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FORMULATION AND EVALUATION OF NOVEL ROOT BASED VEGETABLE SUNSCREEN PREPARATION

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ABSTRACT

The increasing awareness regarding the harmful effects of ultraviolet (UV) radiation has accelerated the demand for natural and herbal sunscreen formulations. Synthetic sunscreens are associated with adverse reactions such as skin irritation, phototoxicity, endocrine disruption, and environmental hazards. Therefore, the present study aimed to formulate and evaluate a novel beetroot-based herbal sunscreen preparation using natural phytoconstituents possessing antioxidant and photoprotective activity. Beetroot (*Beta vulgaris*) contains betalains, flavonoids, phenolic compounds, vitamin C, and carotenoids which contribute significantly toward UV absorption and free radical scavenging activity. In this study, ethanolic extract of beetroot was incorporated into cream formulations at varying concentrations. The formulations were evaluated for organoleptic characteristics, pH, viscosity, spreadability, washability, homogeneity, stability, skin irritation, antioxidant activity, and Sun Protection Factor (SPF).The optimized formulation exhibited acceptable physicochemical properties with good stability and skin compatibility. SPF values increased proportionally with extract concentration, indicating promising photoprotective potential. Antioxidant studies confirmed significant free radical scavenging activity due to the presence of betalains and polyphenols. The formulation demonstrated broad-spectrum UV protection and may serve as a safer alternative to synthetic sunscreen products. The results suggest that beetroot extract possesses considerable potential as a natural sunscreen active ingredient in cosmeceutical formulations.

KEYWORDS: Beetroot, Herbal sunscreen, SPF, Antioxidants, Betalains, UV protection, Natural cosmetics.

INTRODUCTION

Human skin is continuously exposed to environmental pollutants, chemicals, and ultraviolet radiation from sunlight, which can produce harmful effects on the skin. Ultraviolet radiation is one of the major causes of skin disorders such as erythema, sunburn, premature aging, pigmentation, wrinkles, and skin cancer. UV radiation is classified into UVA, UVB, and UVC rays according to wavelength. Among these, UVA and UVB rays penetrate the skin and generate reactive oxygen species that damage proteins, lipids, and DNA of skin cells. To prevent such harmful effects, sunscreen preparations are widely used as protective agents against ultraviolet radiation.

Sunscreens are topical formulations designed to absorb, scatter, or reflect ultraviolet radiation before it penetrates into deeper layers of skin. Conventional sunscreens mainly contain synthetic chemicals such as oxybenzone, octinoxate, and avobenzone. Although these synthetic agents provide protection against UV radiation, they are associated with several side effects including skin irritation, allergic reactions, hormonal imbalance, phototoxicity, and environmental toxicity. Continuous use of synthetic sunscreen products may also affect marine ecosystems and coral reefs. Due to these disadvantages, the demand for natural and herbal sunscreen products has increased significantly in recent years.

Herbal sunscreens contain plant-derived ingredients possessing antioxidant and photoprotective properties. Plant extracts rich in polyphenols, flavonoids, carotenoids, and vitamins are capable of scavenging free radicals generated by UV radiation and may provide natural UV protection. Herbal formulations are generally considered safer, biodegradable, eco-friendly, and compatible with human skin. Among various medicinal plants and fruits, beetroot (*Beta vulgaris*) has gained considerable attention because of its strong antioxidant and therapeutic properties.

Beetroot is a nutrient-rich root vegetable containing betalains, betacyanins, flavonoids, phenolic compounds, carotenoids, and vitamin C. These phytoconstituents possess antioxidant, anti-inflammatory, anti-aging, and photoprotective activities. Betalains present in beetroot are natural pigments capable of absorbing ultraviolet radiation and reducing oxidative stress in skin cells. The antioxidant activity of beetroot helps neutralize reactive oxygen species formed due to sunlight exposure, thereby minimizing skin damage and premature aging. Because of these beneficial properties, beetroot can be utilized as a natural sunscreen active ingredient in cosmetic and pharmaceutical formulations.

The present study focuses on the formulation development and evaluation of a novel beetroot-based sunscreen preparation. The study aims to prepare a stable, effective, and cosmetically acceptable sunscreen cream using beetroot extract and to evaluate its physicochemical characteristics, antioxidant activity, Sun Protection Factor (SPF), stability, and safety for topical application.

Fig. no. 1: Beetroot.

Skin is the outer protective covering of the human body and is considered the largest organ of the body. It acts as a barrier between internal organs and the external environment. The skin protects the body from pathogens, chemicals, mechanical injuries, and harmful ultravioletradiation. It also helps regulate body temperature and prevents excessive water.

