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Original Research Article

Preparation and evaluation of herbal sunscreen creams

Yamini Shah[1], Rajvee Mewada[1,*]

[1] *Dept. of Pharmaceutics and Pharmaceutical Technology, L. M. College of Pharmacy, Ahmedabad, Gujarat, India*

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ABSTRACT

Presently herbal sunscreens are widely used by almost everyone on this planet to prevent from harmful effects of UV radiation from sunlight. Herbals are preferable because of fewer side effects and a better safety profile. This study is about the preparation and evaluation of herbal sunscreen creams possessing anti-UV radiation effectiveness and anti-inflammatory properties. Creams were prepared from the extract of plant materials, such as *Glycyrrhiza glabra and Tinospora cordifolia, Terminalia arjuna* respectively. *Glycyrrhiza glabra, Tinospora cordifolia and Terminalia arjuna*, total polyphenol and flavonoid content. Evaluation of prepared herbal sunscreen creams was performed on parameters such as organoleptic properties, pH, rancidity, spreadability and drug content. The effectiveness of the products was evaluated by measuring Sun Protection Factor (SPF). These products showed good spreadability, consistency, homogeneity, appearance, desired pH, ease of removal and no evidence of phase separation. Our formulation of sunscreen creams is considered to be effective sunscreen in healing, softening and rejuvenating the skin.

1. Introduction

The use of sunscreen is a necessity these days to protect our skin from the harsh ultraviolet (UV) rays. It is difficult to find good sun protection formulation which is non-greasy and moisturizing to the skin. The herbal sunscreen will not only protect the skin from the effects of harmful UV rays but also eliminate the use of chemical sunscreens. Presently, public awareness has increased regarding the safety of sunscreens using chemicals. Chemical-based sunscreen gets absorbed into the skin and causes discomfort and itchiness of the skin.[1] Therefore, manufacturers all over the world have begun manufacturing herbal sunscreens to prevent side effects caused by synthetic chemical products. Herbal sunscreens include natural oils such as almond oil, olive oil, rose oil, coconut oil and jojoba oil etc., which penetrate deeper into the layers of the skin plunge the signs of early aging by hydrating the skin. Herbal ingredients such as green tea, amla, lemon, turmeric etc. have shown properties such as absorbance of a broad spectrum of UV rays, anti-oxidant and anti-inflammatory effects. They also cause skin tightening, help prevent skin damage, heal acne, fade scars, lighten dark circles and effectively make skin radiant. These herbal products also provide self-color so the use of artificial colors may be avoided.

Sunscreen products can be formulated in the form of lotions, creams, sticks, aerosols, gels, powders and ointments.[2] Sunscreen preparations are designed to be used topically to prevent UV radiation from entering the skin directly by absorbing or reflecting from the skin. Regulatory considerations are also taken into account during the design and development of sunscreen products.[3] Creams are of emulsion type either W/O or O/W based mainly on manufacturers' preference.[4]

* *Corresponding author.*
E-mail address: rajveemewada@gmail.com (R. Mewada).

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In the present study, herbal sunscreen creams were prepared using *Glycyrrhiza glabra, Tinospora cordifolia* and *Terminalia arjuna,* which show anti-inflammatory, anti-oxidant and wound healing properties along with whitening of skin.[5–7] Phytochemical evaluation, total phenolic and flavonoid content of herbal extracts, and physicochemical characterization of prepared formulations were examined. The sun protection effectiveness of the creams was assessed in terms of SPF values by using an *in vitro* spectrophotometric method.

2. Materials and Methods

2.1. Plant Materials

Herbal sunscreen creams were prepared by using various plant materials such as *Glycyrrhiza glabra* (Family: Fabaceae), *Tinospora cordifolia* (Family: Menispermaceae), *Terminalia arjuna* (Family: Combretaceae). All herbal powders were purchased from the LVG Ayurvedic store, in Ahmedabad, Gujarat.

2.2. Other Chemicals

Triethanolamine, stearic acid and sodium lauryl sulfate (SLS) were purchased from Loba Chemie Pvt. Ltd., Mumbai, India. Cetyl alcohol and Methylparaben were purchased from Central Drug House (P) Ltd., India. Olive oil was purchased from Del Monte Extra Virgin Olive Oil and was obtained from the store at the pharmaceutics department of L. M. College of Pharmacy, Ahmedabad, India. Glycerol was purchased from S. D. Fine Chem Limited, Mumbai, India. Starch was purchased from Spectrochem Private Limited, Mumbai, India.

