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Research Paper

Formulation And Evaluation of Sunscreen for UV Protection

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ABSTRACT

Recently, many people have experienced sun tanning and skin darkening. Sun tanning can lead to sunburn, redness, weakened immunity, premature aging, and even skin cancer. Because skin is delicate, this study aimed to develop a cream that offers both sun protection and skin-brightening benefits, while being easy to use and minimizing side effects. Oxybenzone is known to protect against UVB rays. This research evaluates the sunscreen effect of oxybenzone and the skin-brightening effect of Arbutin. The chemical ingredients were first tested for quality, including color, odor, pH, melting point, residue after burning, moisture loss, and purity. Several cream bases were tried, and three were evaluated. Based on pH, thickness, and appearance, the second base (B2) was chosen to add the active ingredients. A cream with 6% Oxybenzone and 1.5% Arbutin was selected for further testing. Observations showed that the cream improved skin tone, made the skin softer, and was easy to apply. Therefore, it may be used as both a sunscreen and a fairness cream.

INTRODUCTION

Skin is the outermost and largest part of the body, and it is most sensitive to photodamage because it is directly exposed to solar radiation and other environmental factors. The harmful effects of solar radiation are usually caused by the ultraviolet (UV) region of the electromagnetic spectrum, which can be divided into three regions: UVA(320-400nm), UVB (290-320nm), and UVC (200-290nm). UVC radiation is filtered out by the

ozone layer before reaching Earth. UVA and UVB radiation are not completely filtered out by the ozone layer and are responsible for the damage due to sunburn and premature aging of the skin[1]. Exposure to UV radiation can result in various detrimental effects on the eyes, skin, and immune system. Extended contact with UV rays may trigger the generation of reactive oxygen species, leading to oxidative damage and disruption of the antioxidant defense mechanism. These damages hinder the skin's metabolic processes, resulting in

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issues such as photoaging, redness, swelling, sunburn, fine lines and wrinkles, increased sensitivity to light, immunosuppression, DNA harm, and in extreme cases, skin cancer. [2]. As a result, various sunscreen ingredients are commonly included in numerous cosmetic products like creams, lotions, moisturizers, and other skincare items [3]. The primary function of sunscreen is to shield the skin from UVA and UVB rays while helping to maintain the skin's moisture levels and its natural oils, which can be depleted through exposure to sunlight [4]. The sunscreen must be effective, stable in terms of chemistry, gentle on the skin, safe for use, and resistant to breakdown from sunlight [5]. The skin produces its own natural sun protection, including squalane, proteins, absorbing lipids, and nucleotides, which have been utilized for many years. Squalane helps safeguard the skin's delicate lipids. Allantoin, which is derived from the breakdown of purine nucleotides, is also included [6] Substance that is found naturally within the body can absorb various UV radiation wavelengths; hence, it is incorporated into sun protection products and skincare lotions due to its capacity to heal small injuries and encourage healthy skin [7]. Phenolics, which consist of an aromatic ring with at least one hydroxyl group, demonstrate a diverse range of beneficial biological functions, including antiviral, antibacterial, immune-enhancing, antioxidant, anti-allergic, anti-hypertensive, antiarrhythmic, anti-thrombotic, liver-protective, cholesterol-lowering, anti-inflammatory, and anti-cancer properties. Flavonoids like quercetin, luteolin, and catechins have been shown to provide superior antioxidant effects compared to other antioxidants, such as vitamin C, vitamin E, and β -carotene, which are commonly found in various cosmetic products. Quercetin, apigenin, and rutin have been indicated to be effective against UVA and UVB radiation. Consequently, phenolics may be useful in mitigating UV-induced production of oxygen

free radicals and lipid peroxidation, both of which contribute to photoaging and the development of skin cancer[8]. The most frequently utilized herbs in cosmetology include aloe vera, basil, green tea, almond, olive, jojoba, and cucumber, among others. Photo protection against ultraviolet radiation can be assessed either in vivo or in vitro. For several years, the in vivo assessment through photo testing in human subjects has been employed. This method is complex, time-consuming, and expensive. As a result, researchers have created an in vitro method to evaluate the effectiveness of sunscreen. The in vitro test serves as a rapid, cost-effective screening technique [9].

Types of sunscreens:

The types of sunscreen are divided into two types. They are given below;[10][11]

- **Physical sunscreen**
- **Chemical sunscreen**

Physical sunscreen:-

- Physical sunscreens, often referred to as mineral sunscreens, function by forming a physical barrier on the skin that protects against the sun's rays. These sunscreens provide broad-spectrum defense by reflecting UV radiation away from your skin.
- Physical sunscreens include mineral components like titanium dioxide or zinc oxide that function by laying on the skin's surface to reflect harmful UV rays. Advantages: A smaller amount is necessary for skin protection since there is no chance of gaps between the sunscreen particles once applied
- "They create a physical barrier that redirects light rays away from the skin." The American Academy of Dermatology advises choosing a mineral sunscreen (rather than a chemical one) if your skin is sensitive or prone to acne.



Chemical sunscreen:-

- Chemical sunscreens penetrate the skin and absorb ultraviolet rays, transforming them into heat and then releasing them from the body. Active components in chemical sunscreens feature avobenzone, octinoxate, and oxybenzone. Physical sunblocks sit on the surface of the skin and reflect the sun's rays.
- "Chemical sunscreen refers to a type of SPF that utilizes active components to absorb sunlight, convert it into heat, and then expel that heat through the skin," explains Marino. Lancôme Bienfait UVSPF50+Super Fluid Facial Sunscreen is an example of a chemical sunscreen. Chemical sunscreens are also known as organic sunscreens, which is confusing, because that usually means "natural".