The skin consists of three major layers

Epidermis: The epidermis is the outermost layer composed mainly of keratinized cells. It provides the first line of defense against environmental damage.

Dermis: The dermis contains connective tissues, collagen fibers, sebaceous glands, sweat glands, nerves, and blood vessels.

Hypodermis: The hypodermis or subcutaneous tissue contains fat and connective tissue that provide insulation and cushioning.

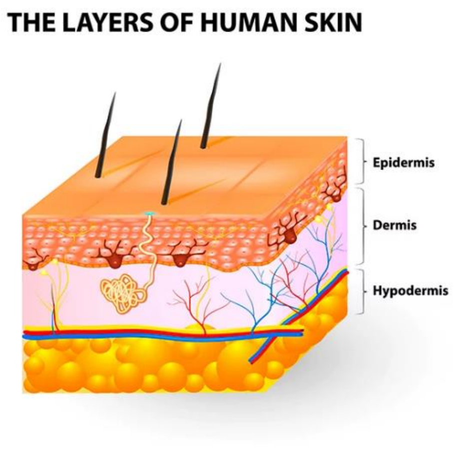

Fig. no. 2: Layers of skin.

Ultraviolet Radiation: Ultraviolet radiation is electromagnetic radiation emitted from sunlight. UV radiation is classified into three categories depending on wavelength.

UVA Radiation (320–400 nm): UVA rays penetrate deeply into the skin and are mainly responsible for:

- Skin aging
- Wrinkle formation
- Loss of skin elasticity
- Pigmentation

UVB Radiation (290–320 nm): UVB rays affect the epidermis and are responsible for:

- Sunburn
- DNA damage
- Erythema
- Skin cancer

UVC Radiation (200–290 nm): UVC rays are highly dangerous but are mostly absorbed by the ozone layer and do not reach the earth’s surface.

Harmful Effects of UV Radiation: Long-term exposure to UV radiation can produce several harmful effects such as:

- Premature skin aging
- Hyperpigmentation
- Sunburn
- DNA mutation
- Oxidative stress
- Suppression of immune response
- Melanoma and non-melanoma skin cancers

The generation of free radicals due to UV exposure is one of the major causes of skin damage.
Sunscreens: Sunscreens are topical formulations that help protect the skin from harmful ultraviolet radiation.
Sunscreens contain ingredients that absorb, reflect, or scatter UV rays before they penetrate the skin.

Classification of Sunscreens

Chemical Sunscreens: Chemical sunscreens absorb UV radiation and convert it into heat.

Examples

- Oxybenzone
- Octinoxate
- Avobenzone

Physical Sunscreens: Physical sunscreens reflect and scatter UV radiation.

Examples

- Zinc oxide
- Titanium dioxide

Herbal Sunscreens: Herbal sunscreens contain natural ingredients possessing antioxidant and photoprotective properties.

Examples

- Aloe vera
- Turmeric
- Green tea
- Beetroot

Limitations of Synthetic Sunscreens: Synthetic sunscreen agents are associated with several adverse effects including:

- Skin irritation
- Allergic reactions
- Hormonal disturbances
- Phototoxicity

- Environmental toxicity
- Coral reef damage

These limitations have increased demand for natural and herbal alternatives.

Herbal cosmetics are cosmetic products prepared using plant-based ingredients. They are widely accepted because they are safer, eco-friendly, biodegradable, and possess therapeutic benefits.

Advantages of herbal cosmetics

- Better skin compatibility
- Lower toxicity
- Antioxidant activity
- Reduced side effects
- Sustainable and eco-friendly

Beetroot as a Natural Sunscreen Agent**:** Beetroot (*Beta vulgaris*) is a root vegetable rich in natural pigments and antioxidants. It contains various phytoconstituents that may protect the skin against UV-induced damage.

Major constituents include

- Betalains
- Betacyanins
- Flavonoids
- Phenolic compounds
- Carotenoids
- Vitamin C

These compounds exhibit

- Antioxidant activity
- Anti-inflammatory action
- UV absorption
- Skin protective effects

Due to increasing concerns regarding the toxicity of synthetic sunscreen agents, there is a need to develop safer and natural sunscreen preparations. Beetroot possesses antioxidant and UV protective properties that may enhance photoprotection while reducing harmful side effects.

The present research focuses on the development and evaluation of a novel beetroot-based sunscreen preparation.

REVIEW OF LITERATURE

Several researchers have investigated the use of herbal ingredients in sunscreen formulations due to increasing concerns regarding the safety of synthetic sunscreen agents. Plant extracts rich in antioxidants and polyphenolic compounds have shown promising photoprotective properties against ultraviolet radiation. Herbal formulations containing green tea, turmeric, aloe vera, carrot, cucumber, and grape seed extracts have demonstrated considerable Sun Protection Factor values along with antioxidant activity.