2.3. Preparation of herbal extracts

Dried powder samples were separately packed in polythene bags to avoid contamination.[8] The plant material was exhaustively extracted with ethanol, using a reflux condenser extraction apparatus followed by a maceration process.[8,9] 10 gm of each powder was weighed using a digital weighing balance (SCALE-TEC) and were macerated for 15 hours at room temperature with 150 ml 0f 90% ethanol respectively and then filtered to separate liquid menstruum from residue. The ethanolic menstruum was collected this way and further purified in a round bottom flask, using a reflux condenser for 1 hour at a constant temperature. After 1 hour of extraction, extracts were filled in a separate container (Figure 1) and stored in a refrigerator for their further evaluation and use.

3. Formulation of Herbal Sunscreen Creams

Four batches of sunscreen creams were prepared by varying the concentration of herbal plant extracts (Table 1).

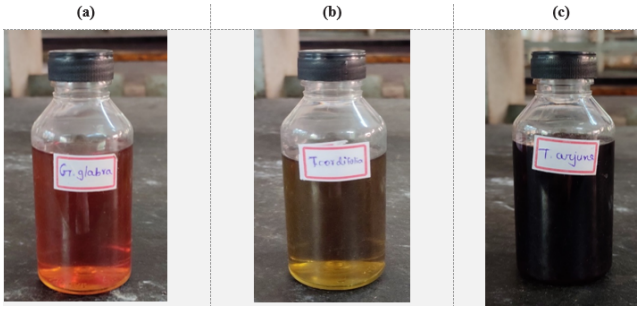

Fig. 1: Ethanolic extract of plant materials **(a)** Ethanolic extract of *Glycyrrhiza glabra* **(b)** Ethanolic extract of *Tinospora cordifolia* **(c)** Ethanolic extract of *Terminalia arjuna*

3.1. Preparation of herbal sunscreen creams (O/W)

Oil phase: The emulsifier (stearic acid) and other oil-soluble components (cetyl alcohol and olive oil) were dissolved in the oil phase on a hot water bath.

Water phase: Preservatives and other water-soluble components (methylparaben, glycerol, SLS, starch, triethanolamine, extract) were dissolved in the aqueous phase and mixed and a sufficient quantity of water was added to the mixture on a hot water bath.

Then both the phases were mixed, and continuous stirring was done till a homogenous product was obtained. Creams were filled in a separate glass container and used for further evaluation (Figure 2).

Fig. 2: Prepared creams in four batches (C1, C2, C3, C4)

4. Evaluation of Herbal Extracts

4.1. Percent yield

Crude extracts were concentrated using a rotary vacuum evaporator (BUCHI Rotavapor R-210) at a reduced pressure and an elevated temperature (70°C) for 1 hour. Concentrated extracts were allowed to dry at room temperature. Dried extracts were weighed and stored in a refrigerator in airtight vials. The percent yield of the extracts was calculated by using the following formula:[8,9]

$$Yield\ (\%) = \frac{"Amount\ of\ extract"}{"Dry\ weight\ of\ sample"} * 100$$

Table 1: Formulation ofsunscreen creams

Ingredients	Quantity (%w/w)	C1	C2	C3	C4
Stearic acid	8.5	+	+	+	+
Cetyl alcohol	3.5	+	+	+	+
Olive oil	15.59	+	+	+	+
Methylparaben	0.01	+	+	+	+
Glycerol	3.78	+	+	+	+
Sodium lauryl sulphate (SLS)	1	+	+	+	+
Starch	1.5	+	+	+	+
Triethanolamine	q.s.	+	+	+	+
Water	q.s.	+	+	+	+
Glycyrrhiza glabra extract	5	+	-	-	+
Tinospora cordifolia extract	5	-	+	-	+
Terminalia arjuna extract	5	-	-	+	+
Rose oil	10	+	+	+	+

4.2. UV Spectrophotometric Analysis

The UV spectrum of 10 ml pure ethanolic extract was recorded using a UV visible spectrophotometer (UV-1700 Double beam Spectrophotometer, Shimadzu) in the range of 200-800 nm. λmax was recorded.

4.3. Preliminary phytochemical evaluation

Extracts were subjected to several chemical tests to detect the chemical constituents present in them (9).