- The primary distinction between these categories of sunscreens is in their method of blocking rays. Physical (mineral) sunscreens rest on the skin's surface and function as a barrier, whereas chemical sunscreens absorb into your skin and operate more like a sponge. To put it differently, using either mineral or chemical sunscreen is significantly better than not using any at all for the sake of skin health. "The established advantages of applying a chemical sunscreen — lower risk of skin cancer, decreased chance of sunburn, and reduced skin aging — certainly surpass the hypothetical risks associated with absorption.

CLASSIFICATION OF SUNSCREEN PROTECTION:-

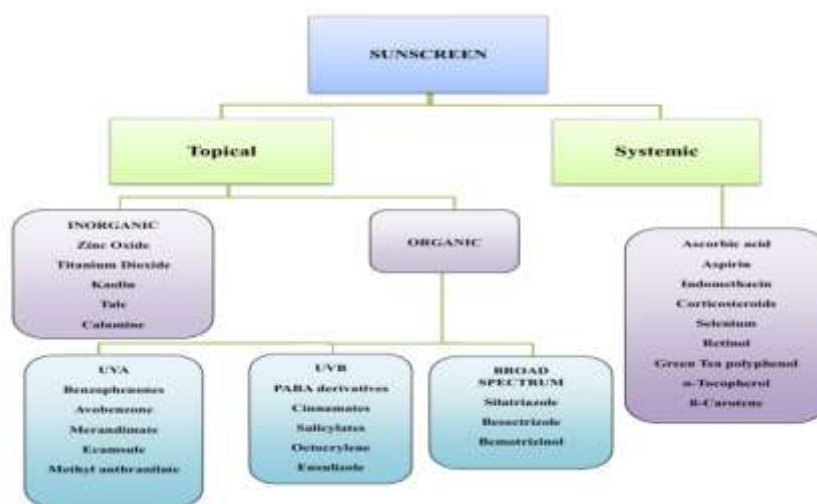


Figure 1 Classification of Sunscreen Protection

- **Topical sunscreen:-** Sunscreens are topical products, either physical or chemical, that diminish the passage of sunlight into the skin through absorption, reflection, or scattering. These topical sunscreens are meant to safeguard the skin by being applied directly to its surface.[12][13][14]
 - They are subdivided into two parts. They are given below:-

- **Inorganic Topical Sunscreen**
- **Organic Topical Sunscreen**

Inorganic Topical Sunscreen:-

Sunscreens are divided into inorganic sunscreens (often inaccurately termed 'physical'), such as zinc oxide and titanium dioxide, and organic sunscreens (also incorrectly labeled as 'chemical'). Contrary to common understanding, both types of sunscreens primarily function by absorbing UV

radiation. Some examples include zinc oxide, titanium dioxide, kaolin, talc, and calamine.[15]

Organic Topical Sunscreen:-

An “organic” sunscreen, by definition, contains carbon-based compounds such as oxybenzone, avobenzone, and octinoxate to reduce the effects of ultraviolet rays. This is what is meant by "organic chemistry," which focuses on the examination of molecules that have carbon structures and carbon-hydrogen connections.

➤ Organic topical sunscreens are subdivided into three parts. They are given below:- [16][17][18]

1. **UV-A Radiation:** This type of radiation falls within the ultraviolet spectrum, covering wavelengths from approximately 320 to 400 nm, and is responsible for skin tanning and contributing to skin aging. Some examples include Benzophenones, Avobenzone, Merandimate, Ecamsule, and Methyl Anthranilate, among others.
2. **UV-B Radiation:** This type of radiation falls within the ultraviolet spectrum, ranging from approximately 280 to 320 nm in wavelength, and is mainly accountable for causing sunburn, skin aging, and the onset of skin cancer. Examples include PABA derivatives,

cinnamates, salicylates, octocrylene, and ensulizole, among others.[19]

3. **Broad spectrum:** A broad-spectrum antibiotic is effective against a diverse array of organisms, including insects and bacteria. Broad-spectrum sunscreens protect the skin from ultraviolet radiation by absorbing or blocking both UVA and UVB rays. Examples include Silatriazole, Bemotrizinol, and Besoctrizole.[20]

- **Systemic Sunscreen:-** Sunscreens in this category are taken orally and demonstrate antioxidant properties, providing protection against harmful UV radiation. Some examples include Aspirin, Retinol, Selenium, Indomethacin, β -carotene, Ascorbic acid, and α -tocopherol, among others.[21]

➤ Grade Of Sun Protection:-

The UPF of sun protection is categorized in the following grades :[22]

Table 1 Grade of sunscreen protection

Grade	UPF
Good Protection	15to24
Very Protection	25to39
Excellent Protection	45to50+