Studies have shown that antioxidants play an important role in protecting skin against UV-induced oxidative stress. Ultraviolet radiation generates reactive oxygen species that damage cellular structures including proteins, lipids, and DNA. Antioxidants neutralize these free radicals and reduce skin inflammation, aging, and pigmentation. Polyphenols and flavonoids present in medicinal plants also absorb ultraviolet radiation and contribute to photoprotection.

Research on beetroot has revealed its significant antioxidant and anti-inflammatory activities due to the presence of betalains and phenolic compounds. Beetroot extract has been reported to possess free radical scavenging ability, anti-aging effects, and protective effects against oxidative stress. Recent studies on beetroot-based cosmetic preparations demonstrated improved SPF values and enhanced skin protection. Beetroot pigments such as betacyanins can absorb UV radiation and reduce photodamage in skin cells. Therefore, beetroot has emerged as a promising natural ingredient for sunscreen and cosmeceutical formulations.

Various herbal sunscreen creams developed by researchers exhibited good stability, spreadability, homogeneity, and skin compatibility. These findings support the use of natural ingredients in topical photoprotective formulations. The increasing consumer preference for herbal cosmetics further emphasizes the need for developing safe and effective plant-based sunscreen preparations.

DRUG PROFILE

Beetroot (*Beta vulgaris*)

Beetroot, scientifically known as *Beta vulgaris*, is one of the most important root vegetables widely used for nutritional, medicinal, and cosmetic purposes. It belongs to the family Chenopodiaceae and is commonly known as red beet, garden beet, or table beet. Beetroot is cultivated throughout the world and is highly valued because of its rich nutritional composition and therapeutic properties. The root portion of the plant is mainly utilized in food products, pharmaceutical preparations, nutraceuticals, and cosmetic formulations due to its high content of biologically active compounds. In recent years, beetroot has attracted considerable attention in pharmaceutical and cosmetic research because of its antioxidant, anti-inflammatory, antimicrobial, and photoprotective activities. The presence of natural pigments and polyphenolic compounds makes beetroot a promising ingredient for herbal sunscreen formulations and other skin care products.

The beetroot plant is a biennial herbaceous plant that grows well in cool climatic conditions. It possesses broad green leaves with reddish veins and a fleshy taproot that varies in shape from round to elongated. The root is usually dark red or purple in color due to the presence of betalain pigments. Beetroot is cultivated extensively in India, Europe, the United States, China, and several other countries. It is commonly consumed as a vegetable, juice, salad ingredient, or dietary supplement because of its nutritional value and health benefits. Besides its dietary uses, beetroot has become increasingly popular in herbal medicine and cosmetic science due to its natural antioxidant content and therapeutic potential.

Taxonomically, beetroot belongs to Kingdom Plantae, Division Magnoliophyta, Class Magnoliopsida, Order Caryophyllales, Family Chenopodiaceae, Genus *Beta*, and Species *vulgaris*. The biological source of beetroot is the fleshy root of *Beta vulgaris*. Different varieties of beetroot are cultivated worldwide depending on climatic conditions and agricultural practices. The root is the most valuable part of the plant and contains numerous phytochemicals responsible for its medicinal and cosmetic activities.

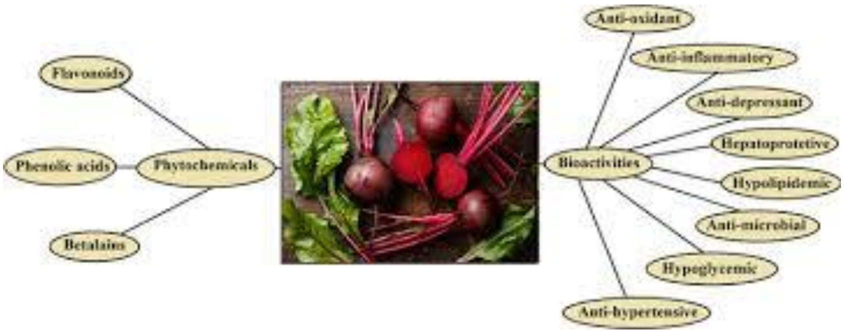

Fig. no. 3: Beetroot (*Beta vulgaris*).

Beetroot is rich in several bioactive compounds including betalains, betacyanins, flavonoids, phenolic compounds, carotenoids, nitrates, vitamins, minerals, amino acids, and dietary fibers. Among these constituents, betalains are considered the major active compounds responsible for the characteristic red-violet color of beetroot. Betalains are water-soluble nitrogen-containing pigments divided into two categories: betacyanins and betaxanthins. Betacyanins provide red to violet coloration, while betaxanthins provide yellow to orange coloration. Betanin is the most abundant betacyanin found in beetroot and possesses strong antioxidant activity. These pigments protect cells from oxidative stress by neutralizing free radicals generated within the body.

