Research Article

Preparation and Assessment of Antibacterial Herbal Lotion

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ABSTRACT

In this era, there is huge demand of herbal products because of cost and side effects related to allopathic products. There is shift in the choice of therapy to be used by the population. So, companies are coming up with alternatives in the forms of herbal products which are competing with allopathic products in the market. People are taking more interest in their look and taking care of their skin. So, demand of cosmetic products has increased. In cosmetic products, especially, herbal products such as Herbal cream, herbal paste, herbal lotions etc. are gaining importance. This research focused on the formulation of herbal lotion having antibacterial activity which will be beneficial for the skin in terms of its curative and protective action. Prepared Herbal lotion formulations were evaluated for organoleptic properties, Rheologic properties, pH and stability. Formulation (F1) was better when compared with other formulation for evaluation parameters. This formulation was tested for antibacterial activity against *Staphylococcus aureus* and *Escherichia coli*. After testing, it was found that herbal lotion formulation possesses antibacterial activity.

Keywords: Herbal; Formulation; Antibacterial; Lotions; Properties.

INTRODUCTION

Herbal medicines have long been a part of conventional practices of medicine, for instance, Ayurvedic, Unani and Siddha, offering therapeutic benefits through natural means[1]. These time-honored systems have relied on plant-based remedies to cure a comprehensive array of illnesses, including skin disorders. In recent years, the global inclination towards natural and plant-based products has reignited interest in herbal formulations, particularly in personal care and dermatological applications[2]. Consumer preferences are shifting due to increased awareness of the side effects and ecological concerns associated with synthetic chemicals. As a result, there is a significant rise in demand for herbal formulations that are perceived as safer, biodegradable, and more sustainable. Herbal formulations represent an innovative step in using botanicals to manage bacterial infections of the skin without the adverse effects typically associated with synthetic agents[3]. These formulations are being incorporated into creams, gels, lotions, and ointments aimed at improving skin health and combating infections. The active compounds in plants such as flavonoids, alkaloids, phenolics, and essential oils offer multi-targeted action, making them particularly valuable in treating conditions involving inflammation, oxidative stress, and microbial invasion[4]. Skin, the greatest part of the body, serves as a primary barrier against microbial invasion. However, constant exposure to environmental pollutants, ultraviolet radiation, pathogens, and allergens often disrupts the natural balance of skin microflora. This imbalance can lead to dermatological issues such as acne, eczema, rashes, and secondary bacterial infections caused by microorganisms[5]. These pathogens can breach compromised skin and trigger inflammatory responses, further aggravating skin conditions. Synthetic antibacterial agents are widely used in dermatological products to manage such infections. However, their prolonged and indiscriminate use is associated with several issues, including dermal toxicity, allergic reactions, ecological damage, and most notably, the rise of antimicrobial resistance[6]. The WHO has declared antimicrobial resistance a global health threat, prompting researchers and pharmaceutical industries to explore natural alternatives that are both effective and gentle on the skin. Plant-based remedies, with centuries of ethnomedical backing, offer a compelling solution.

In this context, herbal extracts have transpired as encouraging entrants due to their antibacterial, anti-inflammatory, and antioxidant characteristics[4]. These plant-derived compounds can inhibit bacterial growth, reduce inflammation, and neutralize free radicals, thereby supporting skin repair and regeneration. Notably, phytochemical constituents, for instance, eugenol from clove, thymol from thyme, allicin from garlic, and curcumin from turmeric have revealed considerable activity against bacterial pathogens[7]. Unlike synthetic agents, these natural compounds are less likely to disrupt the skin's native microbiota or induce resistance.

Importance of Herbal Extracts and Extraction Methods

The efficacy of herbal formulations largely depends on the method of extraction and the quality of phytochemicals derived. The extraction process must preserve the biological activity of the plant constituents while removing inert or potentially harmful components. The most commonly used processes of extraction are Soxhlet extraction, maceration, steam distillation and ultrasound-assisted extraction[8]. Each method offers distinct advantages and is chosen based on the nature of the bioactive compound and its polarity. For instance, polar

compounds such as glycosides, phenolics, and tannins are typically extracted using water or hydroalcoholic solutions, whereas non-polar phytochemical classes as alkaloids and terpenoids need methanol, ethanol and hexane solvents. Modern extraction processes, such as microwave-assisted extraction and supercritical fluid extraction are also gaining popularity due to their efficiency and reduced environmental impact[8]. Proper formulation also involves stabilizing the extract to prevent degradation, optimizing pH to suit skin compatibility, and using safe excipients that enhance the bioavailability of the active compounds. The incorporation of natural gelling agents (e.g., carbopol, xanthan gum, aloe vera gel) and preservatives (e.g., neem oil, tea tree oil) further improves the texture, shelf life, and efficacy of the final product.