1. Fehling test (Test for Carbohydrates): 1 ml Fehling A and 1 ml Fehling B reagents were added to 1 ml of extract (boiled for 10min). The formation of a brick red color precipitate indicates the presence of carbohydrates. [10]
2. Foam test (Test for Saponins): The extract was mixed with 20 ml of distilled water and agitated for 15 minutes. The formation of a 1cm layer of foam at the top of the liquid showed the presence of Saponins. [11]
3. Sodium hydroxide test (Tests for Flavonoids): Extract was mixed with 1 ml of sodium hydroxide solution. The presence of flavanones is indicated by a yellow to orange color, while flavones are indicated by a yellow color. [11]
4. Lead acetate (Test for Flavonoids): Few drops of 10% lead acetate solution were added to the alcoholic solution of the extract. The presence of flavonoids was shown by the appearance of a yellow precipitate. [12]
5. Salkowski test (Test for Phytosterols): 0.5 ml chloroform extract was added to 1 ml of concentrated sulphuric acid from the sides of the test tube. The presence of phytosterols is indicated by the presence of a reddish-brown color in the chloroform layer. [12]
6. Hager's test (Test for Alkaloids): Extracts were treated with Hager's reagent (saturated solution of picric acid) and the formation of a yellow-colored precipitate indicates the presence of alkaloids (9).
7. Ferric chloride test (Test for Phenolic compounds and Tannins): 2 ml of extract was taken and ferric chloride solution was added to it drop by drop. The presence of phenolic compounds and tannins was indicated by the appearance of a bluish-black precipitate. [12]

4.4. Determination of total polyphenolic content

Folin-Ciocalteu reagent (FCR) or Folin's phenol reagent or Folin Denis reagent or Gallic Acid Equivalence method (GAE) uses a mixture of phosphomolybdate and phosphotungstate for the colorimetric assay of phenolic and polyphenolic antioxidants.

Principle: It works by measuring the amount of the substance needed to inhibit the oxidation of the reagent. As a result, the reagent measures the total reducing capacity of a sample rather than just the level of phenolic compounds. [13]

Standard solution preparation**:** 5 mg of Gallic acid was accurately weighed and 5 ml of distilled water added to it in a volumetric flask. 1 ml of the stock solution was pipetted out and diluted to 10 ml to get 100μg/ml concentration. 0.2, 0.4, 0.6, 0.8, 1.0 and 1.2 ml were pipetted out from the stock solution into 10 ml volumetric flasks. 0.6 ml of Folin-Ciocalteu reagent [1:3 with distilled water] was added to all these volumetric flasks. They were kept aside in darkness for 5 minutes after shaking. 20% w/w sodium carbonate solution in distilled water was added to this volumetric flask and a final volume of up to 10 ml was made with distilled water. The resultant solutions were of 2, 4, 6, 8, 10 and 12 μg/ml concentrations respectively. All solutions were kept aside for 30 minutes and then their absorbance was measured at 765 nm.

Test extract preparation: 100 ml of ethanolic extracts was prepared and then from these extracts pipetted out

the suitable quantity of test extract [0.5/1/2 ml] into 10 ml volumetric flask respectively. 0.6 ml of Folin-Ciocalteu reagent [1:3 with distilled water] was added to all volumetric flasks. They were kept aside in darkness for 5 minutes after shaking. Sodium carbonate solution [20% w/w in distilled water] was added and made a volume of up to 10 ml by adding distilled water to them. All solutions were kept aside for 30 minutes and then their absorbance was measured at 765 nm.

Distilled water was taken as blank and set the absorbance zero. The absorbance of standard and test solutions was measured. Graph of standard absorbance v/s concentration was plotted, Regression equation [y=mx+c] was found out from that and test concentrations were calculated from the equation and from that equation, the value of phenolic content in each extract was measured.

4.5. Determination of total flavonoid content

Standard solution preparation: Quercetin was weighed accurately and then 1mg/10ml solution was prepared by dissolving 5 mg in 50 ml of methanol in a volumetric flask. 0.15, 0.25, 0.3, 0.35 and 0.4 ml were pipetted out from the stock solution into separate 5 ml volumetric flasks. 1.5 ml of 95% ethanol, 0.1 ml of 10 % $AlCl_3$ solution and 0.1 ml of 1 M potassium acetate solution were added to all volumetric flasks and a final volume of up to 5 ml was made with methanol. The resultant standard solutions were of 3, 4, 5, 6, 7 and 8 μg/ml concentrations respectively.

Test extract preparation**:** 100 ml of ethanolic extracts was prepared and then from these extracts pipetted out 0.5 ml of test extract into 5 ml volumetric flask respectively. 1.5 ml of 95% ethanol, 0.1 ml of 10 % $AlCl_3$ solution and 0.1 ml of 1 M potassium acetate solution were added to all volumetric flasks and then make a volume of up to 5 ml by adding methanol to them.