THE HUMAN SKIN:-

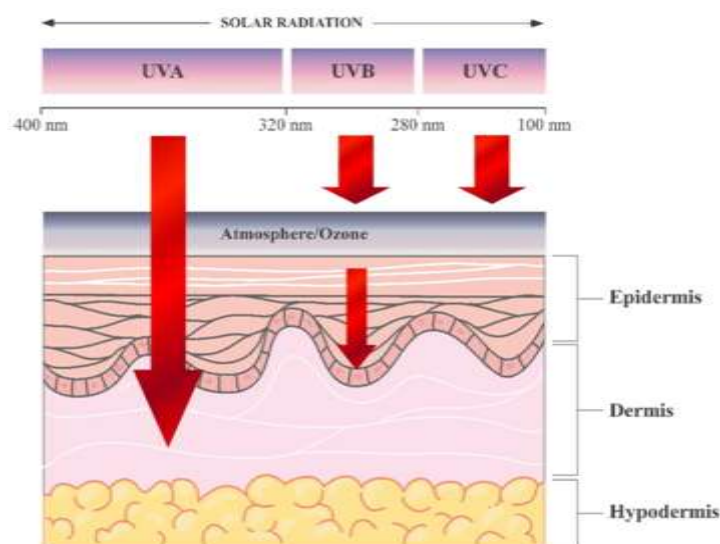


Figure 2 Skin layer anatomy illustrating UVA and UVB radiation penetration into skin layers

The skin constitutes 15% of an adult's overall body weight and is the body's largest organ. [23] Originating from the Latin term "integumentum," the integument refers to the external layer of skin composed of skin, hair, and nails. People can be identified by their skin and hair, along with the various layers of skin and adrenal glands, which encompass sweat glands, sebaceous glands, and hair follicles[24]. The skin comprises three primary layers: the epidermis, dermis, and hypodermis. While each layer has a specific function, the outermost layer mainly serves to guard against pathogens, ultraviolet light, chemicals, and physical pressures. Furthermore, it regulates temperature and the amount of water released into the environment[25].

a. **Epidermis:-** The outer layer is the epidermis. It serves to shield skin color by functioning as a barrier that repels water. Its main purposes are:

- Develop a new complexion.
- Specify the hue of your skin.
- Protect the body from external threats.

Every day, humans lose roughly 500 million skin cells. Actually, 2,630 layers of dead cells make up the outermost portions of the epidermis [26].

b. **Dermis:-** As a supportive layer, the dermis protects the body against tension and pressure. It also imparts elasticity and durability to the skin. Moreover, its main roles include:

- Oils and sweat
- Provide the skin with circulation and sensitivity.
- Hair development

The dermis can perform these functions because it contains blood vessels, lymphatic structures, and hair follicles. Several glands, including sweat glands, produce sebum, an oil that repels water and benefits hair.

c. **The hypodermis:-** The subcutaneous layer, also known as the subcutaneous tissue, is the innermost layer of the skin. While it assists in anchoring the skin to muscles and bones, it is not considered a part of the skin itself. Furthermore, the blood supply and nerves for the dermis originate from the subcutaneous tissue. This layer primarily consists of fat, connective tissue, and elastin, a protein that allows the skin to return to its original shape after being stretched. The dense layers of fat act as insulation, helping to retain heat and minimize heat loss. Additionally, the fat layer provides a protective function by cushioning the bones and muscles. [27]

The skin's function:-

- Keeping water and fats in storage
- Reducing water loss by stopping evaporation
- Defending against infections
- Sensation is produced by nerve endings that sense touch, pressure, temperature, and injury.
- By keeping nutrients from being removed from the skin, it provides water resistance.

ACTIVE INGREDIENTS OF SUNSCREEN:-

Mineral-based sunscreens, often referred to as sunblock, use titanium dioxide or zinc oxide as their active components and shield the skin by reflecting sunlight. Titanium dioxide is frequently a key ingredient in sunscreen due to its effectiveness as a UV filtering agent. [28]

- According to Terry Zickerman, founder of Love Sun Body, the UV filters in sunscreens serve as the active components that shield our skin from harmful UV rays. The inactive ingredients consist of the lotion that carries the UV filters. The active components may be chemical, mineral, or a mixture of various types.
- Chemical sunscreens function by absorbing the sun's rays, similar to how a sponge works. They contain one or more active ingredients



such as oxybenzone, avobenzone, octisalate, octocrylene, homosalate, or octinoxate.

- Oxybenzone, commonly included in broad-spectrum sunscreens, assists in blocking both UVB and short UVA rays. It is among the most widely used ingredients, present in most

sunscreens available in the U.S. market, and may account for up to 6 percent of the total product.

Active ingredients of the sunscreen and their concentration

Table 2 Active ingredients of sunscreen and their concentration

Active ingredients	Maximum concentration	Protection against UVA	Protection against UVB
Oxybenzone	6%(US)10%(AUS, EU)5%(JP)	Yes	Yes
Menthyl anthranilate	5%	Yes	No
Octyl methoxycinnamate	7.5%(US)10%(AUS, EU)20%(JP)	No	Yes
Sulisobenzene	5%(US)10%(AUS, EU,JP)	Yes	Yes
Titanium dioxide	25%(US)no limits(JP)	Yes	Yes
Zinc oxide	25%(US)	Yes	Yes
Avobenzone	3%(US)5%(EU, AUS)10%(JP)	Yes	No

FDA monograph of sunscreen ingredients with maximum concentration

Table 3 FDA monograph of sunscreen ingredients with maximum concentration

UV filter	Maximum concentration
Tinosorb M	10%
Tinosorb S	10%(EU, AUS)3%(JP)
TinosorbA2B	10%

WHAT IS SPF?