Herbal Lotions and Their Dermatological Applications

Skin serves as the first line of defense against physical, chemical, and microbial insults. It is constantly exposed to bacterial threats from the environment, especially pathogens like *S. aureus*, *E. coli*, and *P. aeruginosa*, which are often implicated in infections such as boils, folliculitis, impetigo, and infected wounds[9]. In patients with compromised skin barriers, such as in eczema or diabetic ulcers, these bacteria can penetrate the epidermal layers and delay wound healing. Herbal lotions offer a promising alternative to conventional antimicrobial products by combining the therapeutic benefits of plant extracts with ease of topical application. These lotions typically contain a base formulation enriched with bioactive compounds derived from medicinal plants. These botanicals are known to exhibit broad-spectrum antimicrobial activity, reduce inflammation, and promote wound healing[10]. Additionally, herbal lotions are less likely to cause hypersensitivity reactions and are more eco-friendly than their synthetic counterparts. Studies have shown that plant-based lotions containing essential oils and flavonoids can significantly reduce bacterial load on the skin and improve symptoms in acne and dermatitis patients[10]. Furthermore, the antioxidant properties of herbal constituents help protect the skin from oxidative stress and premature aging, adding to their appeal in cosmetic and therapeutic formulations.

Assessment of Antibacterial Activity

The antibacterial potential of herbal lotions can be evaluated using well-established microbiological assays, primarily designed to measure their inhibitory and bactericidal effects against pathogenic microorganisms. Among these, the agar well diffusion method is widely employed due to its simplicity and reliability. In this technique, the herbal lotion is introduced into wells on an agar plate inoculated with a test organism such as *Staphylococcus aureus* or *Escherichia coli*, and the resulting zone of inhibition is measured after incubation to assess antibacterial effectiveness[11].

Another frequently used method is the disc diffusion assay, which involves impregnating sterile filter paper discs with the lotion and placing them on the bacterial lawn. After incubation, the diameter of zone of inhibition in the vicinity of each disc provides a qualitative estimate of the lotion's antibacterial action[12]. These diffusion-based methods offer preliminary data on antimicrobial potential but do not quantify the minimum effective concentration. For more precise evaluation, MIC and MBC assays are conducted. The MIC is determined through broth or agar dilution methods, where a series of lotion dilutions is tested against bacterial strains to identify the lowest concentration that visibly inhibits microbial growth[13]. Following MIC determination, MBC can be established by sub-culturing the inhibited samples to detect the lowest concentration that kills the bacteria completely. Advanced techniques like assays of time-kill offer insight into the degree and amount of killing of bacterial cell over time, thus offering kinetic data on antibacterial efficacy[14]. For topical products like lotions, Franz diffusion cells can simulate transdermal delivery, allowing simultaneous analysis of percutaneous absorption and antibacterial activity across synthetic or animal skin models[15]. In all these tests, standard microbial strains such as *Staphylococcus aureus*, *Pseudomonas aeruginosa and Escherichia coli* are commonly used to ensure reproducibility and comparability. Furthermore, including both positive controls (standard antibiotics) and negative controls (placebo or base lotion) is essential to validate the results.

OBJECTIVES

- To prepare and evaluate polyherbal lotion formulations
- To assess the antibacterial action of the herbal lotion against *Staphylococcus aureus* and *Escherichia coli* bacterial strains.

MATERIALS AND METHODS

a) ***Glycyrrhiza glabra*** (Part used-Root; Family-Leguminosae)**:** Liquorice, scientifically known as *Glycyrrhiza glabra*, belongs to the Leguminosae (Fabaceae) family and is extensively renowned for therapeutic characteristics in Ayurvedic system. Native to parts of Asia and Europe, this herb is extensively used in traditional healing systems. Although its origins are believed to trace back to Iraq, *G. glabra* is now broadly distributed across several regions, including Italy, Spain, Turkey, the Caucasus, Central Asia, and western China[16].

