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POLYHERBAL COSMETICS FOR SKIN CARE: FORMULATION STRATEGIES, EVALUATION METHODS, AND THERAPEUTIC APPLICATIONS

Kalaivanan Seeni*[1], Harinisri S.[1], Aashis Tony A.[1], Purusothaman S.[1], Blessy Flarance[1], Dr. K. Srinivasan[2], Dr. Rajaganapathy K.[3] , Dr. R. Lavnaya Babu[4], S. Vignesh[5]

[1]Assistant Professor, Department of Pharmacology, Faculty of Pharmacy, Bharath Institute of Higher Education And Research. Chennai.India.

[1]Student ,Faculty of Pharmacy, Bharath Institute of Higher Education And Research. Chennai.India.

[2]Dean and Professor, Faculty of Pharmacy, Bharath Institute of Higher Education And Research. Chennai.India.

[3]Professor, Department of Pharmacology, Faculty of Pharmacy, Bharath Institute of Higher Education And Research. Chennai.India.

[4]Professor, Department of Pharmacognosy, Faculty of Pharmacy, Bharath Institute of Higher Education And Research. Chennai.India.

[5]Assistant Professor, Department of Pharmaceutical Chemistry, Faculty of Pharmacy, Bharath Institute of Higher Education And Research. Chennai.India.

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***Corresponding Author: Kalaivanan Seeni**
Assistant Professor, Department of Pharmacology, Faculty of Pharmacy, Bharath Institute of Higher Education And Research. Chennai.India.

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ABSTRACT:

The increasing demand for safe, natural, and sustainable skincare products is driving the growth of herbal cosmetics. Polyherbal preparations, consisting of multiple medicinal plant extracts, exhibit enhanced therapeutic efficacy due to synergistic interactions among phytoconstituents. These formulations demonstrate antioxidant, anti-inflammatory, antimicrobial, and photoprotective properties, making them suitable for a wide range of skincare applications. Compared to synthetic cosmetics, polyherbal fo rmulations are generally associated with improved skin compatibility and reduced adverse effects. This review focuses on the composition, evaluation methods, therapeutic a pplications, and recent advancements in polyherbal cosmetics. Various dosage forms, including creams, gels, lotion,

nano formulations, and hydrogels, enhance stability, bioavailability, and skin penetration of active constituents. Evaluation techniques, including physicochemical and biological assessment, are employed to ensure product safety, stability, and efficacy. With an emphasis on clinical validation and standardization, polyherbal cosmetics represent a promising and sustainable alternative to modern skincare system.

KEYWORDS: Polyherbal cosmetics, Herbal skincare, Medicinal plants, Cosmeceuticals, Skin care, Natural products.

1. INTRODUCTION

The skin, the largest organ of the body, plays a crucial role in protection against environmental stress, pathogens, and physical damage. In order to protect and enhance the skin, which is essential for general health, cosmetic products play a vital role in maintaining skin health and appearance[1,2]. Natural and herbal-based cosmetics are becoming more popular as worries about the negative effects of synthetic chemicals have grown in recent years[3,4]. Biologically active substances with both cosmetic and therapeutic qualities are found in herbal cosmetics, which are derived from plant extracts.People's interest has been sparked by the synergistic benefits of polyherbal medicines, which combine several medicinal plants. By mixing various phytochemicals with complementary biological actions, these formulations increase efficacy[5,6].

Herbal medications have long been utilized for skincare in traditional systems such as Ayurveda, Unani, and Traditional Chinese Medicine. Recent scientific advances have enabled the development of standardized and stable polyherbal cosmetic formulas.There are numerous applications for polyherbal cosmetics, including skin-brightening, moisturizing, anti-aging, and protective qualities. Additionally, they enhance sensory acceptability, consumer compliance and increase the product's acceptance[7,8].

1.1 Concept of Polyherbal Formulation

The concept of polyherbal formulation compared to single-herb preparations, the idea of polyherbal formulation is combining many plant extracts to provide a synergistic effect that increases medicinal efficacy. This method treats several skin issues at once and increases overall efficacy, which makes it ideal for contemporary dermatological applications[9,10]. Certain medicinal plants, like *Clitoria ternatea*, Aloe vera, *Azadirachta indica* (neem), and Rosa species, are essential to skincare in this composition. Aloe vera has superior moisturizing and wound-healing advantages, while *Clitoria ternatea* is well-known for its

potent antioxidant and skin-brightening qualities. Rosa species have calming and anti-aging properties, and *Azadirachta indica* demonstrates strong antibacterial and anti-acne action[11,12].

1.2 Overview of Herbal Cosmetics Market Growth

In recent decades, there has been a notable movement in the worldwide cosmetics business towards the use of natural and herbal products. Growing consumer knowledge of the negative effects of synthetic chemicals and a desire for safer, environmentally friendly alternatives are the main forces behind this shift[15]. Herbal cosmetics, also known as Phyto-cosmetics or cosmeceuticals, combine biologically active substances derived from plants with cosmetic formulas to offer both cosmetic and medicinal advantages. The phytoconstituents that give these items their antioxidant, anti-inflammatory, antibacterial, and anti-aging qualities include flavonoids, phenolics, alkaloids, and essential oils[16].

Improvements in formulation processes, standardization of plant materials, and extraction technologies all contribute to the growth of the herbal cosmetics sector. The value of natural ingredients is being more widely acknowledged by international organizations and regulatory bodies, which is promoting research and development in this area[17]. Additionally, the usage of herbal substances in skincare formulas has been accelerated by the growing desire for cruelty-free and ecological products. Polyherbal formulations, which combine several plant extracts to improve efficacy and expand therapeutic applications, have emerged as a potential strategy in this regard[18].