The sunscreen protection factor (SPF) is calculated by taking the amount of UV energy needed to cause a minimal erythema dose (MED) on skin that is protected and dividing it by the amount of UV energy required to create a MED on skin that is unprotected. [29]

SPF = $\frac{\text{MED in sunscreen - Protected skin}}{\text{MED in non-sunscreen-protected skin}}$

MED in non-sunscreen-protected skin

The MED is characterized as the minimum duration or amount of UV light exposure necessary to induce a slight, noticeable redness on unprotected skin. [30]

Sun Protection Factor (SPF):-

- SPF indicates the amount of solar energy (UV radiation) needed to cause sunburn on skin that is protected by sunscreen compared to the amount needed to cause sunburn on skin that is unprotected. As the SPF number rises, the level of sunburn protection also rises. [31]
- There is a common belief that SPF indicates the duration of sun exposure. For instance, many people think that if they usually get sunburned in one hour, using an SPF 15 sunscreen would let them stay in the sun for 15 hours (i.e., 15 times longer) without suffering from sunburn.



This is incorrect because SPF is not solely linked to the duration of sun exposure but rather to the total amount of solar energy received. While the total solar energy is influenced by the duration of exposure, various other factors also affect the amount of solar energy. For example, the strength of the solar energy plays a role in determining the amount. The following exposures could yield the same total amount of solar energy:

- 1 hour at 9:00 a.m.
 - 15 minutes at 1:00 p.m.
- On average, the duration of exposure to a given amount of solar energy is shorter at noon than in the early morning or late evening due to the higher intensity of sunlight at noon compared to those times. The intensity of solar energy also varies by geographic location, with lower latitudes experiencing higher solar intensity. Since clouds absorb solar energy, clear days generally have higher solar intensity than cloudy ones. [32]
- In addition to solar intensity, several other factors influence the amount of solar energy that a consumer is exposed to:
- Skin type
 - Amount of sunscreen applied.
 - Reapplication frequency
- Individuals with fair skin tend to absorb more solar energy than those with darker skin under similar conditions. The quantity of sunscreen applied also influences the level of solar radiation absorbed, as applying more sunscreen results in reduced solar energy absorption. Since sunscreens diminish in effectiveness over time, how often they are reapplied is crucial in minimizing solar radiation absorption. The frequency of application is further affected by the activities that individuals engage in. For instance, those who swim while wearing sunscreen need to reapply it more often, as water can wash the sunscreen off their skin. Moreover, engaging

in high levels of physical activity necessitates more frequent reapplication due to the possibility that the activity can physically remove the sunscreen and the potential for heavy sweating to wash it away. Generally, reapplying sunscreen more often is linked to a decrease in solar radiation absorption.[33]

- Due to the various factors affecting solar radiation, SPF does not indicate the duration one can remain in the sun without burning. In other words, SPF is not a measure of time spent in sunlight but rather a relative indicator of the sunburn protection offered by sunscreens. It allows consumers to compare the sunburn protection levels provided by different sunscreen products. For instance, consumers understand that SPF 30 sunscreens provide a higher level of sunburn protection compared to SPF 8 sunscreens.[34]

ADVANTAGES OF SUNSCREEN PROTECTION:-[35]

- Sunscreen aids in avoiding sunburns.
- Sunscreen lowers the risk of skin cancers.
- Sunscreen assists your body in defending against other dangers.
- Sunscreen is one of the most effective methods to prevent premature aging.
- Using sunscreen temporarily halts the formation of wrinkles and sagging skin.
- Sunscreen reduces UV damage to the skin.
- Regular application of sunscreen smooths the skin.
- Sunscreen helps to minimize discoloration.
- Utilizing sunscreen can aid in the prevention of melanoma and squamous cell carcinoma, both of which are forms of skin cancer.

DISADVANTAGES OF SUNSCREEN PROTECTION:-[36]

- Can lead to skin irritation, redness, itching, and swelling.



- Certain individuals may experience an allergic reaction to sunscreen.
- Extended use of sunscreen may result in a potential deficiency in vitamin D.

METARIALS AND METHOD

CHEMICALS

A fresh coconut was taken from the market and a pure coconut oil was extracted from it . Aloe vera was taken from Aloe vera plant for the requirement of gel in formulation and all other chemicals were obtained from the laboratories of Shree Dev Bhoomi Intitute of Education ,Science and Technology College, Dehradun. Triethanolamine was used as a neutralizer to adjust the pH. .All the chemicals used were of analytical grade. The chemicals used for formulation of cream base is given in figure number 2 .

- Coconut oil
- Cetyl Alochol
- Stearic Acid
- Triethanolamine
- Aloe vera gel
- Titanium Dioxide
- Ditilled Water
- Glycerine

Method Of Preparation Of Cream

1. Preparation of Oil Phase:

- Weigh the following ingredients accurately:
Coconut oil (5g), Cetyl alcohol (2.5g), Stearic acid (2.5g)
- Transfer them into a beaker.
- Heat the mixture on a water bath to 70-75°C with gentle stirring until all the ingredients are

completely melted and a clear solution is obtained.

2. Preparation of Aqueous Phase:

- In another beaker, take distilled water (1g) and heat it to 70-75°C.
- Add Triethanolamine (1g) to the hot water and stir until it is completely dissolved.

3. Emulsification:

- Slowly add the hot aqueous phase to the hot oil phase with continuous stirring.
- Stir the mixture using a mechanical stirrer or homogenizer for 5-10 minutes until a uniform emulsion (cream base) is formed.

4. Cooling Phase:

- Allow the emulsion to cool to about 40-45°C with continuous stirring.
- Add Aloe vera gel (5g), Glycerine (2g), and mix well until uniform.