b) ***Cinnamomum verum*** (Part used-Bark; Family-Lauraceae**):** *Cinnamomum verum*, generally recognized as true cinnamon, is a spice herb renowned for its medicinal and pharmacological properties. Its former botanic synonym, *Cinnamomum zeylanicum*, originates from "Ceylon," the historical title for Sri Lanka. Native to Sri Lanka and the southern regions of India, this plant has been used since ancient times both as a medicinal condiment and a culinary spice. The usable part is the dried inner bark, stripped of its outer cork and underlying parenchyma. *Cinnamomum verum* is widely rated in conventional and modern system of medication for its diverse therapeutic uses and continues to be

incorporated in pharmaceutical formulations and food products for the cure of various ailments[17].

c) ***Terminalia bellirica*** (Part used-Dried fruit Covering; Family- Combretaceae): The plant is widely distributed across the subcontinent of India. In India, it is commonly referred to as "Bahera" (in Hindi), while it is known as "Beleric Myrobalan" (in English) and "Bibhitaki," (in Sanskrit). The species is a large deciduous tree attaining a height of approximately 20-30 meters. It is distinguished by a prominent buttressed trunk and thick, brownish-grey bark exhibiting shallow longitudinal fissures. The leaves are clustered near the apices of branches, arranged alternately, and exhibit entire margins with an elliptic-obovate form, terminating in either a rounded or sub-acute apex. Young leaves are initially pubescent but become glabrous upon maturation. The inflorescences consist of pale greenish-yellow flowers possessing a distinctly unpleasant odor, borne on axillary spikes that exceed the length of the petioles but remain shorter than the leaves. The plant bears ovoid drupes that are initially pink and spherical but become five-ridged and grayish upon drying. Each fruit contains a single ellipsoid seed[18].

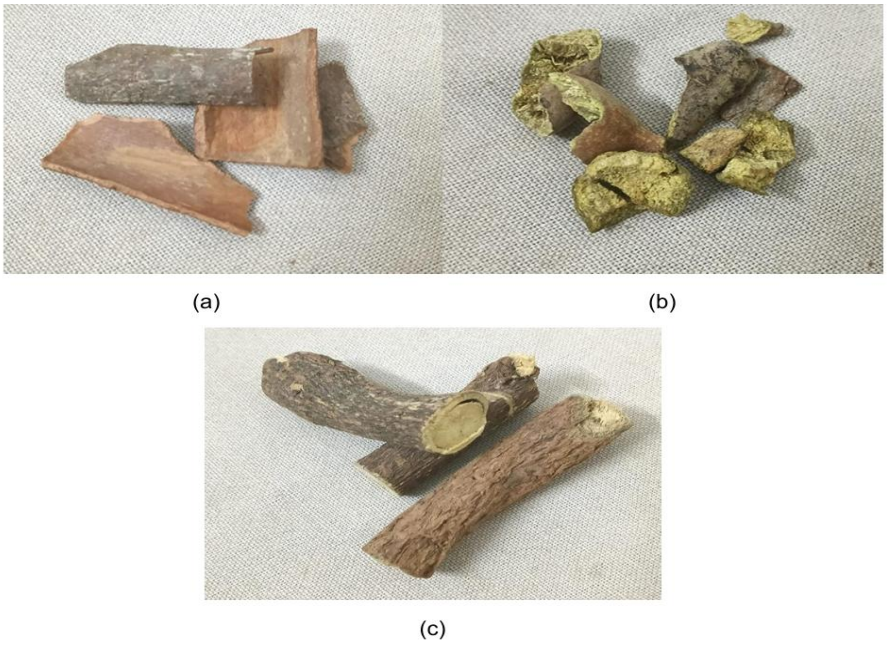

Figure 1: Selected Medicinal Plant Materials

(a) Bark of *Cinnamomum verum*; (b) Fruit covering of *Terminalia bellirica*; (c) Root of *Glycyrrhiza glabra*

Procurement of Plant materials

- *Glycyrrhiza glabra:* Roots were obtained from local market of Hansi, Hisar. Plant Specimen was authenticated by Dr. S.S. Yadav, Department of Botany, M. D. University, Rohtak, Haryana, India
- *Cinnamomum verum:* Barks were obtained from local market of Hansi, Hisar. Plant Specimen was authenticated by Dr. S.S. Yadav, Department of Botany, M. D. University, Rohtak, Haryana, India
- *Terminalia bellirica:* Dried fruits covering were obtained from local market of Hansi, Hisar. Plant Specimen was authenticated by Dr. S.S. Yadav, Department of Botany, M. D. University, Rohtak, Haryana, India.