1.3 Limitations of Synthetic Creams

Synthetic creams have a number of drawbacks that raise questions about their safety and long-term use, despite their ubiquitous availability and instant cosmetic effects. Parabens, sulphates, silicones, artificial colourants, and scents are examples of synthetic additives used in many conventional formulations that might have negative skin reactions[19]. These reactions include hypersensitivity, erythema, allergic contact dermatitis, and irritation, especially in those with sensitive skin. Long-term use of synthetic treatments can also damage the skin barrier's natural lipid composition, increasing trans epidermal water loss (TEWL), dryness, and early ageing[20].

Additionally, several chemical components have been linked to endocrine disruption and possible carcinogenic concerns; however, these effects are contingent upon exposure time and concentration. Synthetic chemicals frequently show poor biodegradability, which contributes to ecological imbalance and environmental pollution in addition to health risks[21].

The absence of multifunctionality in many synthetic formulations, which are usually created to target a single skin condition, is another significant drawback. This raises the possibility of chemical interactions and cumulative toxicity by requiring the usage of several products. These disadvantages highlight the need for safer, more environmentally friendly, and multi-targeted substitutes, like herbal and polyherbal formulations[22].

1.4 Advantages of Polyherbal Formulations

The foundation of polyherbal formulations is the idea of synergism, which states that the combined action of several plant ingredients results in a more potent therapeutic impact than each component acting alone[23]. Modern pharmacological research has provided scientific backing for this method, which has its roots in traditional medical systems. By concurrently addressing multiple dermatological issues like oxidative stress, microbial infections, inflammation, and dehydration, polyherbal creams provide a comprehensive skincare solution.

Broad-spectrum activity is one of the main benefits of polyherbal compositions. For example, anti-inflammatory components lessen skin irritation and redness, antibacterial agents inhibit harmful microorganisms, and antioxidant chemicals neutralize free radicals. Natural emollients and humectants further improve the elasticity and moisture of the skin[24].

Additionally, because of the balanced interaction of phytoconstituents, polyherbal creams typically have better safety profiles, which may lessen the possibility of negative effects. Additionally, using natural substances improves biocompatibility with the skin, leading to improved efficacy and absorption[25]. When appropriately optimised, polyherbal systems can increase stability and shelf life from the standpoint of formulation. Additionally, these formulas are in line with customer preferences for natural, holistic, and environmentally friendly skincare products[26].

2. HERBAL COSMETICS: OVERVIEW

The term "Herbal Cosmetics" refers to a developed product that uses several valuable cosmetic components to create the basis in which one or more herbal additives are used to achieve specific medicinal and cosmetic effects. when there are no immediate healing effects from herbs. They provide a means of aligning the body with the natural world. The fact that herbal cosmetics are produced entirely of herbs and shrubs is their best feature. Instead of having any negative effects on the human body, the natural content of the herbs enriches the body with beneficial minerals and nutrients. European (European Directives Commission) products are defined as any defined 93/35/EEC cosmetic substance or preparation that is

meant to be applied to the various external parts of the human body (such as the epidermis, hair system, nails, lips, and external genital organs) or to the teeth and oral mucous membranes with the sole or primary purpose of cleaning, perfuming, altering their appearance, correcting body odors, protecting, or maintaining them. Herbal cosmetics, often known as natural cosmetics, have been the basis for the development of numerous toiletry and cosmetic ideas[27].

Different cosmetic elements are utilised to form the base of herbal cosmetics, which are then used to treat a variety of skin and hair conditions. Herbal remedies are becoming more and more popular because they are safe for the skin and have no negative side effects. Because herbal cosmetics are created entirely of herbs and shrubs, they have no negative side effects, which is their best feature. These days, people all around the world are turning back to using herbal products and adopting a more natural lifestyle[28].

For a healthy existence, people prefer natural foods, herbal remedies, and natural healing methods. Vegetable items grown organically or biologically without the use of artificial pesticides and fertilizers are quite popular[29]. In the personal care system, the use of herbal cosmetics has multiplied, and there is a high demand for them. All of this occurred as a result of the overuse of synthetic-based products, synthetic chemicals, chemical dyes, and items developed from them during the past 150 years; their manufacture and use pose health risks to people and have a number of negative impacts that can result in various diseases. Additionally, it significantly polluted the environment and disrupted our ecosystem[30].

Figure 1 Types of herbal cosmetics.

2.1 Herbal cosmetics provide the following benefits:

- Customers prefer natural products due to their adaptability to different skin types[31].
- Safety for the environment and biodegradability[32].
- Herbal cosmetics is wide selection to choose from
- Herbal cosmetics is fitting your budget.
- Herbal cosmetics is not tested on animals.
- Reduced possibility of adverse effects.
- Herbal cosmetics have no harmful effects and reduce the risk of an unfavorable reaction.
- Applying herbal cosmetics to the skin and hair is a simple process.
- Patient acceptability and tolerance are higher for herbal cosmetics[33].
- Herbal cosmetics are a sustainable supply of treatment.
- Widespread availability, particularly in poor nations like India. Effective in little amounts compared to commercial cosmetics[34].
- Vegetable extracts reduce the bulk of cosmetics and produce appropriate pharmacological outcomes.
- Easily accessible and available in a wide range of quantities.
- Cosmetics made from herbs are less expensive
- Herbal cosmetics are safe to use.
- All skin types are compatible with it[35].

These formulas are commonly used for skincare purposes like hydration, anti-aging, acne therapy, and skin protection.

3. PHYTOCHEMICAL COMPONENTS IN POLYHERBAL COSMETICS

Phytochemicals are bioactive compounds found in plants that enhance their therapeutic properties. The therapeutic and cosmetic advantages of polyherbal formulations are greatly enhanced by phytochemicals, which are naturally occurring bioactive substances found in medicinal plants. These ingredients have a variety of pharmacological properties that are very helpful in skincare applications, including antioxidant, anti-inflammatory, antibacterial, wound healing, and photoprotective actions. Through the synergistic interactions between several phytoconstituents, the combination of several plant extracts improves the overall efficacy of polyherbal cosmetics[36].