5. Incorporation of Insoluble Ingredient:

- Disperse Titanium dioxide (1g) in a small amount of glycerine or water to form a smooth paste.
- Add this paste to the cream base with gentle stirring to ensure uniform distribution.

6. Final Mixing and Storage:

- Continue stirring until the cream cools completely to room temperature.
- Transfer the prepared cream base into a clean, air-tight container.
- Label it properly and store in a cool place.

Note: All glassware and equipment should be clean and dry before use.

Formulation of Cream Base

Table 4 Formulation of cream base

S.NO	Ingredients	Formulation(20g)
1	Coconut oil	5g
2	Cetyl alcohol	2.5g
3	Steraic acid	2.5g
4	Triethanolamine	1g



5	Aloevera gel	5g
6	Titanium dioxide	1g
7	Distilled water	1g
8	Glycerine	2g
	Total	20g



Figure 3 Sunscreen

Coconut oil :-

- There are many studies proving that coconut oil can help in blocking up to 20 percent of harmful sunlight. This is according to the SPF of 30 or higher provided by the American Academy of Dermatology, which blocks up to 97 percent of harmful sun rays.
- We understand that ultraviolet rays are harmful to us and cause skin cancer and aging skin. However, coconut oil blocks approximately 20 percent of the sun's harmful rays.
- There are many studies that prove that the SPF for coconut oil is 4.5, and there are antioxidants present in it, thus making it helpful to protect the skin from the sun's harmful radiation.

Cetyl Alcohol :-

- Cetyl alcohol is a substance used to stop separation between cream into oil and liquid components. The ingredient that assists in maintaining cohesion between liquid and oil components is referred to as the emulsifier and may also increase viscosity or foamability of the product.

- Cetearyl alcohol is absolutely safe for use in skincare products! In contrast to denatured alcohol or ethanol that causes drying effects on the skin, cetearyl alcohol is an emollient.

Stearic Acid:-

- The use of stearic acid in lotions and creams is very important as it provides the ability to thicken the lotion and makes its application on the body more glossy. Additionally, it provides a smooth and silky feeling once it is applied to the skin.
- Therefore, the use of stearic acid may help in building up the skin barrier. Anti-aging properties: By increasing the strength of the skin barrier, it also acts as an anti-aging component.

Triethanolamine: -

- Triethanolamine (TEA) is one of those ingredients which are present in most cosmetics like lotions, sunscreens, foundations, and creams. It works as a pH modifier or emulsification stabilizer so that cosmetics can work better. This ingredient does not exceed more than 1-3% in cosmetics because it is considered to be safe to use on the skin.
- Triethanolamine is used in surfactant production, for example, emulsifier.

Aloevera Gel:-

- The sole use of aloe vera may not be enough to protect oneself from sunlight because it has been found that an herbal preparation containing aloe vera with SPF 14-16 provides good protection in sunscreen lotions; however,

specialists advise us to use a product containing aloe vera along with at least SPF 30.

- Aloe vera gel is very famous for curing sunburn and wound healing. The use of aloe vera gel on the skin subjected to sun rays heals the skin affected by sunburn, redness, and inflammation.

Titanium Dioxide:-

- In sunscreen preparations, titanium dioxide generally comes in fine particles which increase its capacity to guard against harmful UVB rays. Fine particles will also make it more difficult to detect on skin surfaces, thus suitable for people with dark complexions.
- Mineral-based sunscreen uses nanoparticles of zinc oxide or titanium dioxide as active ingredients. Both titanium dioxide and zinc oxide were proposed by the FDA as safe and effective substances.

Distilled Water: -

- Distilled water acts as a solvent in cosmetics and personal care products since it dissolves a

number of ingredients which have skin benefits.

- Distilled water acts as a solvent in cosmetics and personal care products since it dissolves a number of ingredients which have skin benefits such as cleansing and conditioning agents.

Glycerine:-

- Sunscreen protects the skin from any harmful effects of UV rays. Glycerine may also be included in some sunscreens for moisturizing purposes and to facilitate easier spreading of sunscreen. Moisturizers: The outstanding property of glycerine lies in its moisturizing properties.
- The most widely known application of glycerin is its use as humectant. Humectants act by attracting moisture from air and thus moisturize the skin (some other commonly used humectants include hyaluronic acid and d-panthenol).

NOTE :- Thus these are the ingredients that I have used in making sunscreen protection formulation of cream base.



Figure 4 Images of the chemicals used in formulation of cream

EVALUATION OF CREAM

The cream's physicochemical characteristics, including color, scent, pH level, viscosity, spreadability, and thermal stability were assessed.

1. PH measurement :

One gram of cream was mixed with 9 milliliters of distilled water to measure the pH at 27° C utilizing a pH meter.[37]

2. Determination of viscosity :

Procedure: Viscosity of the formulation was determined by Brookfield Viscometer at 25 rpm, using spindle no. 647.[38]

3. Spreadability

The parallel plate method is the most commonly utilized technique for assessing the spreadability of semisolid formulations. A modified laboratory setup was employed to assess this property. The arrangement consists of two glass slides positioned on a tripod stand, with an excess of cream (3g) applied between them. The upper slide is movable while the lower slide is securely affixed to the stand. A weight of 100 g was placed on the slides for 5 minutes to compress the cream to a consistent thickness, and any excess cream was removed from the edges. Subsequently, a 50 g weight was added to one side of the slide, and the slide was drawn until it spanned a distance of 10 cm. The duration in seconds taken to separate the two glass slides by 10 cm was recorded as a measure of spreadability. A shorter duration suggests better spreadability. Spreadability was calculated using the following formula:

$$S = m * l / t$$

Where S = Spreadability, m = Weight attached to the upper glass slide, l = Length of the glass slide, and t = Time taken for separation.