Processing of Plant materials

- Dried *Glycyrrhiza glabra* roots were kept in boiled water for a period of 30 minutes. After this, solution was filtered using filter paper and filtrate was dried by rota vapor to obtain crude extract. Then, Crude extract was collected and weighed.
- Dried *Cinnamomum verum* barks were powdered in a mixer grinder. Powdered plant material was macerated in Chloroform for a period of 3 days. After this period, solution was filtered and filtrate was dried by rota vapor to obtain crude extract. Then, Crude extract was collected and weighed.
- Dried *Terminalia bellirica* fruits covering was powdered in a mixer grinder. Powdered material was macerated in ethanol: water (80: 20 v/v) for 3 days. After this period, solution was filtered and filtrate was dried by rota vapor to obtain crude extract. Then, Crude extract was collected and weighed.

Phytochemical Screening

Procedure[19,20,21]

Carbohydrates

- Molisch's Test: Two drops of Molisch's reagent were added to the plant extract, followed by careful layering of concentrated sulfuric acid along the side of the test tube. The formation of a violet or purple ring at the

junction of the two layers indicated the presence of carbohydrates.

- Benedict's Test: The extract was mixed with 2 mL of Benedict's reagent and heated in a boiling water bath for five minutes. A color change resulting in green, yellow, or brick-red precipitate signified the presence of reducing sugars.
- Iodine Test: A few drops of iodine solution were added to the plant extract. The appearance of a blue-black coloration confirmed the presence of starch.

Glycosides

- Borntrager's Test: The extract was boiled with dilute hydrochloric acid, cooled, and filtered. The filtrate was shaken with chloroform, and the separated organic layer was treated with ammonia. The development of a pink to red coloration in the ammoniacal layer indicated the presence of anthraquinone glycosides.
- Keller-Killiani Test: The extract was combined with glacial acetic acid containing a trace amount of ferric chloride, followed by gentle addition of concentrated sulfuric acid along the side of the test tube. A reddish-brown ring at the interface suggested the presence of cardiac glycosides.

Alkaloids

- Dragendorff's Test: Addition of Dragendorff's reagent to the extract resulted in the formation of an orange or reddish-brown precipitate, indicating the presence of alkaloids.
- Mayer's Test: The extract was treated with Mayer's reagent. The appearance of a creamy white precipitate indicated a positive result for alkaloids.
- Wagner's Test: Upon addition of Wagner's reagent to the extract, a reddish-brown precipitate confirmed the presence of alkaloidal compounds.

Terpenoids

- Salkowski Test: The extract was mixed with chloroform, and concentrated sulfuric acid was carefully added down the side of the test tube. A reddish-brown coloration at the interface was indicative of terpenoids.

Phenolic Compounds

- Ferric Chloride Test: A few drops of 5% ferric chloride solution were added to the extract. The development of a deep blue, green, or purple color confirmed the presence of phenolic constituents.

Flavonoids

- Sodium Hydroxide Test: The extract was treated with 10% sodium hydroxide solution, resulting in a yellow coloration. The disappearance of this color upon the addition of diluted hydrochloric acid confirmed the presence of flavonoids.
- Lead Acetate Test: The extract was mixed with 10% lead acetate solution. Formation of a yellow precipitate indicated the presence of flavonoids.

Preparation of Herbal Lotion formulations

Herbal lotion formulations are prepared by mixing various ingredients in step-wise manner. Dried crude extract of all three plant materials was added after preparation of lotion. Crude extracts were mixed with the lotion with continuous stirring until they were properly mixed.

Evaluation of Lotion Formulations

a) Organoleptic Properties

Homogeneity: Visual assessment of the lotion's color, clarity, and uniformity to ensure it is free from any visible particles or clumps.

After feel: To assess the herbal lotion's absorption characteristics, texture during application, and interaction with the skin's surface, the process entailed applying it directly to the skin.

Ease of removal: Clean, dry skin was covered evenly with the herbal lotion, which was then left to sit for a predetermined amount of time. Either plain water or a moist cotton swab with light wiping motions were used for removal.

Color: Herbal lotion Formulations were checked visually for color.

Odor: Odor of the Herbal lotion Formulations were examined by sensing the smell of the formulations.

