 hours, allthe Petri dishes were incubated at 30°C. The inhibitory zones' sizes were measured in millimeters. All the formulations' anti-fungal efficacies were compared to that of reference ketoconazole.

2.13 Minimum Inhibitory Concentration (MIC)

The common agar dilution method was used to calculate the MICs. Due to their partial water solubility, the formulations were first dissolved in 10 gµ/ml of DMF before being further diluted with sterile distilled water to create the solution. After that, different tubes containing the solutions of different formulations were added to the molten nutritional agar to create a final concentration of 25, 50, or 100 g/ml. To create sterile nutrition agar plates with different amounts of formulations, the molten nutrient agar media was poured and solidified onto sterile 100 mm Petri dishes. After that, these plates were placed in a freezer (4°C) for 24 hours so that the produced formulations may diffuse evenly into the nutritional agar substrate. Before spot inoculation, the plates were then dried at 37°C for 2 hours. The test organism overnight peptone water culture was divided into one loopful (diameter: 3 mm) and deposited in a Petri plate labelled using the checkerboard method. The total amount of CFU that was put onto the agar plates was 10^{10}. The MIC values were obtained when the spot-inoculated plates were incubated at 30°C for 48 hours. The MIC was determined to be the lowest concentration of the plates that failed to exhibit any discernible growth during incubation. The control was an agar plate with only sterile distilled water. The MIC, or minimum inhibitory concentration, of each produced substance, was evaluated against *Malassezia furfur* organisms. The concentration of the test formulation/s that completely inhibits the growth of the microbe or 100% transparency, was noted as the Minimum Inhibitory Concentration (MIC).

3. Result and Discussion

3.1 Physical Appearance/Visual Inspection

3.1.1 The Physical Appearance of All Formulations (F1-F5)

It has been shown that the pH of the shampoo significantly influences how much hair qualities are increased and improved, how much eye pain is decreased, and how the ecological balance of the scalp is maintained. pH is one technique for reducing hair damage. Moderate acidity reduces oedema and encourages scaling, which results in shine. Figure 1 shows that all of the shampoos were acid balanced and had pH values between 5.09 and 7.02, which are closer to those of the skin (Figure 1). According to Tarun, *et al.* (2014), the ideal pH range (between 7 and 5) was identified in marketed shampoos (Dove: 6.12, Herbal Essences: 6.04)[31]. Although the acid-balanced values in commercial shampoos were noted, the pH of the shampoo that was specifically designed (F4) was found to be quite close to skin pH.

Since the samples' viscosity gradually varies as rpm increases, the results of the rheological evaluation

(Viscosity) indicated that the shampoo compositions were time-dependent. Second, the shampoo formulations were shear thinning or pseudoplastic because the data showed that viscosity reduces with an increase in rpm. These formulations demonstrated pseudoplastic behaviour, which is a desired characteristic in shampoo composition. The viscosity of the herbal shampoos was high at low rpm but decreased as the shear rate increased; this is a beneficial attribute that makes it easier to disperse the shampoo on hair. Using linear or non-linear regression, the rheological study data were fitted into various flow behaviours. The goodness of fitting indices for Newtonian, plastic, and pseudoplastic flow modes is displayed in Figure 1.

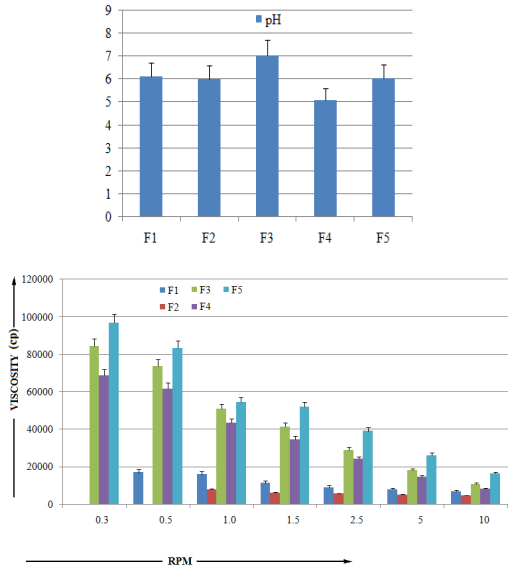


Figure 1 (a and b). pH and Viscosity (cp) of all formulations (F1-F5).