Flavonoids and phenolic compounds present in beetroot contribute significantly to its antioxidant and anti-inflammatory properties. Phenolic compounds help reduce oxidative damage caused by reactive oxygen species and improve skin protection against environmental stress. Flavonoids possess UV-absorbing ability and may contribute to photoprotection when incorporated into topical formulations. Carotenoids present in beetroot also exhibit antioxidant activity and protect skin cells against oxidative damage caused by ultraviolet radiation.

Beetroot contains several essential vitamins and minerals including vitamin C, vitamin A, folic acid, potassium, magnesium, calcium, phosphorus, iron, and zinc. Vitamin C is an important antioxidant that supports collagen synthesis, wound healing, and skin regeneration. It also helps reduce pigmentation and improve skin elasticity. Minerals present in beetroot contribute to various physiological processes and improve overall skin health. The presence of nitrates in beetroot enhances blood circulation and oxygen supply to tissues, thereby promoting healthy skin function.

The pharmacological activities of beetroot have been extensively studied by researchers. Beetroot exhibits strong antioxidant activity due to the presence of betalains and phenolic compounds. Antioxidants help neutralize reactive oxygen species and reduce oxidative stress responsible for aging and cellular damage. Beetroot also demonstrates anti-inflammatory activity by inhibiting inflammatory mediators and reducing tissue inflammation. In addition, beetroot possesses antimicrobial activity against certain microorganisms and may help prevent skin infections.

Fig. no. 4.

Beetroot is widely recognized for its hepatoprotective and cardioprotective activities. Studies have shown that beetroot extract may reduce blood pressure, improve cardiovascular function, and protect liver cells against oxidative damage.

The nitrate content of beetroot contributes to vasodilation and improved blood circulation. Furthermore, beetroot has been investigated for anticancer activity due to the ability of betalains to inhibit cancer cell proliferation and reduce oxidative stress associated with tumor development.

In cosmetic science, beetroot is increasingly used as a natural ingredient in formulations such as creams, lotions, lip balms, face packs, soaps, shampoos, and sunscreens. The natural pigments present in beetroot provide attractive coloration without the use of synthetic dyes. Beetroot extract is also used in anti-aging and skin-brightening products because of its antioxidant properties. The photoprotective potential of beetroot has made it an important ingredient in herbal sunscreen formulations. Betalains and polyphenols present in beetroot absorb ultraviolet radiation and reduce skin damage caused by UV exposure. The antioxidant activity of beetroot also helps minimize photoaging, pigmentation, and oxidative stress induced by sunlight.

The use of beetroot in sunscreen formulations offers several advantages over synthetic sunscreen agents. Natural sunscreen preparations containing beetroot are generally safer, biodegradable, eco-friendly, and less likely to cause irritation or allergic reactions. Beetroot-based formulations provide additional therapeutic benefits such as antioxidant protection, anti-aging effects, and skin nourishment. The increasing consumer preference for herbal and natural cosmetics has further encouraged the use of beetroot in topical photoprotective formulations.

Various extraction methods are used to obtain beetroot extract for pharmaceutical and cosmetic applications. Common extraction methods include maceration, Soxhlet extraction, ultrasonic extraction, and solvent extraction using ethanol, methanol, or water. Ethanolic extraction is widely preferred because it efficiently extracts betalains, flavonoids, and phenolic compounds. The extract obtained is concentrated and incorporated into formulations depending on the desired application.

The safety profile of beetroot is generally considered favorable. Beetroot is widely consumed as a food product and is regarded as safe for human use. Topical formulations containing beetroot extract are usually non-irritant and well tolerated by the skin. However, stability of betalain pigments may be affected by environmental factors such as temperature, pH, oxygen, and light exposure. Therefore, proper formulation techniques and storage conditions are important to maintain the stability and effectiveness of beetroot-based cosmetic products. beetroot is a highly valuable natural ingredient possessing numerous pharmacological and cosmetic benefits. Its rich content of betalains, flavonoids, phenolic compounds, vitamins, and minerals contributes to its antioxidant, anti-inflammatory, and photoprotective activities. Beetroot extract has significant potential for use in herbal sunscreen formulations because of its ability to absorb ultraviolet radiation and protect skin against oxidative damage. The natural origin, safety, therapeutic benefits, and eco-friendly nature of beetroot make it an ideal candidate for the development of modern herbal cosmetic and pharmaceutical preparations

AIM AND OBJECTIVES

The primary aim of the present research work was to formulate and evaluate a novel beetroot-based sunscreen preparation possessing effective photoprotective and antioxidant properties suitable for topical application. The study was designed to develop a stable, safe, cosmetically acceptable, and herbal sunscreen formulation using beetroot (*Beta vulgaris*) extract as the natural active ingredient. The research focused on utilizing the antioxidant-rich phytoconstituents present in beetroot for protection against harmful ultraviolet radiation and oxidative stress induced by sunlight exposure.