Irritancy: A tiny amount of the herbal lotion was applied to the hand's lateral region and left undisturbed for a full day in order to gauge skin irritancy. At regular intervals, the area was checked for any obvious symptoms of irritation, like redness, swelling, or itching. Following the 24-hour period, the area was reassessed for any delayed skin reactions and the lotion was carefully removed.

b) Rheological properties

Viscosity: The viscosity of the formulated herbal lotions was determined using a Brookfield digital viscometer (Model LV DV–II Ultra, Programmable Rheometer, USA). Spindles 1 and 2 were rotated at 25 rpm for one minute in order to perform the assessment at 30 °C.

Extrudability: It was checked by applying pressure at the crimp end of the collapsible tube after filling it with herbal lotion formulations with a closed cap for a period of 10 s. Extruded herbal lotion formulation was weighed.

Spreadability: It was noted by placing the herbal lotion formulations between the two glass slides and keeping a weight of 100 g on the upper slide for a period of 5 min using a formula as:

$S = m \times L/T$

Where S- Spreadability

m- Mass in gram placed on the upper glass slide

L- Length of the herbal lotion formulation achieved after applying a pressure for a specific time

T- Time period used for the spreading of the formulation

pH: Measurement of the lotion's acidity or alkalinity using a Digital pH meter, ensuring it is within the acceptable range for topical application and won't cause skin irritation.

Stability: Evaluating the lotion's physical and chemical stability over time, including its appearance, pH, drug content, and other properties, to ensure it remains effective and safe throughout its shelf life.

Antibacterial Activity

Antibacterial activity of formulations is performed by Cylindrical Plate method. Muller-Hinton Agar medium was used as a culture medium for Bacterial strains of *Staphylococcus aureus* and *Escherichia coli*. Bacterial strains were transferred to the agar plates using spread plate method. Total of three wells were prepared on each agar plate. Concentration of herbal lotion formulation was added to the one of the well on agar plate containing bacterial culture. One well was used for Standard antibacterial substance (Streptomycin sulphate) and other one for blank (containing solvent). After 24 h of incubation at 37 °C, the antibacterial activity of the herbal lotion formulation was evaluated by measuring the diameter of the zone of inhibition surrounding the well containing the formulation. The results were compared with the inhibition zone diameter produced by the standard reference substance.

RESULTS

Outcomes of extraction Process

Crude extracts of plant materials were obtained after completion of extraction processes. Percentage yield has been calculated for each plant material after drying and weighing of crude extract and mentioned in the Table 1.

Table 1: Percentage Yield of Crude Extracts

Plant Material	Solvent Used	% Yield
Fruit covering of *Terminalia bellirica*	Ethanol: Water (80:20 v/v)	3.7
Root of *Glycyrrhiza glabra*	Water	1.0
Bark of *Cinnamomum verum*	Chloroform	0.5

v/v: volume by volume

Outcomes of Phytochemical Screening

Phytochemical classes such as Alkaloids, Terpenoids, Flavonoids and Phenols are present in all three crude extracts. Glycosides are found in *Cinnamomum verum* and *Terminalia bellirica*. Carbohydrates are present only in *Cinnamomum verum*. Outcomes of Phytochemical class are mentioned in Table 2. Photographs of Phytochemical screening outcomes are shown in Figure 2.