4. Determination of thermal stability :

The cream was transferred into a glass bottle with the help of a spatula and tapped to settle to the

bottom. Filled up to two-thirds of the capacity of the bottle, the plug was inserted, and the cap was tightened. The filled bottle was kept in the incubator at 450 °C for 48 hr.[39]

5. Determination of in vitro:

SPF 1.0 g of cream formulation and commercial cream were weighed, transferred to a 100 ml volumetric flask, diluted to volume with ethanol and water (40:60), then sonicated for 5 minutes, filtered through Whatman No. 1 filter paper, and the filtrate was rejected, rejecting the first 10 ml of filtrate. 5.0 ml of aliquot was taken in 50 ml volumetric flask and diluted to volume with ethanol and water (40:60). Subsequently 5.0 ml of aliquot was transferred to 25ml volumetric flask and the volume completed with ethanol and water (40:60). The absorbance values of each aliquot prepared were determined from 290 nm to 320 nm at 5 nm interval, using ethanol and distilled water (40:60) solution as a blank. The readings were taken in triplicate, and the determinations were made at each point. The obtained absorbance values between 290 and 320 nm were multiplied by the respective $EE(\lambda)$ values. Their summation was taken and multiplied by the correction factor (10) to obtain the SPF values. Data were expressed as \pm standard error mean.[40]

6. Photo stability determination :

2 mg/cm² of each sunscreen cream was weighed and spread evenly between two plates of polis665hed fused quartz silica (thickness 5 mm and diameter 25 mm). To avoid absorption distortion, a thinner layer was applied. The AUC for UVA, UVA1(340–400nm), UVA2(320–340nm), and UVB was measured for each spectrum before (AUC before) and after (AUC after) UV artificial (980 kJ/m² UVA and 12 kJ/m² of UV radiation (UVB included) and before and after UV natural. If the AUCI (AUCI=AUC after/AUC before) was > 0.80, the sunscreen was



considered photostable. The AUC was calculated with the following equation ;

λ_{max}

$\sum A(\lambda)\Delta\lambda$

λ_{min}

Where A is absorption and λ is wavelength. It was measured in steps of 1 nm.

For UVA, $\lambda_{max} = 400$ nm and $\lambda_{min} = 320$ nm. The same measurement was done for every UV range, respectively, before and after UV artificial, and before and after UV natural.[41]

7. Determination of total fatty substance content :

Weighed 2 g of the material with 25 ml of dilute hydrochloric acid and refluxed until the solution was clear. The contents of the flask were cooled to room temperature. Add 50 ml of petroleum ether in portions of 10 ml and pour it into the separating funnel. The separating funnel was shaken well and left until the layers separated. Separated the aqueous phase and shook it with 50 ml portions of petroleum ether twice. Combined all the ether extracts and washed them with water until free of acid (when tested with methyl orange indicator solution). The petroleum ether extract was filtered through a filter paper containing sodium sulphate into a conical flask, which had been previously

dried at a temperature of 90 °C and then weighed. Washed the sodium sulphate on the filter with petroleum ether and combined the washings with the filtrate. Distilled the petroleum ether and dried the material remaining in the flask at a temperature of 90 °C up to constant mass.[42]

Total fatty substance % By mass = $M1/M2$

M1 Mass in g of the residue.

M2 =Massing of the material taken for the test.

8. Determination of fairness activity :

This study was an open, prospective, non-comparative phase III clinical trial. Cream was given to ten subjects (5 male and 5 female), aged between 18 and 45 years, for 4 weeks to carry out the subjective evaluation on the basis of their feedback. All the volunteers were followed up at weekly intervals for a period of 4 weeks, and the symptom score evaluation was done during each follow-up visit. Response to fairness cream was evaluated on a 5- point visual analogue scale (0- Nil, 1-Mild, 2-Moderate, 3-Good, 4-Excellent).[43]

RESULT

Physiochemical parameter of cream

Table 5 Showing physiochemical parameter of cream

Parameters	Base
Color	White
Odour	Odourless
pH	6.69
Spreadability	17.25±0.35

Monitoring the pH value is essential to know the stability of the product being formulated. Any alteration of pH value indicates there is a reaction occurred within the formulation, indicating the quality of the final product. Normal pH value of human skin is about 4.5 – 6.0. However due to constant cleansing using soaps, skin is deprived of

acid value. It is therefore necessary to use moisturizers with acid pH value. The recommended pH value for moisturizer is in the range of 5 – 8. pH values of cream formulations were in the range of 6.5-7.5, which is in the acceptable range and will not irritate skin. Therapeutic efficiency of the formulation depends



greatly on the spreadability of the cream. F3 had a greater spreadability than F1 and F2. Cream formulation is homogenous, emollient and easily spreadable.

Determination of In vitro SPF

SPF is a quantified measure of efficacy of sunscreen formulation. SPF determination for the

cream formulation of oxybenzone and arbutine was done using the in vitro SPF technique in the present study. The obtained SPF values are presented in Table and spectra of all formulations were obtained from 290nm-400nm and illustrated in Figure 1 & 2.