Flavonoids, phenolic compounds, alkaloids, tannins, saponins, and terpenoids are major types of phytochemicals that are frequently used in polyherbal cosmetic formulations. As potent antioxidants, flavonoids and phenolic substances counteract free radicals and lessen oxidative stress, which is the cause of premature skin ageing[37]. Alkaloids and terpenoids have antibacterial and anti-inflammatory qualities that help treat acne and skin infections, while tannins have astringent qualities that help constrict pores and improve skin texture. Because of their rich phytochemical profile, a number of medicinal plants are used extensively in polyherbal cosmetics. Polysaccharides and glycoproteins found in aloe vera have wound-healing and moisturizing properties. Azadirachtin and nimbidin, which have potent antibacterial and antifungal properties, are abundant in *Azadirachta indica*, or neem[38].

While Rosa species are rich in flavonoids and volatile oils that have calming and skin-refreshing benefits, *Clitoria ternatea* has anthocyanins with strong antioxidant qualities. These phytochemical-rich plant extracts boost skin hydration, strengthen collagen protection, lower inflammation, and support general skin health when added to cosmetic formulas. Phytochemicals are essential to the creation of safe, efficient, and sustainable polyherbal cosmetics because of their natural origin and multipurpose medicinal qualities[39]. "Table 1 shows the role of phytochemicals in polyherbal cosmetics."

Table 1Phytochemical constituents and their role in polyherbal cosmetic formulations.

S.NO	PHYTOCHEMICAL CONSTITUENTS	SOURCE / EXAMPLE PLANTS	ROLE IN POLYHERBAL COSMETICS
1.	Flavonoids	Rose, *Clitoria ternatea*	Antioxidant activity, protects skin from oxidative stress and aging
2.	Phenolic compounds	Neem, Turmeric	Anti-inflammatory and antimicrobial properties
3.	Alkaloids	Neem, Aloe vera	Wound healing and antibacterial action
4.	Tannins	Rose, Neem	Astringent effect, tightens skin pores
5.	Terpenoids	Rose oil, Herbal essential oils	Skin rejuvenation and fragrance enhancement
6.	Saponins	Aloe vera	Cleansing and foaming properties
7.	Anthocyanins	*Clitoria ternatea*	Free radical scavenging and photoprotective effect
8.	Polysaccharides	Aloe vera	Moisturizing and skin soothing activity

These phytochemicals interact together in polyherbal formulations to improve general skin health.

3.1 Flavonoids:

Numerous therapeutic plants include naturally occurring polyphenolic chemicals called flavonoids. Their potent antioxidant qualities, which shield the skin from oxidative stress and free radical damage, are widely recognised[40]. Flavonoids contribute to the photoprotective, anti-aging, and skin-brightening properties of polyherbal cosmetics. Additionally, they lessen the appearance of fine lines and wrinkles and preserve the flexibility of the skin. Owing to their capacity to scavenge free radicals, flavonoids are frequently utilised in sunscreen and herbal anti-aging formulas[42].

3.2 Phenolic Compounds:

Bioactive plant components known as phenolic compounds have phenol groups with antibacterial and antioxidant properties. These substances protect the skin from bacterial infections, lessen inflammation, and enhance the general health of the skin[43]. Additionally, they help stop the oxidative degradation of skin cells brought on by UV radiation and environmental stress. Herbal cosmetic compositions' stability and skin protection are both improved by phenolic chemicals[44].

3.3 Alkaloids:

Alkaloids are chemical molecules that naturally contain nitrogen and are produced by plants. They are helpful in herbal cosmetic formulations for acne and skin protection because of their antibacterial, anti-inflammatory, and wound-healing qualities. Alkaloids also aid in tissue repair and lessen redness and irritation of the skin. They are useful components of medicinal herbal skincare products because of their therapeutic properties[44].

3.4 Tannins:

Tannins are polyphenolic substances that dissolve in water and have an astringent effect. They enhance the firmness and texture of the skin, tighten pores, and regulate excessive oil secretion. Additionally, tannins help reduce microbial growth and skin irritation by forming a protective layer over the skin. They are frequently used to formulas meant for skin that is greasy and prone to acne[45].

3.5 Terpenoids:

Terpenoids are fragrant chemicals that come from essential oils and medicinal plants. In cosmetic products, they aid in scent, skin renewal, anti-inflammatory action, and skin attractiveness enhancement. These substances also encourage healthy skin renewal and enhance blood circulation in the skin. Terpenoids are widely utilised in herbal lotions, creams, and aromatherapy-based cosmetics because of their calming properties[46].

3.6 Saponins:

When combined with water, saponins, which are naturally occurring glycosides, create foam. Because of their cleaning, emulsifying, and foaming qualities, they are frequently used in herbal cleansers and face washes. Saponins aid in clearing the skin of pollutants, excess oil, and dirt without making it unduly dry. Additionally, they make cosmetic formulas more textured and spreadable[47].

3.7 Anthocyanins:

The colored flavonoid pigments called anthocyanins give plants like Clitoria ternatea their blue, purple, and red hues. These substances have potent photoprotective and antioxidant properties that help delay the ageing process of the skin. Additionally, anthocyanins aid in preventing oxidative damage brought on by environmental contaminants and UV radiation. Additionally, their inherent colouring ability enhances the aesthetic attractiveness of herbal cosmetics[48].

3.8 Polysaccharides:

Plants like aloe vera have complex carbohydrate molecules called polysaccharides. They help preserve the smoothness and barrier function of the skin by having calming, hydrating, and moisturising actions. By holding onto moisture and enhancing skin hydration for extended periods of time, these substances aid in skin restoration. Particularly useful for treatments for dry and sensitive skin are polysaccharides[49].