The amount of surfactant needed to lower surface tension is indicated by the surface tension in shampoo. The shampoo's power to clean is stronger the lower the surface tension. A shampoo is considered high-grade if it lowers the surface tension of pure water from 72.28 dyn/cm to around 40 dyn/cm[32]. All the shampoos put to the test displayed comparable surface tension reductions, ranging from 31.68 to 38.72 dyn/ cm (Table 3). Their effective detergent action is demonstrated by the decrease in surface tension. Surface tension was lowered by the shampoo formulation to 31.68 dyn/cm, which is on par with semi-herbal or synthetic shampoos. Commercial synthetic or semi-herbal shampoos may reduce surface tension as a result of their high detergent content, which suggests that they have the best cleansing power but also strips the hair of up to 80% of its natural oil and damages it. We have prevented this by including a gentle detergent in our shampoo.

As they are simple to apply to the hair and rinse off, great shampoos often include 20% to 30% solids. Too little solid will make it extremely watery and wash away quickly, just as too much solid would make it difficult to work into the hair or difficult to remove. All of the tested shampoo's per cent solid contents were found to be between 22 and 25 per cent (Table 3), and they should all wash out with ease.

Wool yarn in grease was used to test the cleansing action. The efficacy of formulations developed to remove grease from wool yarn was assessed and reported. Several surfactants were included in the formulation, which produced a 34.76% cleaning action. From the different surveys, the percentage of cleaning activity for the marketed sample was 32.54%, which was just a little bit less than the herbal formulation (Table 3). The inclusion of two surface active chemicals, shikakai and ritha, at an optimal concentration may be the source of the produced formulation's improved percentage cleaning activity.

Table 3. Evaluation of formulation F1-F5 for Surface tension, % of solids contents, % of cleansing action, Dirt dispersion and Wetting ability

Characterizations	F1	F2	F3	F4	F5	*P*-Value
Surface tension (dyn /cm)	37±2.34	34±2.65	33±1.23	31.68±1.77	38.72±2.02	0.004*
Solids contents (%)	31±2.12	30±1.34	25±1.23	23.54±1.00	35.02±1.02	0.004*
Cleansing action (%)	26.45±1.42	29.78±1.31	31.23±1.23	34.76±0.91	28.12±1.50	-----
Dirt dispersion	Light	Light	Light	Light	None	-----
Wetting time (Sec.)	157±2.51	145±1.34	168±3.36	188±4	160±2	<0.001*
Results are mean ± SD (n = 3); *Significant difference p < 0.05) by Anova single factor						

A crucial factor in determining how well shampoo cleans is how much dirt it disperses. Shampoos that cause the ink to concentrate in the foam are thought to be of inferior quality since the ink or dirt that remains in the foam is difficult to remove and commonly redeposited on hair[33,34]. The dirt should stay in the water component for improved washing action. The ink was concentrated in the water portion of every shampoo, ensuring their adequate cleansing capacity and practical usefulness. None, mild, moderate, or heavy was the expected level of ink in the foam (Table 3). Ossify drops would make it easier to spread on the hair and enable this[35,36].

A surfactant's wetting ability or wetting time (sec.), which depends on concentration, is frequently used to gauge how effective it is. The canvas disc method is a rapid, effective, and trustworthy test to determine a shampoo's wetting capacity[37,38]. Three shampoos' wetting times were observed to be 145<157<160<168<188 seconds for F2, F1, F5, F3, and F4, respectively (Table 3). Because F2 had the shortest wetting time and F4 had the longest, according to the results, F2 had the highest concentration of detergents, whilst F4 had the lowest.

3.1.2 Foam Stability and Foaming

Foam generation is a significant factor in evaluating shampoos even though it has little to do with how well they clean hair. This is because it is so important to consumers. In distilled water, the foaming qualities of all five shampoos were comparable[39,40]. Similar foaming qualities were displayed by all five shampoos. Figure 2 displays the foam stability of herbal shampoos. It's important to note that detergency and foaming do not appear to be directly related, which only serves to corroborate the idea that shampoo with good foam does not necessarily clean well. The final formulation generated stable foams with minimal volume variation.

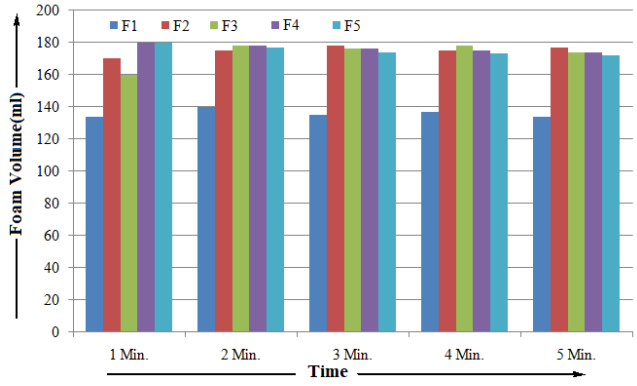
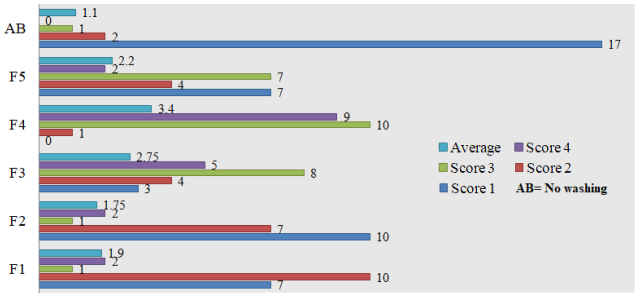


Figure 2. Foam value of all the formulations (F1-F5).