The increasing incidence of skin disorders caused by ultraviolet radiation, along with the adverse effects associated with synthetic sunscreen agents, has created a growing demand for herbal and natural sunscreen products. Synthetic sunscreen chemicals may produce side effects such as skin irritation, allergic reactions, hormonal disturbances, phototoxicity, and environmental hazards. Therefore, the present study aimed to explore the potential of beetroot as a natural and eco-friendly alternative for sunscreen formulation development.

Beetroot is rich in bioactive compounds including betalains, flavonoids, phenolic compounds, carotenoids, and vitamin C, which possess strong antioxidant and anti-inflammatory activities. These phytoconstituents may help absorb ultraviolet radiation and neutralize free radicals generated due to UV exposure. The present investigation aimed to incorporate beetroot extract into a cream base and evaluate its suitability as a natural sunscreen preparation with enhanced therapeutic and cosmetic benefits.

Another important aim of the study was to determine the physicochemical stability and cosmetic acceptability of the prepared formulations. The sunscreen cream was intended to provide effective UV protection while maintaining desirable characteristics such as smooth texture, good spreadability, acceptable viscosity, skin compatibility, and ease of application. The study also aimed to determine the Sun Protection Factor (SPF) and antioxidant activity of the formulations to assess their photoprotective potential.

The research further aimed to contribute to the development of herbal cosmetic products by utilizing plant-based ingredients with minimal side effects and improved safety profile. The study emphasized the importance of natural antioxidants in protecting skin against oxidative stress, premature aging, pigmentation, and photo-induced skin damage. Through this investigation, an attempt was made to establish beetroot extract as a promising natural ingredient for pharmaceutical and cosmeceutical sunscreen formulations.

The objectives of the study included preparation of beetroot extract using suitable extraction methods, formulation of sunscreen cream with varying concentrations of beetroot extract, and evaluation of physicochemical parameters such as color, odor, texture, pH, spreadability, viscosity, washability, and homogeneity. The study also aimed to determine the antioxidant activity and Sun Protection Factor (SPF) of the prepared formulations and to assess their stability and safety for topical application.

OBJECTIVES

- To collect and authenticate fresh beetroot roots for the preparation of extract.
- To prepare beetroot extract using a suitable extraction method.
- To perform preliminary phytochemical screening of beetroot extract.
- To formulate herbal sunscreen cream containing different concentrations of beetroot extract.
- To evaluate the prepared formulations for physicochemical parameters such as color, odor, texture, homogeneity, pH, viscosity, spreadability, and washability.
- To determine the antioxidant activity of beetroot extract and sunscreen formulations using suitable methods.
- To evaluate the Sun Protection Factor (SPF) of the prepared formulations by spectrophotometric analysis.
- To conduct stability studies under suitable storage conditions.
- To perform skin irritation studies to assess the safety of the formulations for topical application.
- To compare different formulations and identify the optimized sunscreen preparation with maximum photoprotective activity and cosmetic acceptability.

MATERIALS AND METHODS

Materials

The present study was carried out using various natural and synthetic ingredients required for the formulation of a beetroot-based sunscreen cream. Fresh beetroot (*Beta vulgaris*) roots were used as the primary natural source for extraction of bioactive compounds. The beetroot was selected due to its high content of betalains, flavonoids, phenolic compounds, vitamin C, and other antioxidant constituents responsible for photoprotective activity.

The formulation of sunscreen cream required several excipients to develop a stable emulsion-based system. Stearic acid was used as an emulsifying agent and consistency enhancer. Cetyl alcohol was incorporated as a thickening agent and stabilizer, which also improved the texture of the formulation. Glycerin was used as a humectant to maintain skin hydration and improve moisturizing properties of the cream. Triethanolamine was used as a neutralizing agent to adjust the pH and assist in the formation of stable emulsions. Methyl paraben was used as a preservative to prevent microbial contamination and extend shelf life of the formulation. Distilled water was used as the aqueous vehicle for preparing the cream base.

Ethanol was used as a solvent for extraction of phytoconstituents from beetroot due to its efficiency in extracting both polar and semi-polar compounds. All chemicals used in the study were of analytical or cosmetic grade and were used without further purification.