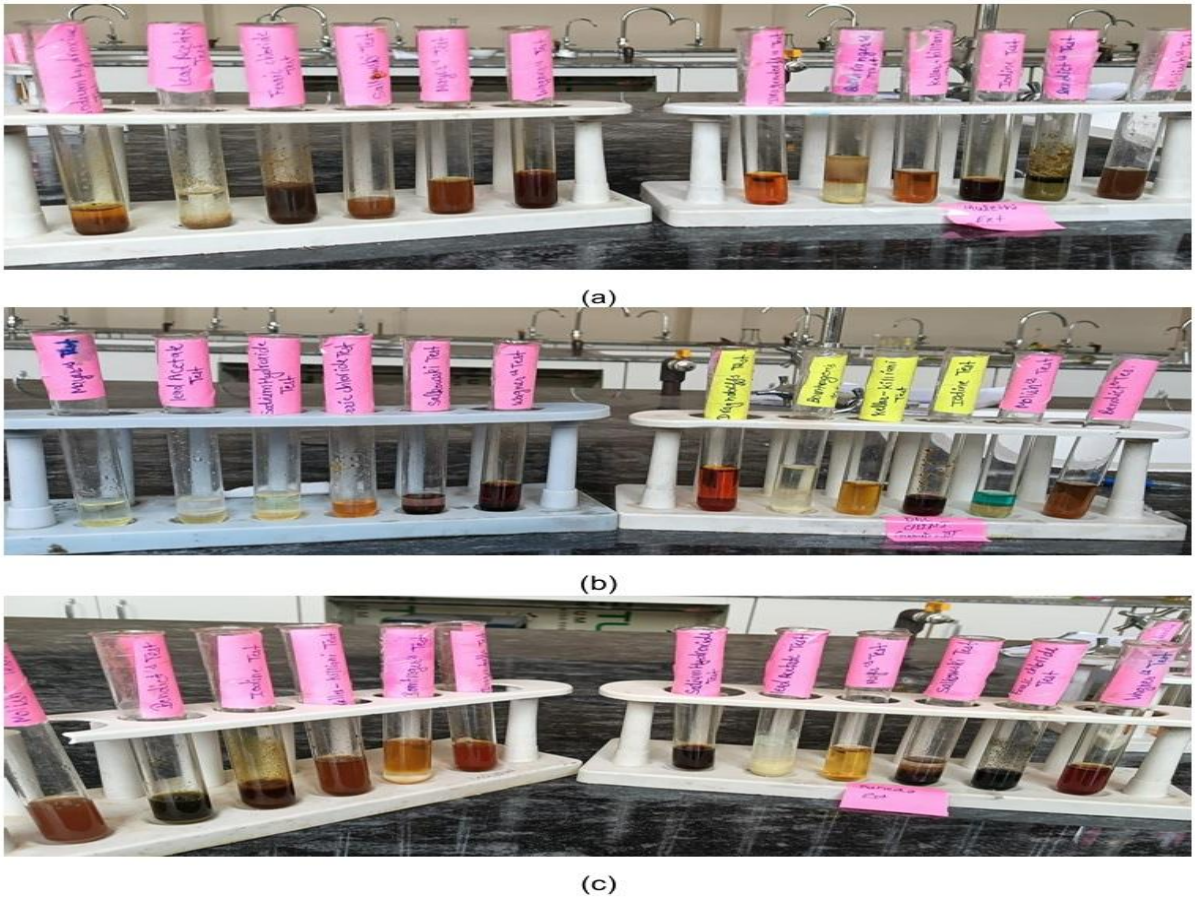

Figure 2: Photographs of Phytochemical screening of Extracts
(a) *Glycyrrhiza glabra;* (b) *Cinnamomum verum;* (c) *Terminalia bellirica*

Table 2: Outcomes of Phytochemical Screening

Phytochemicals Class	Fruit covering of *Terminalia bellirica*	Roots of *Glycyrrhiza glabra*	Bark of *Cinnamomum verum*
Carbohydrates	-	-	+
Alkaloids	++	+	++
Terpenoids	++	++	++
Glycosides	+	-	+
Flavonoids	+	++	++
Phenols	++	++	++

++: Present in Excess amount; +: Present in reasonable amount; -: Not Present

Table 3: Formulae of Herbal lotion formulations

Ingredients	F1 (% w/v)	F2 (% w/v)
Castor oil	15.0	16.0
Beeswax	4.0	4.5
Glycerin	8.0	9.0
Propylene glycol	10.0	12.0
Polysorbates 80	4.0	3.5
Extract of *Glycyrrhiza glabra*	1.0	1.0
Extract of *Cinnamomum verum*	0.5	0.5
Extract of *Terminalia bellirica*	1.0	1.0
Methyl Paraben	0.05	0.05
Rose water	q.s.	q.s.
Water	q.s.	q.s.

w/v: weight by volume; q.s.: quantity sufficient

Figure 3: Photographs of Herbal lotion formulations

(a) Formulation 1; (b) Formulation 2

Herbal Lotion Formulations

Two Herbal lotion formulations were designed by varying composition of the ingredients as mentioned in Table 3. Oil phase soluble components were mixed gently and heated to 70°C. The water-soluble components of the aqueous phase were combined and heated separately to 70 °C. Subsequently, the aqueous phase was gradually added to the oil phase under continuous stirring to ensure proper emulsification. The mixture was stirred until it cooled to room temperature. Preservatives and extracts of herbs were added during cooling. Prepared lotion formulations were transferred to suitable containers. Photographs of Herbal Lotion Formulations are shown in Figure 3.

It is quite clear from the Table 4 that Herbal lotion Formulation (F1) is better than F2. So, antibacterial activity testing was performed for Herbal lotion formulation (F1).