Sun Protection Factor (SPF) values for cream

Table 6 Sun Protection Factor (SPF) values for cream

Sample	wavelength	290	295	300	305	310	315	320	SPF
		EE(λ)XI(λ)							
F1	A	0.532	0.455	0.373	0.324	0.306	0.310	0.319	3.4 ±
	EE XIX A	0.0079	0.0371	0.1072	0.1062	0.0570	0.0260	0.0057	0.03
F2	A	0.555	0.456	0.366	0.312	0.291	0.292	0.300	3.36 ±
	EE XIX A	0.0083	0.0372	0.1051	0.1022	0.0542	0.0244	0.0054	0.03
F3	A	0.912	0.787	0.652	0.570	0.543	0.550	0.564	6.09 ±
	EE XIX A	0.0136	0.0642	0.1873	0.1868	0.1012	0.0461	0.0101	0.06

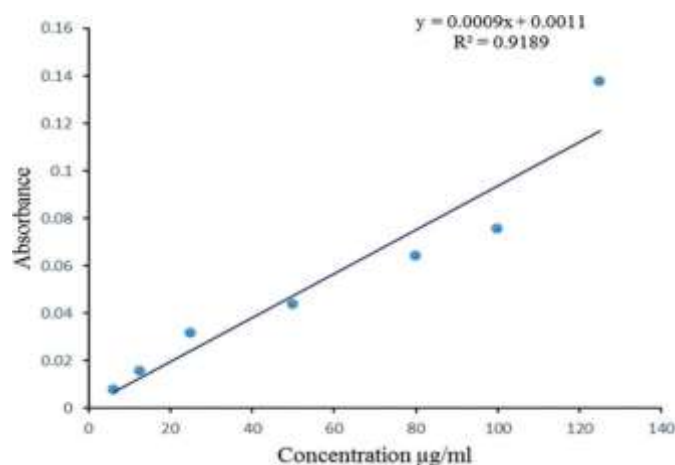


Figure 5 Absorbance concentration for SPF

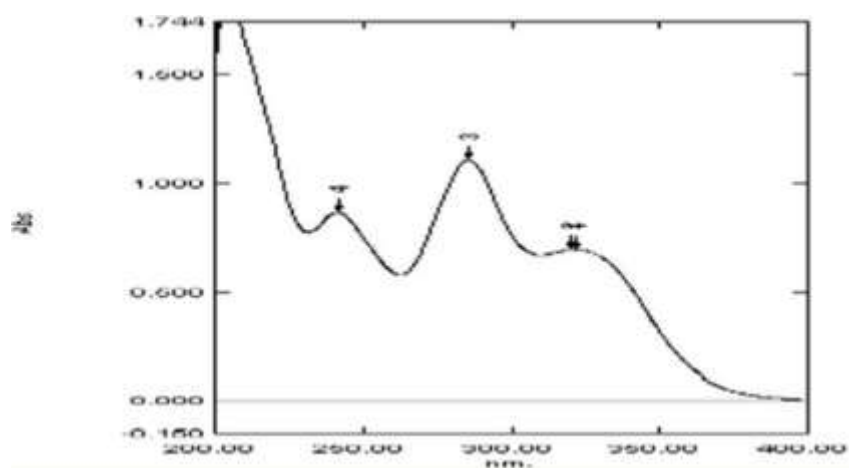


Figure 6 Absorbance spectrum of F3 for SPF

Determination of photo stability

The photo stability test was performed on all formulations of the sunscreen and revealed that the formulations are very stable. There is not much change in the spectrum of the samples kept in the plates before and after keeping in 50 oC for 20 mins. Photo unstable sunscreen starts degrading

when exposed to sunlight rapidly. It was revealed that after 120 mins of UV natural, AUCI value is less than 0.70 for sunscreen F1 and F2. So they are photounstable. But when the exposure was made of F3, it was found stable in both artificial UV and UV Natural. So F3 is considered photo stable.

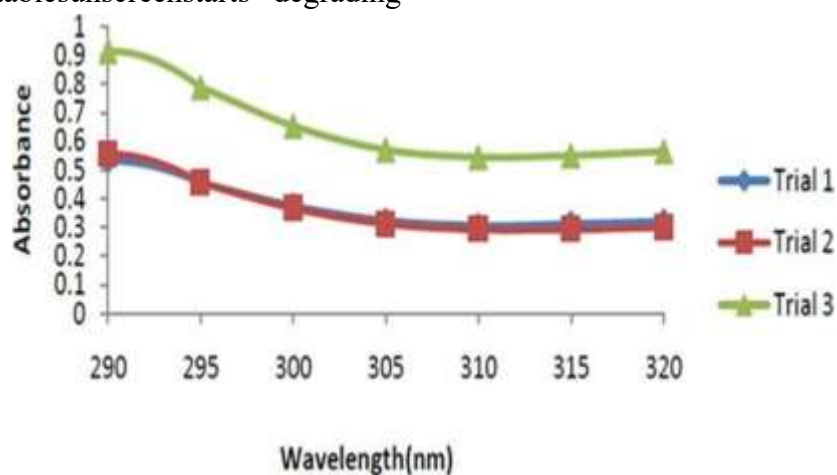


Table 8 Results of photo stability evaluation of sunscreen cream batches

AUCI (AUCI before/ AUCI after)						
			After UV natural exposure		After UV artificial exposure	
Formulation	Exposure time	UVA radiation (kJ/m ²)	UV A	UV B	UV A	UVB
F1	30	55	0.65	0.68	0.72	0.72
	90	165	0.68	0.63	0.65	0.69
	120	235	0.59	0.61	0.71	0.77
F2	30	58	0.45	0.59	05	0.73