Collection and Authentication of Plant Material

Fresh beetroot roots were collected from a local vegetable market. The collected samples were carefully inspected to ensure they were free from physical damage, fungal contamination, and spoilage. The plant material was washed thoroughly under running tap water to remove dirt, soil particles, and other impurities. The washed beetroot was then air-dried under shade conditions to prevent degradation of heat-sensitive phytoconstituents.

Authentication of beetroot was performed based on morphological characteristics and comparison with standard botanical references. The roots were identified as *Beta vulgaris* belonging to the family Chenopodiaceae. After authentication, the plant material was processed immediately for extraction to preserve the active constituents.

Fig. no. 5: Collection of Beetroot.

Preliminary Phytochemical Screening

The beetroot extract was subjected to qualitative phytochemical screening to identify the presence of various bioactive compounds responsible for its therapeutic activity. Standard chemical tests were performed for detection of flavonoids, alkaloids, phenolic compounds, tannins, glycosides, and betalains.

The presence of flavonoids was confirmed by color change reactions using alkaline reagent tests. Phenolic compounds and tannins were detected using ferric chloride test, which produced a characteristic dark coloration. Alkaloids were identified using Dragendorff's and Mayer's reagents, while glycosides were detected using specific hydrolysis-based tests. The presence of betalain pigments was confirmed by observing the deep red-violet coloration of the extract, which is characteristic of beetroot.

The results of phytochemical screening indicated that beetroot extract is rich in antioxidant and UV-absorbing compounds, making it suitable for sunscreen formulation development.

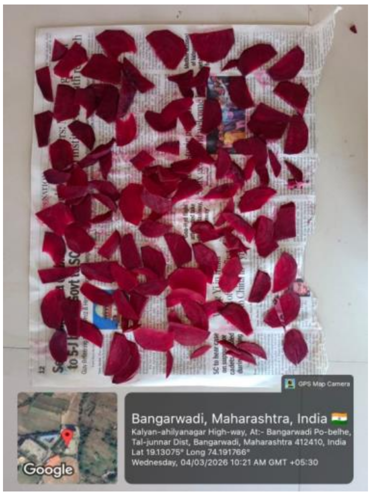

Fig. no. 6: Screening.

Preparation of Beetroot Extract

The extraction of bioactive compounds from beetroot was carried out using the maceration method. The air-dried beetroot was cut into small pieces and further dried in a hot air oven at a controlled temperature of approximately 40°C to remove residual moisture. The dried material was then ground into a coarse powder using a mechanical grinder.

Fig. no. 7: Beetroot Poweder.

A known quantity of powdered beetroot was accurately weighed and placed in a conical flask. Ethanol (95%) was added as the extraction solvent in sufficient quantity to completely immerse the plant material. The mixture was kept for maceration for 72 hours with occasional shaking to enhance the extraction process and ensure maximum diffusion of phytoconstituents into the solvent.

After completion of maceration, the mixture was filtered using muslin cloth followed by Whatman filter paper to obtain a clear filtrate. The filtrate was then concentrated using a rotary evaporator or by gentle heating on a water bath to remove excess solvent. A semi-solid concentrated beetroot extract was obtained and stored in an airtight container under refrigerated conditions until further use.

Fig. no. 8: Extraction.

Step-wise Procedure

1. Fresh beetroot was cut into small slices after proper cleaning.
2. The slices were dried in a hot air oven at 40°C until constant weight was achieved.
3. The dried material was pulverized using a mechanical grinder to obtain coarse powder.
4. A known quantity of powdered beetroot was weighed accurately and transferred into a clean conical flask.
5. Ethanol (95%) was added as solvent in sufficient quantity to completely immerse the powdered material.
6. The flask was tightly closed and kept for maceration for 72 hours at room temperature.
7. The mixture was shaken intermittently to enhance diffusion of phytoconstituents into the solvent.
8. After completion of extraction, the mixture was filtered using muslin cloth followed by Whatman filter paper.
9. The filtrate was concentrated using a water bath at controlled temperature to remove excess solvent.
10. A semi-solid beetroot extract was obtained and stored in an airtight container under refrigerated conditions for further use.

The obtained extract was dark red in color due to the presence of betalain pigments.

Standardization of Extract

The prepared beetroot extract was standardized to ensure consistency and quality before formulation. Standardization included determination of physical appearance, yield, and preliminary chemical characteristics.

The percentage yield was calculated using the formula:

$$\% \, Yield = \frac{Weight \ of \ Extract}{Weight \ of \ Raw \ Material} \times 100$$

The extract was also evaluated for color, odor, and solubility characteristics. The results confirmed the suitability of extract for cosmetic formulation development.