3.9 Essential Oils:

Essential oils are fragrant chemicals that are derived from medicinal plants and are volatile. In polyherbal cosmetic compositions, they offer scent in addition to antibacterial, calming, and skin-refreshing qualities. Applying essential oils to the skin also encourages relaxation and produces a cooling effect. The functional and sensory aspects of herbal cosmetics are enhanced by their therapeutic scent and biological activity[50].

Table 2 Common Medicinal Plants Used in Poly Herbal Cosmetics.

S.NO	COMMON NAME	BIOLOGICAL NAME	BIOLOGICALLY ACTIVE COMPOUNDS	THERAPEUTIC / COSMETIC FUNCTIONS
1.	Aloe vera	*Aloe barbadensis Miller*	Polysaccharides, Vitamins, Glycoproteins	Moisturizing, wound healing, skin soothing and anti-inflammatory activity
2.	Neem	*Azadirachta indica*	Azadirachtin, Nimbidin, Flavonoids	Antimicrobial, anti-acne, antifungal and skin protective action
3.	Turmeric	*Curcuma longa*	Curcumin, Essential oils	Anti-inflammatory, antioxidant and skin brightening effect
4.	Rose	*Rosa damascena*	Flavonoids, Phenolics, Volatile oils	Cooling, soothing, antioxidant and skin refreshing properties
5.	Butterfly pea	*Clitoria ternatea*	Anthocyanins, Flavonoids	Antioxidant, anti-aging and photoprotective activity
6.	Tulsi	*Ocimum sanctum*	Eugenol, Tannins, Flavonoids	Antibacterial, anti-inflammatory and skin purifying action
7.	Lemon	*Citrus limon*	Vitamin C, Citric acid, Flavonoids	Skin cleansing, exfoliating and skin brightening effect
8.	Cucumber	*Cucumis sativus*	Vitamins, Silica, Water content	Hydrating, cooling and skin calming activity
9.	Tea tree	*Melaleuca alternifolia*	Terpenoids, Essential oils	Antimicrobial and anti-acne properties
10.	Sandalwood	*Santalum album*	Santalol, Sesquiterpenes	Cooling, anti-inflammatory and fragrance enhancement

4. FORMULATION STRATEGIES FOR POLYHERBAL COSMETICS

Polyherbal cosmetic formulations include a variety of plant extracts into suitable dosage forms to enhance both medicinal efficacy and aesthetic acceptance. The choice of formulation type is influenced by the intended use, the kind of skin, and the physicochemical properties of the herbal components[51,52]. "Table 3 and Figure 2 summarize various formulation types."

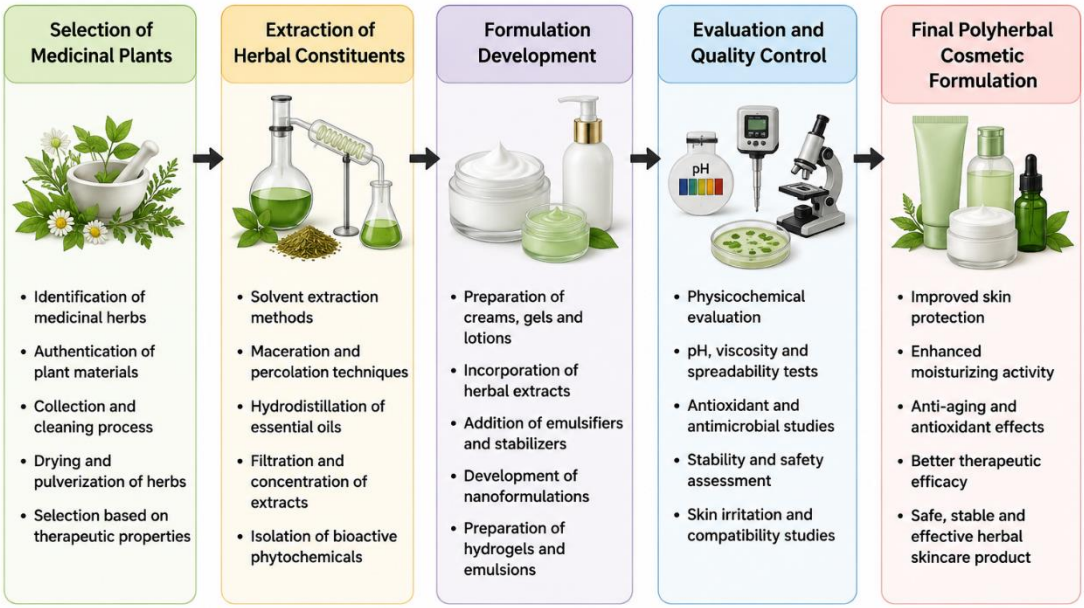

Figure 2 Formulation strategies for polyherbal cosmetics.

4.1 Creams

Creams are the most popular dosage forms because they are easy to apply, have a high patient acceptability rate, and are well-liked by consumers. Oil in water (O/W) or water in oil (W/O) emulsions are frequently used in their production. W/O creams offer superior moisturization and are recommended for dry skin conditions, while O/W creams are non-greasy and appropriate for usage during the day. Natural emulsifiers that are frequently used include lecithin, beeswax, and plant-based fatty acids[53].

4.2 Gels

Herbal gels are non-greasy, semi-solid solutions that have a cooling effect. They are particularly effective for oily, acne-prone skin. Gelling agents such as Carbopol, xanthan gum, and guar gum are used to provide the desired consistency. Because gels absorb quickly and are non-greasy, they improve patient compliance[54].

4.3 Lotions

Lotions are emulsions with low viscosity that can be applied to a wide range of surfaces. They're easy to distribute and refreshing. Herbal lotions are frequently used to moisturise and soothe irritated skin[55].

4.4 Emulsions

Emulsion-based approaches increase the delivery and stability of active phytoconstituents. The choice of emulsifying agents has a big impact on stability and shelf life[56].

Table 3 Types of Polyherbal Formulations and Their Characteristics.

