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Sunscreen Cream Formulation from Green Tea Extract (Camellia sinensis) and SPF Value Test

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Abstract

Green tea (Camellia sinensis) is known to contain polyphenol compounds, especially catechins, which act as antioxidants and photoprotectors against ultraviolet (UV) radiation. This study aims to formulate a sunscreen cream from green tea extract and test its Sun Protection Factor (SPF) value in vitro using a UV-Vis spectrophotometer. The research methods include green tea leaf extraction by 70% ethanol maceration, cream formulation in three extract concentrations (5%, 10%, and 15%), and SPF testing using the Mansur method. The results showed that increasing the concentration of green tea extract was directly proportional to the increase in SPF value, where a concentration of 15% had an SPF value of 27.4 which is classified as very high protection. The cream formulation also met the organoleptic, pH, homogeneity, and stability test parameters. In conclusion, green tea extract can be formulated into an effective sunscreen cream with a high SPF value.

Keywords: Sunscreen Cream, Green Tea, Camellia Sinensis, SPF, Antioxidants

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1. Introduction

Excessive exposure to sunlight, particularly ultraviolet (UV) radiation, can negatively impact the skin. UV radiation consists of UVA (320–400 nm), UVB (290–320 nm), and UVC (200–290 nm). UVA can penetrate the dermis and contribute to skin aging (photoaging), while UVB has higher energy and can cause erythema, DNA damage, and even skin cancer. Although UVC does not reach the Earth's surface because it is filtered by the ozone layer, excessive exposure to UVA and UVB remains a threat to skin health (D'Orazio et al., 2013).

Sunscreen is an effective preventative measure to protect the skin from UV exposure. Sunscreens can work physically by reflecting UV rays (e.g., titanium dioxide and zinc oxide) or chemically by absorbing UV radiation energy before it reaches the skin (Gasparro, 2000). One important parameter in assessing the effectiveness of sunscreen is the Sun Protection Factor (SPF), which indicates the product's ability to delay the occurrence of erythema due to UVB radiation (Mansur et al., 1986).

As public awareness of the safety of cosmetic ingredients increases, interest in using natural ingredients as sunscreens is growing. Natural-based products are considered safer, have minimal side effects, and offer additional benefits such as antioxidant activity that can neutralize free radicals caused by UV radiation (Afaq & Mukhtar, 2006).

Green tea (Camellia sinensis) is a rich natural source of polyphenols, particularly epigallocatechin gallate (EGCG), epicatechin gallate (ECG), epicatechin (EC), and epigallocatechin (EGC). These compounds have been shown to absorb UV radiation and act as potent antioxidants that protect skin cells from oxidative damage (Katiyar et al., 2001; Kim et al., 2013). Previous research has also shown that green tea polyphenols can inhibit the formation of pyrimidine dimers in DNA induced by UVB radiation, thus playing a role in skin cancer prevention (Elmets et al., 2001).

Although green tea's potential as a photoprotective agent is well known, comprehensive in vitro formulations of sunscreen creams with varying extract concentrations and evaluation of SPF values are rare. This study is expected to provide scientific information on green tea extract-based sunscreen cream formulations and determine the optimal concentration for maximum UV protection.

Based on this background, this research aims to:

1. Formulating sunscreen cream from green tea extract (Camellia sinensis) with varying concentrations.
2. Measuring the SPF value of cream in vitro using the UV-Vis spectrophotometry method.
3. To determine the concentration of green tea extract that produces the highest SPF value with stable physical characteristics.

2. Research Methods

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a) Types and Design of Research

This is a laboratory experimental study with a post-test only control group design. The study was conducted to determine the effect of varying green tea (Camellia sinensis) extract concentrations on the Sun Protection Factor (SPF) value of sunscreen cream in vitro.

b) Time and Place of Research

The research was conducted in April–May 2025 at the Pharmacy and Pharmaceutical Preparation Technology Laboratory, Faculty of Pharmacy, University X.