Formulation of Sunscreen Cream (Emulsion Method)

The sunscreen cream was formulated using the oil-in-water (O/W) emulsion technique. Different formulations were prepared by varying the concentration of beetroot extract to evaluate its effect on SPF and physicochemical properties.

Preparation of Phases

Oil Phase: Stearic acid and cetyl alcohol were weighed and melted together at approximately 70°C with continuous heating.

Aqueous Phase: Distilled water, glycerin, and triethanolamine were mixed and heated separately to the same temperature as the oil phase.

Emulsification Process: The oil phase was slowly added to the aqueous phase under continuous stirring using a mechanical stirrer. The mixture was stirred until a smooth and uniform emulsion was formed.

After emulsification, the system was allowed to cool to room temperature with continuous stirring to avoid phase separation.

Incorporation of Extract**:** Beetroot extract was incorporated into the base cream at different concentrations (e.g., 2%, 4%, and 6%) and mixed uniformly to ensure even distribution.

Packaging: The final formulations were transferred into clean, sterile containers and stored for further evaluation.

Fig. no. 9: Maceration.

EVALUATION PARAMETERS

The prepared beetroot-based sunscreen formulations were evaluated using a series of standard physicochemical, cosmetic, microbiological, and functional tests. These evaluations were performed to ensure the safety, stability, efficacy, and aesthetic acceptability of the formulation for topical application. Each parameter is described in detail below.

1. Physical Evaluation (Organoleptic Properties)

Physical or organoleptic evaluation is the initial and most important step in assessing cosmetic formulations. It provides information about the general appearance and user acceptability of the product.

Procedure: The prepared formulations were visually examined under normal daylight and artificial light conditions.

Parameters Observed:

- Color
- Odor
- Texture
- Consistency
- Appearance
- Phase separation (if any)

Observation: The beetroot-based formulations exhibited a characteristic reddish to deep pink color due to betalain pigments present in beetroot extract. The odor was pleasant and herbal in nature. The texture was smooth, non-gritty, and uniform, indicating proper emulsification. No phase separation or clumping was observed.

Importance: Physical evaluation ensures product acceptability by consumers and confirms successful formulation development.

2. pH Determination

The pH of a topical formulation plays a vital role in determining skin compatibility and stability of active ingredients.

Procedure:

- A 1% aqueous solution of the formulation was prepared.
- The pH was measured using a calibrated digital pH meter.
- The electrode was dipped into the solution and readings were recorded after stabilization.

Ideal Range: Skin-friendly pH range is between **4.5 to 6.5**

Significance:

- Prevents skin irritation
- Maintains skin barrier function
- Ensures stability of betalain pigments
- Improves formulation compatibility

Observation: The formulations showed pH within acceptable skin range, indicating suitability for topical use.

3. Viscosity Measurement

Viscosity determines the flow behavior and consistency of the cream formulation.

Instrument Used: Brookfield Viscometer

Procedure

- A fixed quantity of cream was placed in the sample container.
- Appropriate spindle was selected and rotated at different speeds.
- Viscosity values were recorded in centipoise (cP).

Importance

- Determines thickness of formulation
- Influences spreadability and application
- Affects product stability
- Controls release of active ingredients

Observation: The formulations showed moderate to high viscosity, indicating good consistency and stability.

4. Spreadability Test

Spreadability is an important parameter that determines how easily the cream spreads on the skin surface.

Procedure:

- A fixed amount of cream was placed between two glass slides.
- A known weight was placed on the upper slide.
- The time taken for the upper slide to move a fixed distance was recorded.

Formula:

$$S = \frac{m \times l}{t}$$

Where:

S = Spreadability

m = Weight tied to upper slide

l = Length of glass slide

t = Time taken to separate slides

Importance

- Ensures easy application
- Improves patient compliance
- Helps uniform distribution of sunscreen over skin

Observation: Formulations with higher beetroot concentration showed slightly improved spreadability due to better emulsion structure.

5. Homogeneity Test

Homogeneity test ensures uniform distribution of ingredients throughout the formulation.

Procedure

The formulation was visually examined and gently pressed between fingers to check for lumps or particles.

Observation

All formulations were smooth, uniform, and free from lumps, indicating proper mixing and emulsification.

Importance

- Ensures dose uniformity
- Prevents irritation due to uneven distribution
- Improves product stability

6. Washability Test

This test determines how easily the formulation can be removed from the skin surface.

Procedure

- A small quantity of cream was applied on the skin.
- After drying, it was washed with water.
- Ease of removal was recorded.

Observation

The formulations were easily washable with water without leaving greasy residue.

Importance

- Ensures user comfort
- Prevents clogging of pores
- Suitable for daily cosmetic use

7. Skin Irritation Test

Skin irritation study is essential to confirm the safety of topical formulations.