S.NO	FORMULATION TYPE	CHARACTERISTICS	USES
1	Cream	Semi-solid, smooth texture, moisturizing, prolonged skin contact	Moisturizing, anti-aging, skin nourishment and protection
2	Gel	Non-greasy, transparent, cooling effect, rapid absorption	Acne treatment, oily skin care and anti-inflammatory applications
3	Lotion	Low viscosity, easy spreadability, refreshing and light consistency	Skin hydration, large area application and dry skin management
4	Emulsion	Stable mixture of oil and water phases with smooth consistency	Creams, lotions, moisturizers and sunscreen formulations
5	Nano formulations	Enhanced penetration, improved stability, controlled release of active constituents	Anti-aging, targeted delivery and improved therapeutic efficacy
6	Hydrogel	Water-rich polymeric network, cooling and sustained hydration	Wound healing, soothing effect and sensitive skin applications

4.5 Nano formulations:

Nanotechnology has changed the way herbal cosmetics are made. Liposomes, solid lipid nanoparticles, and nano emulsions increase the solubility, stability, and skin penetration of herbal active substances. These techniques enable both controlled release and targeted distribution[57,58].

4.6 Hydrogels:

Hydrogels are three-dimensional polymeric networks that have a great capacity to hold water. Because they offer long-lasting hydration, cooling effects, and prolonged release of herbal actives, they are ideal for wound healing and sensitive skin applications.

5. EVALUATION METHODS FOR POLYHERBAL COSMETICS

Polyherbal cosmetics must be evaluated to verify their quality, safety, stability, and efficacy. A variety of physicochemical, biological, and safety tests are performed.

5.1 Physical Evaluation:

The formulated polyherbal cream was further evaluated by the following:

5.1.1 Appearance and Odor

A number of physical characteristics of the polyherbal cream were assessed, such as colour, odour, consistency, appearance, and formulation state. The prepared formulation's acceptability and general quality are assessed using these measures. The cream was examined visually to make sure it had a smooth appearance and a consistent texture.

5.1.2 Homogeneity

Both visual inspection and light touch were used to evaluate the homogeneity of the cream formulation. To guarantee that the ingredients were distributed evenly throughout the formulation, the manufactured cream was examined for the presence of aggregates, lumps, or coarse particles.

5.1.3 pH Determination

A clean beaker was filled with 100 millilitres of distilled water and a precisely weighed 5 grams of the herbal cream. A glass rod was used to thoroughly agitate the liquid, and it was then let to stand at room temperature for two hours. Using a calibrated digital pH meter and standard buffer solutions with pH values of 4.0, 7.0, and 9.2, the formulation's pH was determined. The stabilized reading was recorded when the electrode was submerged in the sample. The process was carried out three times, and the average pH value was determined.

5.1.4 Spreadability

A weight of 125 g was applied for five minutes to compress around 1 g of cream between two glass slides to a consistent thickness. The higher slide was subsequently given more weight, and the time it took for it to pass over the lower slide was recorded. The following formula was used to calculate spreadability:

$$S = \frac{M \times L}{T}$$

Where:

S = Spreadability

M = Weight tied to the upper slide

L = Length moved by the glass slide

T = Time taken to separate the slides completely

The shorter the separation time, the better the spreadability of the formulation.

5.1.5 Viscosity

The prepared cream's viscosity was measured with a Brookfield viscometer. To ensure consistency, a clean beaker was filled with an adequate amount of cream and gently stirred. After carefully submerging Spindle No. 7 in the sample, the readings were taken once it had stabilised. The average viscosity was reported in centipoise (cps) after the tests were made three times.

5.1.6 Irritancy Test

On the left hand's dorsal surface, a 1 cm^2 area was designated for the irritancy test. A little amount of cream was applied to the designated area, and it was monitored for erythema, oedema, itching, or irritation at regular intervals for a whole day. Any skin reaction that was apparent was noted.

5.1.6 Washability Test

A small amount of the cream was applied to the skin, and it was rinsed with water to determine how washable it was. It was noted how easy it was to remove the cream from the skin's surface.

5.1.7 Dye Test

The cream was combined with a water-soluble red dye to conduct the dye test. A tiny amount of the cream was put on a glass slide, covered with a cover slip, and examined under a microscope. The kind of emulsion created in the cream formulation can be ascertained with the use of this test.

5.1.8 Phase Separation

The made cream was kept out of direct sunlight and at room temperature in a sealed container. For thirty days, the formulation was monitored on a regular basis to look for indications of instability, phase separation, or cracking.

5.1.9 Stability Study

ICH criteria were followed for conducting stability testing of the polyherbal cream under various storage settings. To guarantee product stability and shelf life, the formulation was assessed for variations in physical appearance, pH, viscosity, homogeneity, and phase separation during the study period.

Stability experiments are carried out in a variety of environmental variables, including as temperature, humidity, and light exposure, in order to assess shelf life[61,62]. The evaluation techniques are shown in Table 3 and Figure 3

5.2 Biological Evaluation :

To assess the effectiveness of a treatment, biological tests are carried out:

5.2.1 Antioxidant activity:

The polyherbal formulation's antioxidant activity and capacity to scavenge free radicals were assessed using DPPH, ABTS, and FRAP tests. These tests measure the herbal components' capacity to counteract the reactive oxygen species that cause oxidative stress and cellular damage. Strong antioxidant action aids in reducing damage from UV rays and environmental contaminants, wrinkles, pigmentation, and early ageing of the skin. The formulation's antioxidant capacity is greatly increased by the presence of flavonoids, phenolics, and anthocyanins.

5.2.2 Anti-inflammatory activity:

Enzyme inhibition and protein denaturation methods were used to assess the formulation's capacity to lessen skin irritation and inflammation. Herbal extracts' anti-inflammatory properties aid in reducing redness, swelling, itching, and irritation brought on by a variety of skin conditions. Proteins are stabilized against inflammatory damage when protein denaturation is inhibited. These investigations support the polyherbal formulation's calming and protecting properties for inflammatory and sensitive skin.