	90	160	0.85	0.88	0.78	0.81
	120	230	0.65	0.69	0.82	0.87
F3	30	62	0.75	0.70	0.60	0.81
	90	155	0.79	0.72	0.65	0.80
	120	242	0.84	0.87	0.90	0.82

Determination of Total Fatty Content

Table 7 Determination of total fatty content(TFC)

Parameter	Bas E	F1	F2	F3
Total fatty content (% by mass)	3	3.5	3	4

From the findings of subjective evaluation for fairness activity, it was noticed that the cream formulation with 1.5% arbutin was highly appreciated by users. It did not cause any kind of skin irritation when used regularly. The cream also exhibited skin whitening activity in addition to good appearance, ease of spreading, and glow.

Determination of Fairness Activity

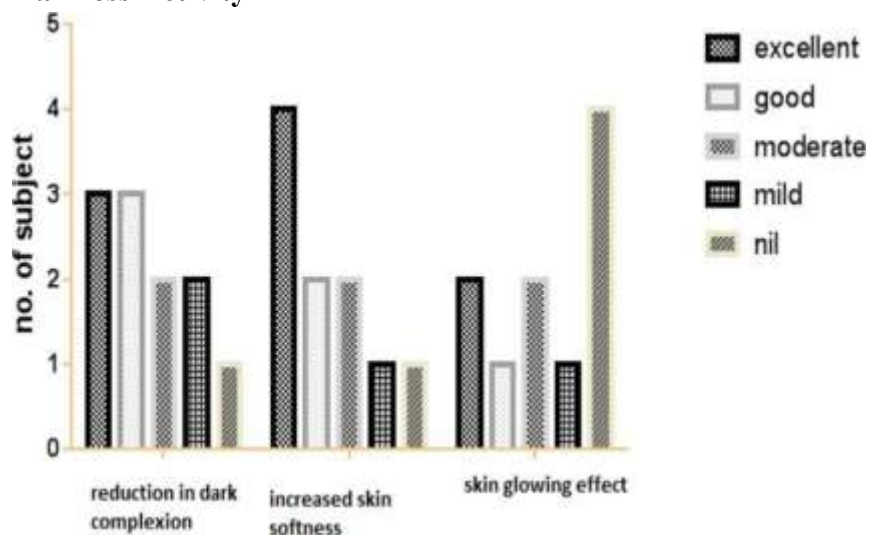


Figure 7 Effect of fairness cream at the end of study.

Stability studies

Stability studies for visual appearance, pH, spreadability, viscosity parameters revealed that no changes were found after a period of 1 month and the results are summarized in Table. In centrifugation studies, it was seen that no phase separation was present in F3 formulation, and therefore, it could be concluded that the formulation is stable at an accelerated rate. All formulations were seen to have increased viscosity after freezing and thawing study. Since all samples of creams were oil-in-water creams, their water content would be lost at varying temperatures. As a result, it could be recommended that a constant

temperature be maintained for such formulations. There was no phase separation or any change in color and odor in all samples after stability studies.

DISCUSSION

Solar ultraviolet (SUV) light includes both ultraviolet light A (UVA) and ultraviolet light B (UVB) wavelengths. These can cause cutaneous squamous cell carcinoma (cSCC) and other skin cancers. To lessen or prevent exposure to UVA and UVB rays from sunlight, people often use sunscreen [33]. As far as we know, a mouse model simulating long-term solar exposure (SSL) has not been utilized to evaluate or compare the



effectiveness of the eight most common sunscreen components that the FDA has approved in preventing skin cancer [38]. Society has become more open to the idea of creating sunscreen products that incorporate natural ingredients. Many individuals think that opting for natural components is safer and less detrimental than relying on chemical options. *Phalleria macrocarpa* serves as a natural resource that can be utilized for sunscreen formulation. The main compound present in *P. macrocarpa* is a benzophenone derivative that provides defense against the harmful impacts of ultraviolet radiation[39]. The primary concerns for the future involve motivating individuals to safeguard their skin through various methods and optimizing the use of sunscreens [40]. The primary immediate advantage of the sunscreens available today is their ability to prevent sunburn caused by UV radiation exposure. This effect has been suggested to have both positive and negative.

CONCLUSION

Thus, the results of the present study conclude that the formulated cream has the potential to protect against UVA and UVB rays, indicating sunscreen activity, as well as the formulations produced by incorporating different concentrations of extracts can be applicable for different types of Skin, respectively, as per SPF value. The use of sunscreens is an important component of sun protection. Regular and appropriate use is associated with a decreased risk of various skin complications and cancers as a result of UV radiation exposure. My conclusion is that it is important that we are aware of UV-ray exposure, even if it isn't a sunny day. However, sunscreen is very effective at blocking that exposure and lasts a surprisingly long time. It also doesn't seem to matter much what level of SPF you use. I learned how effective sunscreen is at blocking UV rays. I learned that even on a cloudy day, the unprotected

beads change colors almost immediately when they are exposed to sunlight. Also, the sunscreens were effective for a much longer period of time than I had expected. It took six hours before the beads changed colors after they were exposed to sunlight. I also found that the SPF (sun protection factor) of the sunscreen didn't make a difference in the effectiveness of the sunscreen. The beads changed colors at almost exactly the same time, regardless of whether the SPF covering the bag was 30, 50, or 70.

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