Procedure:

- A small amount of formulation was applied on a limited area of skin (usually forearm).
- The area was observed for 24 hours.
- Signs such as redness, itching, swelling, or inflammation were checked.

Observation: No irritation, redness, or allergic reaction was observed in any formulation.

Importance

- Confirms safety of herbal formulation
- Essential for cosmetic product approval
- Ensures compatibility with human skin

8. Stability Studies

Stability studies are performed to evaluate the physical and chemical stability of formulations under different environmental conditions.

Conditions Used:

- Room temperature
- Refrigeration temperature
- Elevated temperature (accelerated conditions)

Duration: Generally 1–3 months (or as per study design)

Parameters Observed

- Color change
- Odor change
- Phase separation
- Texture changes
- pH variation

Observation: No significant changes were observed, indicating good stability of the formulation.

Importance

- Ensures shelf life
- Maintains product quality

- Confirms long-term usability

9. Determination of Sun Protection Factor (SPF)

SPF is a key parameter used to evaluate the effectiveness of sunscreen formulations.

Method Used: UV spectrophotometric method (Mansur equation)

Procedure

- Formulation was diluted in suitable solvent.
- Absorbance was measured in UV range (290–320 nm).
- SPF was calculated using standard formula.

Formula

$$SPF = CF \times \sum EE(\lambda) \times I(\lambda) \times Abs(\lambda)$$

Where

CF = Correction factor

EE = Erythemal effect spectrum

I = Solar intensity spectrum

Abs = Absorbance of sample

Importance

- Measures UV protection capacity
- Indicates effectiveness of sunscreen
- Helps compare formulations

Observation: SPF increased with higher concentration of beetroot extract due to increased betalain content.

Antioxidant Activity (DPPH Method)

This test evaluates the ability of the formulation to neutralize free radicals.

Principle: DPPH is a stable free radical. Antioxidants reduce DPPH, causing a color change from purple to yellow.

Procedure

- Sample was mixed with DPPH solution.
- Incubated in dark for 30 minutes.
- Absorbance was measured at 517 nm.

Formula

$$\%\ Inhibition = \frac{A_0 - A_1}{A_0} \times 100$$

Where

A_0 = Control absorbance

A_1 = Sample absorbance

Importance

- Indicates antioxidant capacity
- Protects skin from oxidative stress
- Reduces aging and pigmentation

Observation: High antioxidant activity was observed due to betalains and flavonoids.

RESULTS AND DISCUSSION

The prepared beetroot sunscreen formulations showed satisfactory physicochemical characteristics and cosmetic acceptability. Organoleptic evaluation revealed smooth texture, uniform appearance, pleasant odor, and good consistency. The formulations remained stable without any phase separation or color change during storage.

The pH values of formulations ranged within skin-compatible limits, indicating reduced chances of irritation upon topical application. Spreadability and viscosity studies confirmed good application properties and ease of use. Washability studies showed that the formulations could be easily removed from the skin surface.

The antioxidant study demonstrated significant free radical scavenging activity due to the presence of betalains and phenolic compounds in beetroot extract. Increased concentration of beetroot extract resulted in higher antioxidant activity and SPF values. The optimized formulation exhibited promising SPF, indicating effective protection against ultraviolet radiation.

The results confirmed that beetroot extract can serve as a natural sunscreen active ingredient with antioxidant and photoprotective benefits. The formulation may provide a safer alternative to synthetic sunscreen products.

CONCLUSION

The present study successfully formulated and evaluated a novel beetroot-based sunscreen preparation with significant antioxidant and photoprotective properties. Beetroot extract was effectively incorporated into sunscreen cream formulations, and the prepared formulations exhibited satisfactory physicochemical characteristics, stability, and cosmetic acceptability.

The antioxidant activity and SPF values increased with increasing concentration of beetroot extract, demonstrating its effectiveness as a natural UV protective agent. The formulations were non-irritant, stable, and suitable for topical application. The study concluded that beetroot extract possesses considerable potential for use in herbal sunscreen and cosmeceutical formulations as a safer and eco-friendly alternative to synthetic sunscreen agents.

FUTURE SCOPE

Further research may be carried out to improve the effectiveness and commercial applicability of beetroot-based sunscreen formulations. Nanoformulation techniques may be utilized to enhance penetration, stability, and SPF values. Clinical studies involving human volunteers can be conducted to evaluate long-term safety and efficacy. Combination of beetroot extract with other herbal UV filters or physical sunscreen agents may provide broader spectrum protection. Commercial development of natural sunscreen products using beetroot extract may contribute to the growing demand for herbal and sustainable cosmetic formulations.

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