5.2.3 Antimicrobial activity:

Evaluated against common skin pathogens utilising appropriate microbial culture techniques, such as zone of inhibition or agar well diffusion. Microorganisms that are frequently linked to skin infections, acne, and other dermatological problems were tested against the formulation. The presence of phytochemicals such terpenoids, alkaloids, flavonoids, and tannins is primarily responsible for the antibacterial efficacy. This investigation aids in determining the formulation's capacity to prevent microbial development while preserving skin protection and cleanliness.

5.2.4 Cytotoxicity studies: Evaluated the formulation's safety and cell viability using the MTT test on appropriate cell lines. The MTT assay assesses the cytocompatibility of the herbal formulation and gauges the metabolic activity of living cells. Increased cell viability suggests that the formulation is safe to apply topically to the skin and is not harmful. For polyherbal cosmetic products to be safe, biocompatible, and therapeutically acceptable, cytotoxicity studies are crucial[63,64].

5.3 Safety and Functional Evaluation

For polyherbal cosmetic compositions to be efficacious, stable, and suitable for topical application, safety and functional evaluation are crucial. These investigations aid in determining whether the formulation is safe to use on a regular basis without producing skin irritation or negative reactions.

To evaluate the formulation's quality and safety, a number of tests are frequently carried out, including skin irritation studies, patch testing, microbiological limit tests, and SPF evaluation. Studies on skin irritation and sensitivity are conducted to assess erythema, itching, oedema, or allergic responses following skin application of the formulation. Patch testing on human volunteers aids in determining the product's consumer acceptance and dermatological compatibility. To guarantee the absence of dangerous bacteria and preserve microbiological safety during storage, microbial limit tests are carried out.

- Tests for sensitivity and skin irritation.
- Human volunteers for patch testing.
- Calculating SPF for sunscreen formulas.
- Tests for microbial limits to guarantee product safety[65,66].

Consumer safety and regulatory approval depend on these assessments

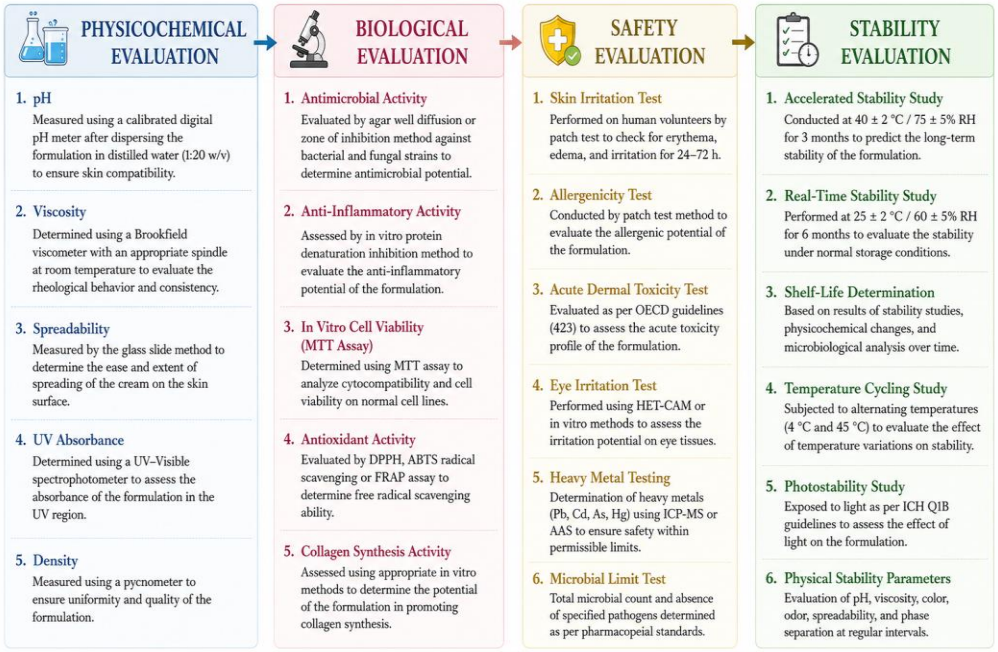

Figure 3 Evaluation workflow for quality, safety, and efficacy of polyherbal cosmetics.

6. THERAPEUTIC APPLICATIONS OF POLYHERBAL COSMETICS

Because several bioactive phytoconstituents found in medicinal plants work in concert, polyherbal cosmetics have a variety of therapeutic advantages[67]. Because of their anti-inflammatory, moisturizing, antioxidant, antibacterial, and photoprotective properties, these compositions are frequently utilised in skincare products. Polyherbal formulations offer greater therapeutic efficacy and better skin compatibility with fewer side effects than synthetic cosmetics[68].

6.1 Anti-aging Applications

Antioxidant-rich polyherbal cosmetic compositions counteract free radicals produced by environmental stress and UV radiation, hence reducing the indications of premature ageing. Skin elasticity and firmness are enhanced by phytochemicals such flavonoids, phenolics, anthocyanins, and vitamins that shield collagen and elastin fibres from oxidative damage. Frequent use of herbal anti-aging formulas helps minimize dryness, photoaging, wrinkles, and fine lines. Because of their revitalizing qualities, medicinal herbs including Clitoria ternatea, turmeric, aloe vera, and rose are frequently used in anti-aging remedies[69].

6.2 Moisturizing Effects

Aloe vera, cucumber, plant oils, and extracts rich in polysaccharides are examples of herbal substances that support skin hydration and moisture balance. These organic humectants

reinforce the skin's barrier function and increase the skin's ability to retain water. Polyherbal moisturizers give dry and injured skin softness, smoothness, and nourishment while preventing transepidermal water loss. These compositions are ideal for sensitive skin applications because of their calming properties[70].