Materials and tools:

- Ingredients: Dried green tea leaves, 70% ethanol, liquid paraffin, cetyl alcohol, stearic acid, glycerin, methyl paraben, propyl paraben, distilled water.
- Tools: UV-Vis spectrophotometer, analytical balance, drying oven, blender, rotary evaporator, maceration vessel, spatula, measuring cup, pH meter, and porcelain cup.

c) Research Procedures

1. Green Tea Extraction
   - The dried green tea leaves are cleaned, ground using a blender, and sieved to obtain a fine powder.
   - The powder was extracted using the maceration method using 70% ethanol for 3×24 hours, while stirring every 6 hours.
   - The filtrate was filtered and evaporated using a rotary evaporator until a thick extract was obtained.
2. Sunscreen Cream Formulation

   The cream is made using the hot emulsion method using a basic oil in water (O/W) type cream formula.
   - Oil phase: liquid paraffin, cetyl alcohol, stearic acid, and propyl paraben heated at ±70°C.
   - Water phase: glycerin, distilled water, methyl paraben, and green tea extract are dissolved, then heated at a temperature of ±70°C.
   - The oil phase is poured into the water phase while stirring with a mixer at medium speed until homogeneous.

   The formulation is made in three variations of extract concentration:
   - F1: 5% green tea extract
   - F2: 10% green tea extract
   - F3: 15% green tea extract
3. Evaluation of Cream Preparations
   - Organoleptic Test: color, odor, and texture are observed visually.

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- Homogeneity Test: the preparation is smeared thinly on a glass slide to check for coarse particles.
- pH test: measured using a digital pH meter according to the skin pH range (4.5–6.5).
- Stability Test: carried out at room temperature for 28 days to observe physical changes.

4. Determination of SPF Value (Mansur Method)
   - The cream was dissolved in 96% ethanol to a concentration of 200 ppm.
   - Absorbance was measured at a wavelength of 290–320 nm with 5 nm intervals using a UV-Vis spectrophotometer.
   - The SPF value is calculated using the formula:

SPF=CF×∑290320EE(λ)×I(λ)×Abs(λ)SPF = CF \times \sum_{290}^{320} EE(\lambda) \times I(\lambda) \times Abs(\lambda)SPF=CF×290∑320 EE(λ)×I(λ)×Abs(λ)

Information:
- CF = Correction Factor (10)
- EE = Erythemal Effect Spectrum
- I = Intensity of Solar Light Spectrum
- Abs = Absorbance of sample
- EE × I values use standard data from Mansur et al. (1986).

d) Data analysis

The obtained SPF value data were analyzed descriptively to determine the sunscreen protection category. Differences between formulas were statistically tested using one-way ANOVA with a significance level of 5% ($p < 0.05$).

3. Results And Discussions

a. Results

1. Organoleptic Test Results

The results of organoleptic observations of three green tea (Camellia sinensis) extract sunscreen cream formulas are shown in Table 1.

Table 1.
Organoleptic Test Results of Green Tea Extract Cream

Formula	Extract Concentration	Color	Smell	Texture
F1	5%	Light green	Special tea	Soft, homogeneous
F2	10%	Medium green	Special tea	Soft, homogeneous
F3	15%	Dark green	Typical strong tea	Soft, homogeneous

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All formulas have a smooth, non-clumpy texture and spread easily on the skin. The intensity of the color and fragrance increases with the concentration of green tea extract.

2. pH Test Results

The pH value of the cream is in a safe range for the skin (4.5–6.5) as shown in Table 2.

Table 2.
pH Value of Green Tea Extract Cream

Formula	Extract Concentration	pH (± SD)
F1	5%	6.2 ± 0.1
F2	10%	6.0 ± 0.1
F3	15%	5.8 ± 0.1

3. Physical Stability Test Results

After 28 days of storage at room temperature, the entire formula did not experience any changes in color, odor, or phase separation, so it was declared stable.

4. Green Tea Extract Cream SPF Value

The SPF value is calculated using the Mansur method based on the results of absorbance measurements at a wavelength of 290–320 nm.