Antibacterial Activity

Antibacterial activity of Herbal Lotion formulation (F1) was performed by Cylindrical Plate method on Muller-Hinton Agar. Bacterial cultures of *Staphylococcus aureus* and *Escherichia coli* were used for ascertaining the antibacterial activity of Herbal lotion formulation. Standard antibiotic (Tetracycline) was utilized as a positive control for comparison of zone of inhibition of herbal lotion formulation with the standard. Dilution of Tetracycline of 10 µg/ml was prepared from stock (1mg/ml in DMSO). Concentrations of Herbal lotion formulation was kept 10 mg/ml and 20 mg/ml in water. DMSO was used as a Negative control (Blank). Diameter of Zone of Inhibition of Heral Lotion Formulation (F1) and Controls is shown in Figure 4.

Table 4: Outcomes of Herbal lotion formulations

Properties	F1	F2
Homogeneity	Uniform	Very Good
After Feel	Excellent	Very Good
Color	Brownish Yellow	Yellow
Odor	Pleasant	Pleasant
Irritancy	No	No
pH	6.4	6.3
Viscosity (cps)	637	649
Spreadability (cm)	9.2	9.1
Extrudability	Excellent	Very Good
Stability (4 weeks)	Stable	Stable

F1: Herbal Lotion Formulation 1; F2: Herbal Lotion Formulation 2

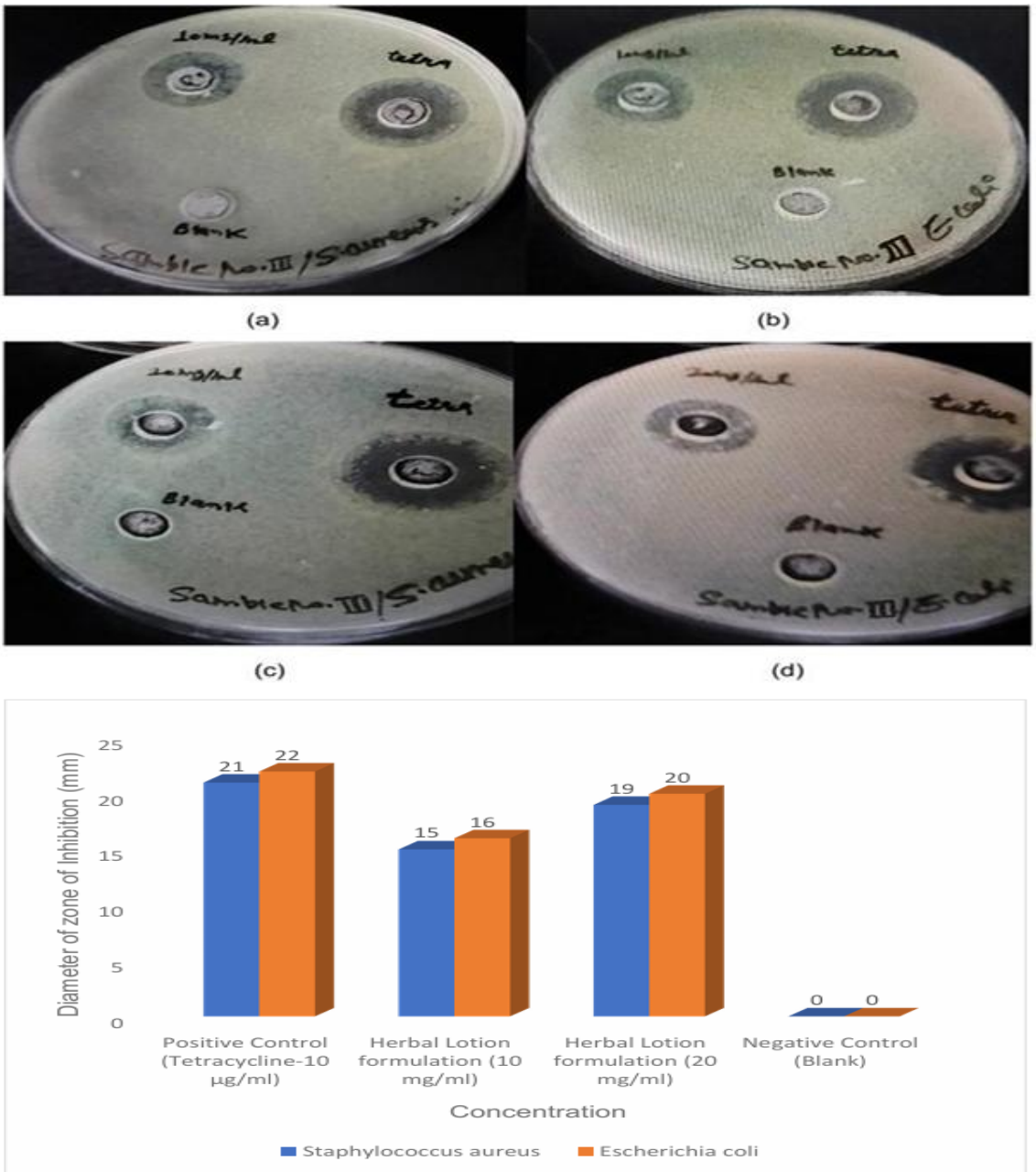

Figure 4: Diameter of zone of inhibition of Herbal Lotion Formulation (F1) and Controls

It has been observed from the above Figure 4 that approximately 25 mg/ml of Herbal lotion formulation will be equivalent to the Positive control (Tetracycline-10 µg/ml) concentration. Herbal lotion formulation is showing very good antibacterial activity against G (+) *Staphylococcus aureus* and G (-) *Escherichia coli* bacterial cultures.

DISCUSSION

Using extracts of the roots of *Glycyrrhiza glabra,* barks of *Cinnamomum verum* and fruits covering of *Terminalia bellirica,* the Herbal lotion formulations demonstrated beneficial properties for topical application. The therapeutic potential of the formulations was highlighted by phytochemical screening, which confirmed the presence of classes of phytochemicals with antimicrobial, anti-inflammatory, and wound-healing properties. On organoleptic evaluation, both Herbal lotion formulations are uniform with very good consistency, having pale yellow color and pleasant odor, all contribute to its high user acceptability. Mild viscosity, good spreadability, and ease of extrusion were confirmed by rheological evaluation. Formulations are found stable on stability testing for a period of 4 weeks. Antibacterial activity of the Herbal lotion formulation (F1) confirms that the formulation can be used for topical application for preventive and therapeutic effects in various skin ailments.

CONCLUSION