6.3 Skin Brightening Activity

By preventing melanin formation and decreasing hyperpigmentation, a number of herbal extracts have the ability to lighten and depigment the skin. Natural phytoconstituents including curcumin, flavonoids, and vitamin C enhance skin tone and improve skin complexion. Without the negative side effects of synthetic skin-whitening chemicals, polyherbal formulations aid in the reduction of dark spots, blemishes, tanning, and dullness. Extracts of lemon, turmeric, sandalwood, and rose are frequently used to enhance the complexion and shine of the skin[71].

6.4 Anti-acne Activity

Acne and other skin infections can be effectively treated using polyherbal cosmetics that contain antibacterial and anti-inflammatory herbs. Tulsi, tea tree, and neem are examples of medicinal plants that prevent the growth of bacteria that cause acne and lessen inflammation in acne lesions. These formulas reduce skin irritation, regulate excess sebum production, and aid in the healing of skin prone to acne. Phytochemicals' antimicrobial and calming properties enhance skin health overall and lessen acne recurrence[72].

6.5 Photoprotective Effects

Flavonoids, phenolic chemicals, and anthocyanins are found in polyherbal preparations that offer protection against UV radiation. These phytochemicals lessen oxidative damage brought on by extended sun exposure by absorbing UV radiation. Sunburn, skin pigmentation, collagen deterioration, and early ageing can all be avoided with the use of herbal photoprotective substances. Additionally, natural antioxidants strengthen skin defence systems and lessen reactive oxygen species produced by UV radiation[73].

6.6 Wound Healing and Soothing Effects

Numerous therapeutic herbs with wound-healing and skin-soothing qualities are used in polyherbal cosmetics. Herbal components promote cell proliferation, collagen synthesis, and tissue regeneration, which speeds up the healing of damaged skin and wounds. In addition to encouraging healthy skin regeneration, aloe vera, rose, and neem extracts help lessen redness,

irritation, and inflammation. These formulas are particularly helpful for skin issues that are damaged, inflamed, or sensitive[74].

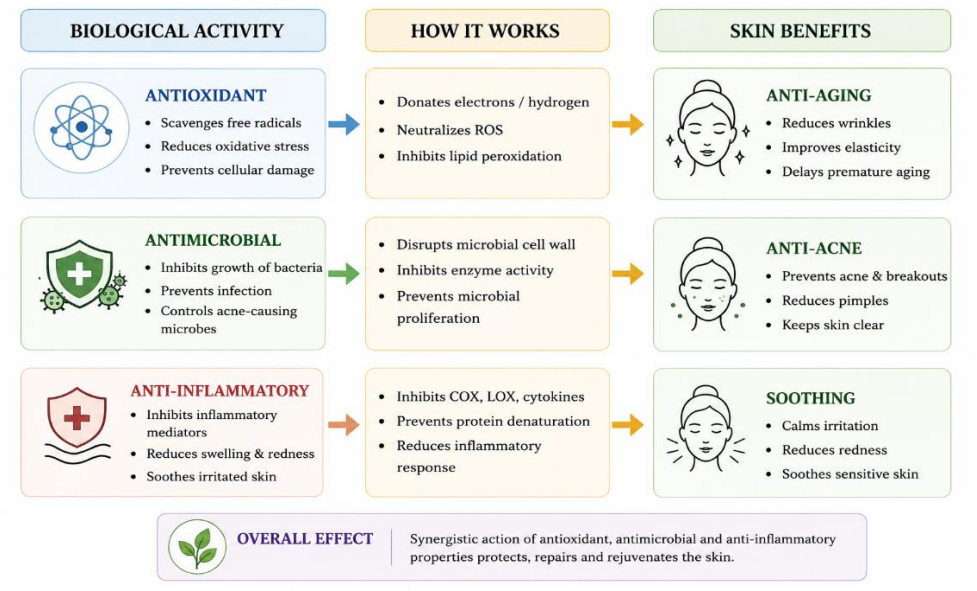

Figure 4 Therapeutic actions of polyherbal cosmetics.

7. RECENT ADVANCES IN POLYHERBAL COSMETICS

The effectiveness, stability, and therapeutic performance of polyherbal cosmetic formulations have been greatly enhanced by recent technological advancements. Enhancing the bioavailability, controlled release, skin penetration, and long-term stability of herbal active ingredients are the main goals of contemporary formulation techniques. The use of herbal cosmetics in the pharmaceutical and cosmetic sectors has increased thanks to sophisticated medication delivery methods and formulations based on nanotechnology[75].

7.1 Nanotechnology-Based Systems

By enhancing the delivery of potent phytoconstituents into the skin's deeper layers, nanotechnology has transformed herbal cosmetic compositions. Herbal drugs' solubility, stability, and absorption are improved by liposomes, solid lipid nanoparticles, nanostructured lipid carriers, and nanoemulsions. These approaches lessen the discomfort and instability that come with traditional formulations while increasing therapeutic efficacy. Additionally, nanoformulations increase the duration of action by releasing active ingredients in a regulated and sustained manner.

7.2 Liposomal Drug Delivery Systems

Modern herbal cosmetics frequently use liposomal systems to encapsulate and deliver active herbal elements in a targeted manner. Phytoconstituents are shielded by liposomes from environmental deterioration brought on by oxidation, light, and temperature. These vesicular carriers increase the bioavailability at the target site and enhance the penetration of herbal actives across the epidermal barrier. Additionally, liposomal formulations improve the stability of delicate herbal ingredients and lessen their toxicity[76].

7.3 Hydrogel-Based Formulations

Hydrogels are three-dimensional networks of polymers that can hold a lot of water and keep you hydrated for a long time. Herbal hydrogels are ideal for applications involving sensitive skin and wound healing because of their cooling, calming, and oisturizing properties. Because these systems are pleasant and non-greasy, they enhance patient compliance and offer prolonged release of herbal actives. The usage of hydrogel formulations in skin healing, anti-aging, and anti-inflammatory therapies is growing.