Figure 3 displays the conditioning performance of all formulations (F1-F5) based on the mean scores of student referees. Most of the students felt that the F4-washed hair gave the best conditioning performance, and as predicted, the control hair (without washing) received the lowest rating (1.1). The results of testing the conditioning effectiveness of hair washed with the designed shampoo ranged from 1.75 to 3.4. The outcomes made it abundantly evident that the shampoo F4's formulation provides good conditioning efficacy.

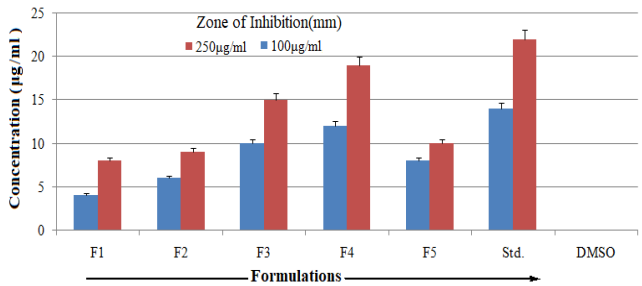


Score 4 = Excellent, score 3 = Good, score 2 = Fair, score 1 = Poor

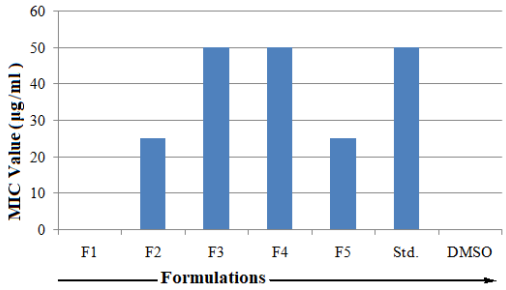
Figure 3. The mean score of the student volunteers opinion on the conditioning performance of the tresses after treatment with shampoos (n = 20).

A 1% v/v solution of the specially prepared shampoo in water is applied to the skin and left in contact for 2 hours to test for skin irritation. As there were no signs of inflammation, redness, itchiness, or irritation in the applied area during this time, the herbal shampoo was safe to use.

The antifungal efficacy of the anti-dandruff formulation was evaluated using the agar-well diffusion method and the Minimum inhibitory concentration method. According to the findings displayed in Figure 1, the polyherbal anti-dandruff formulation has inhibitory efficacy against *M. furfur*. With a zone of inhibition value of 19.6 mm and MIC value of 50 µg/ml, F4's anti-malassezial activity demonstrates strong action. Thus, using polyherbal anti-dandruff shampoo topically helps treat dandruff. The activity of the remaining poly herbal formulations ranged from moderate to poor (Figure 4).



4 (a). Zone of inhibition



4(b). Minimum inhibitory concentration

Figure 4. *In-vitro* anti-dandruff activity of all formulations (F1-F5).

4. Statistical Analysis

Data are provided as Mean and Standard Deviation, and the full test was run in triplicate. The significance was assessed using a one-factor ANOVA. *P* values 0.05 and lower were regarded as significant.

5. Conclusion

The purpose of this project was to create an all-herbal shampoo that could compete with commercially available synthetic shampoo. We formulated herbal shampoo utilizing plant extracts that are well-known for their cleansing effects on hair in Asia and are frequently used in traditional medicine. The components of shampoo are entirely safer than silicones and polyquaterniums, which are synthetic conditioning agents and may significantly prevent the loss of hair or protein during combing. Antimicrobial testing confirmed that the herbal anti-dandruff shampoo reduces dandruff and infection. A pH of 5.09 demonstrates compatibility with skin. The polyherbal anti-dandruff compounds developed by the current research work well. We have used Shikakai, Amla, and other plant extracts to provide anti-dandruff and conditioning properties in place of cationic conditioners. The physicochemical characteristics of both produced and commercially available shampoos were compared and evaluated by several experiments. For quality control tests, our formulated shampoo produced results that were comparable to those of commercial shampoo. The evaluation study revealed strong wetting, good rinsing, stability, foam foaming, and good dirt dispersion activity; however, more research and development are needed to raise the product's overall quality.

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