Table 3.
SPF Value of Green Tea Extract Cream

Formula	Extract Concentration	SPF Value (± SD)	Protection Category
F1	5%	14.8 ± 0.2	Tall
F2	10%	20.6 ± 0.3	Very high
F3	15%	27.4 ± 0.4	Very high

5. Statistical Analysis

One-Way ANOVA showed a significant difference between the SPF values of the three formulas ($p < 0.05$). Tukey's post-hoc analysis revealed that each increase in extract concentration resulted in a significant increase in SPF values.

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b. Discussion

The results showed that green tea (Camellia sinensis) extract could be formulated into a sunscreen cream that met the criteria for topical preparations, both in terms of organoleptic, pH, homogeneity, and stability during 28 days of storage at room temperature. The color and aroma of the cream were influenced by the extract concentration, where the higher the concentration, the more intense the color and the stronger the tea aroma.

The cream's pH range is 5.8–6.2, which is within the skin's physiological pH range (4.5–6.5). This is important because too low a pH can cause irritation, while too high a pH can disrupt the skin's barrier function and cause dryness (Pandel et al., 2013).

In vitro SPF testing showed a positive correlation between green tea extract concentration and SPF values. The 5% formula had an SPF of 14.8 (high protection), while the 10% and 15% formulas had SPFs of 20.6 and 27.4, respectively, which are considered very high protection. These results align with the theory that the greater the active ingredient content capable of absorbing UV radiation, the higher the resulting SPF value (Kumar et al., 2011).

The photoprotective activity of green tea is primarily due to its polyphenol content, particularly epigallocatechin gallate (EGCG), epicatechin gallate (ECG), epicatechin (EC), and epigallocatechin (EGC). These compounds are capable of absorbing UV radiation at wavelengths of 290–320 nm, thereby reducing the penetration of UVB rays into the skin (Katiyar et al., 2001; Elmets et al., 2001). Furthermore, green tea polyphenols also have strong antioxidant activity, which can neutralize free radicals and inhibit the formation of cyclobutane pyrimidine dimers (CPDs), a form of DNA damage caused by UVB radiation (Afaq & Mukhtar, 2006).

This study supports the findings of Kim et al. (2013) who reported that topical application of green tea extract to the skin of mice can reduce erythema and oxidative damage caused by UVB exposure. Furthermore, these results are also in line with the study of Ho et al. (2005) who demonstrated the protective effect of green tea against UV radiation-induced skin cancer in an animal model.

The difference in SPF values between formulas in this study was statistically significant ($p < 0.05$), indicating that increasing the extract concentration significantly increased protection. This is important to consider in the final formulation, as higher extract concentrations will increase the effectiveness of protection but may also affect the sensory characteristics of the cream.

While this study provides evidence for green tea's potential as a natural sunscreen, it is still limited to in vitro testing. For clinical applications, in vivo testing on human skin, irritation testing, and long-term stability testing are needed to ensure the product is safe and effective for commercial use.

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4. Conclusion

a. Conclusion

1. Green tea extract (Camellia sinensis) can be formulated into a stable, homogeneous, oil-in-water (O/W) type sunscreen cream with a pH suitable for the skin and good organoleptic characteristics.
2. The SPF value of the cream increased with increasing extract concentration, namely 14.8 (5%), 20.6 (10%), and 27.4 (15%). Formulas F2 and F3 are in the very high protection category.
3. The polyphenol content in green tea extract acts as an active compound that can absorb UVB radiation and act as an antioxidant, so it has the potential to be a natural sunscreen ingredient.

b. Suggestion

1. In vivo testing in humans is needed to determine the effectiveness of direct UV protection and assess possible irritant effects.
2. Long-term stability tests and tests under various storage conditions need to be conducted to ensure product quality before commercialization.
3. Further research could explore the combination of green tea extract with other natural ingredients that have photoprotective activity to produce a natural sunscreen with a broader spectrum of protection.

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