7.4 Smart Delivery Systems

The medicinal efficacy of polyherbal cosmetics has been increased through the development of sophisticated smart delivery technologies. These systems release active ingredients at the appropriate location in response to environmental cues such temperature, pH, and moisture variations. Targeted medicine distribution is improved and active compound waste is reduced with stimuli-responsive formulations. These cutting-edge methods enhance formulation efficacy and improve patient outcomes.

7.5 Green and Sustainable Formulation Approaches

Eco-friendly and sustainable formulation methods are becoming more and more popular in the modern herbal cosmetics industry. To lessen the influence on the environment, natural preservatives, biodegradable packaging, and green extraction techniques are being used. Product safety and sustainability are enhanced by the use of solvent-free extraction techniques and renewable plant resources. The development of green polyherbal cosmetics has been further spurred by consumer demand for natural and ecologically friendly goods[77].

8. SAFETY AND REGULATORY ASPECTS

The modern herbal cosmetics business is seeing an increase in the use of sustainable and eco-friendly formulation techniques. Green extraction methods, biodegradable packaging, and natural preservatives are employed to reduce the impact on the environment. Utilising renewable plant resources and solvent-free extraction methods improves product safety and sustainability. Consumer demand for natural and eco-friendly products has further fuelled the development of green polyherbal cosmetics[78].

8.1 Skin Irritation Test

To determine whether the formulation may result in erythema, oedema, itching, or irritation following topical application, skin irritation studies are carried out. Over a predetermined amount of time, the produced product is applied to a particular area of the skin and any observable reactions are monitored. The composition is dermatologically safe and appropriate for regular cosmetic usage when there is no irritation. Herbal components with calming and anti-inflammatory properties also aid in lowering irritation and enhancing skin compatibility.

8.2 Allergic and Sensitivity Reactions

Some essential oils and herbal components may cause hypersensitivity or allergic reactions in susceptible people. To ascertain the formulation's potential for allergies, patch testing and allergenicity tests are thus conducted. These investigations aid in identifying any negative immunological reactions brought on by extended exposure to cosmetic chemicals, such as redness, rashes, swelling, or itching. A thorough safety evaluation reduces the possibility of hypersensitive reactions and guarantees improved customer acceptance.

8.3 Microbial Safety Evaluation

Consumer safety, product stability, and quality can all be impacted by microbial contamination in cosmetic formulations. Because of the moisture and organic components, polyherbal compositions with natural substances may be more prone to microbial development. To find out if harmful microorganisms including bacteria, fungus, and yeast are present, microbial limit tests are performed. Maintaining microbiological safety and preventing product spoiling requires the use of suitable preservatives and hygienic manufacturing techniques.

8.4 Heavy Metal Analysis

Trace levels of heavy metals that have been absorbed from soil, water, or environmental contamination may be present in herbal raw materials. Heavy metals including lead, cadmium, mercury, and arsenic can have harmful effects on human health when present in excess. In order to guarantee that the concentration of these pollutants stays within acceptable

safety limits, heavy metal analysis is performed using established analytical procedures. Consumer protection, regulatory compliance, and product safety all depend on this assessment.

8.5 Cytotoxicity and Biocompatibility Studies

To assess the formulation's safety and biocompatibility at the cellular level, cytotoxicity tests are carried out using appropriate cell lines. Cell viability and metabolic activity following exposure to the herbal preparation are commonly assessed using assays like MTT. Improved compatibility with skin tissues and non-toxic nature are indicated by higher cell viability. These investigations support the safe topical application of polyherbal cosmetics.

8.6 Regulatory and Quality Considerations

Regulations and quality requirements set by national and international agencies must be followed by polyherbal cosmetic compositions. Commercialization necessitates proper labelling, ingredient standardization, microbiological safety, and stability testing. Consumer confidence, product performance, and product uniformity are all enhanced by standardizing herbal substances and following Good Manufacturing Practices (GMP)[78,79].

9. FUTURE PERSPECTIVES

Growing consumer awareness of natural and environmentally friendly skincare products is driving up demand for polyherbal cosmetics. Future research will primarily concentrate on enhancing the efficacy, stability, and safety of herbal cosmetic formulations through cutting-edge technologies like Nano formulations, liposomes, hydrogels, and controlled drug delivery systems. These contemporary approaches may improve skin penetration, bioavailability, and therapeutic performance of herbal active constituents. Standardization of herbal ingredients, quality control, and regulatory guidelines are crucial for guaranteeing the efficacy of polyherbal cosmetic formulations.

Polyherbal cosmetics are anticipated to have a significant impact on the pharmaceutical and cosmetic sectors in the future because of their many uses and few adverse effects. Polyherbal cosmetics have a promising future due to increased consumer knowledge and demand for natural products.

Key areas for future research include:

- Validation of clinical practice using human subjects
- Standardization of herbal formulations and extracts
- Finding the active phytoconstituents
- Innovation in distribution methods

- Combining nanotechnology with biotechnology

Furthermore, worldwide marketing and adoption of herbal cosmetics will be facilitated by the harmonization of global regulatory norms.

10. CONCLUSION

Polyherbal cosmetics have emerged as a promising alternative to synthetic cosmetic products due to their natural origin, therapeutic efficacy, and improved safety profile. The presence of bioactive phytochemicals such as flavonoids, phenolics, alkaloids, tannins, and terpenoids contributes to antioxidant, antimicrobial, anti-inflammatory, moisturizing, and anti-aging activities beneficial for skin health.

The synergistic action of multiple herbal ingredients enhances the effectiveness of the formulation while reducing adverse effects commonly associated with synthetic chemicals. Evaluation parameters including physicochemical analysis, biological studies, safety assessment, and stability studies are important for ensuring the quality and safety of the formulation.

Overall, polyherbal cosmetics provide a safe, effective, and sustainable approach for skincare applications and possess significant potential for future advancements in herbal cosmetic research and development.

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