Herbal lotion formulations were formulated having Antibacterial activity against G (+) and G (-) bacteria. Both formulations were evaluated in terms of organoleptic properties, Rheological Properties, pH and stability. Out of two Herbal lotion formulations, one formulation (F1) is better than other in terms of Organoleptic, Rheologic properties.

SUMMARY

In this study, extracts from the roots of *Glycyrrhiza glabra,* barks of *Cinnamomum verum* and fruits covering of *Terminalia bellirica,* were used to formulate and evaluate a topical Herbal lotion. The primary goal was to address the growing problem of antimicrobial resistance by creating a safe, efficient, and ecologically friendly substitute for synthetic topical antibiotics. Maceration and decoction techniques were used to obtain crude extracts from plant materials. Phytochemical classes such as Alkaloids, Terpenoids, Flavonoids and Phenols are present in all three crude extracts. Glycosides are found in *Cinnamomum verum* and *Terminalia bellirica*. Carbohydrates are present only in *Cinnamomum verum*. These substances are known to have important antimicrobial, anti-inflammatory, and wound-healing properties. The formulated Herbal lotion formulations were investigated for Organoleptic properties, Rheological properties, pH and Stability. In terms of functionality, the formulation was readily absorbed, non-greasy, leaving a pleasant feel. Additionally, it was simple to remove with water or a moist cotton swab, leaving no discoloration or residue behind. Mild, very good spreadability, and excellent extrudability were found by rheological analysis, guaranteeing a useful and user-friendly application. Lotions color, consistency, aroma, and structural integrity were all preserved over time on testing for stability for a period of 4 weeks as per ICH guidelines. Herbal lotion Formulation (F1) was tested against *Staphylococcus aureus* and *Escherichia coli* bacterial strains revealed the formulation's antibacterial coverage against G (+) and G (-) bacteria. The study's overall findings support sustainable and evidence-based herbal medicine practices by showing that the Herbal lotion offers a stable, economical, and natural substitute for topical antibiotics.

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ETHICAL STATEMENT

This study did not involve any animal experimentation in compliance with ethical research practices.

ABBREVIATION

WHO: World Health Organization

MIC: Minium Inhibitory Concentration

MBC: Minimum Bactericidal Concentration

RH: Relative Humidity

ICH: International Conference on Harmonization

DMSO: Dimethyl Sulfoxide

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