All standard and test solutions were kept aside for 30 minutes to maintain a temperature between 40-50 °C. The absorbance of standard and test solutions was measured at 451nm. $AlCl_3$ in Distilled water was taken as blank and set the absorbance zero. Then absorbance was measured. A graph of standard absorbance v/s concentration was plotted, Regression equation [y=mx+c] was found out from that and test concentration was calculated from the equation. The total content of flavonoid compounds in plant methanol extracts in quercetin equivalents was calculated by the following equation:

C=(c×V)/mWhere, C = Total content of flavonoid compounds, mg/gm plant extract, in quercetin equivalent;

c = The concentration of quercetin established from the calibration curve in mg/ml,

V = Volume of extract in ml,

m = Weight of crude plant extract in gm.[12]

4.6. Preparation of calibration curve

Standard calibration curves of ethanolic extracts were obtained by plotting absorbance vs. concentration. The experiment was performed in triplicate. An equation for the best line fit was generated.

Preparation of stock solution: Accurately measured 5 ml (7 mg/ml) of the extract was taken. Then 90% ethanol was added to the flask to make the volume up to 35 ml. This solution had a concentration of 1000μg/ml.

Preparation of aliquots: Serial dilution was carried out from the stock solution for 1ml, 2 ml, 3 ml, 4 ml, 5 ml, 6 ml, 7 ml, 8 ml samples and diluted up to 100 ml to get concentration of 10 μg/ml, 20 μg/ml, 30 μg/ml, 40 μg/ml, 50 μg/ml, 60 μg/ml, 70 μg/ml, 80 μg/ml respectively.

The results of all these evaluation parameters are given in section 8.

5. Characterization and Evaluation of Herbal Sunscreen Creams

5.1. Organoleptic properties

For evaluation, organoleptic parameters such as appearance, color, transparency, smoothness and homogeneity of the final formulations were checked visually.[13,14]

5.2. pH

About 1 gm of cream was accurately weighed and dispersed in 100 ml of purified water. A digital pH meter (Digital pH meter MK VI) was used to determine the pH of the dispersion.[13]

5.3. Rancidity

This test was performed by using the phloroglucinol solution. The oxidation of fats and oils causes rancidity. These free fatty acids react with the phloroglucinol solution and show pink color. A pink color indicates the rancidity of the product.[13]

5.4. Spreadability

About 0.5 gm of cream was placed in a circle of 1 cm diameter on a 20×20 cm glass plate, over which the second glass plate was placed. A weight of 500 gm was allowed to rest on the upper glass plate for 5 min and then an increase in the diameter of the cream due to spreading was noted.

5.5. Drug content

The drug content of the cream formulations was determined by dissolving an accurately weighed quantity of cream (about 500 mg) in about 50 ml of ethanol. These solutions were transferred quantitatively to volumetric flasks and dilutions were made with the same solvent. The resulting

mixture was then filtered through Whatman filter paper before subjecting the solutions to spectrophotometric analysis. The linear regression equation derived from the calibration data was used to calculate drug content.[3,15]

5.6. Determination of sun protection factor (SPF)

The sun protection factor (SPF) is a measurement of the fraction of sunburn that is caused by the sun. These SPF values should represent the measure of the period during which the product protects the skin from the detrimental effects of ultraviolet (UV) radiation. The sun protection factor was determined using the UV-spectrophotometric method. In this method, 1 g of cream were weighed accurately and 90% ethanol was added to make 10 ml of the final volume. The absorbance values of each aliquot prepared were determined from 290 nm to 320 nm at 5 nm intervals, using 90 % ethanol solution as a blank. The SPF was calculated using the following equation;

SPF spectrophotometric = CF×SPF spectrophotometric

$$=\sum_{290}^{320} EE(\lambda)\, Abs(\lambda) \times CF$$

Where, CF = Correction factor (10)

EE = Erythrogenic effect of radiation with wavelength (λ)

Abs (λ) = Spectrophotometric absorbance values at wavelength The value of EE × I is constant (as shown in Table 2).[3,16,17]

Table 2: Value of EE*I at different wavelengths.[18]

Wavelength (nm)	EE*I (constant) Employed
290	0.0150
295	0.0817
300	0.2874
305	0.3278
310	0.1864
315	0.0837
320	0.0180
Total	1

The results of all these characterization and evaluation parameters are given in section 8.

6. Results and Discussion

6.1. Percent yield

The results of the percent yield of plant extracts are shown in Table 3.

Table 3: % Yield of plant extracts

	% Yield
Glycyrrhiza glabra	9.8%
Tinospora cordifolia	7.4%
Terminalia arjuna	8.6%

6.2. UV Spectrophotometric analysis

Absorbance maxima of plant extracts were observed in a UV spectrophotometer. The identification peak of ethanolic extracts was found in the UV spectrum of 90% ethanol. The absorbance maxima of all three extracts in 90% ethanol were found to be 412 nm, 399 nm and 564 nm respectively. The UV spectrum of these three plant extracts have been shown in Figure 3.

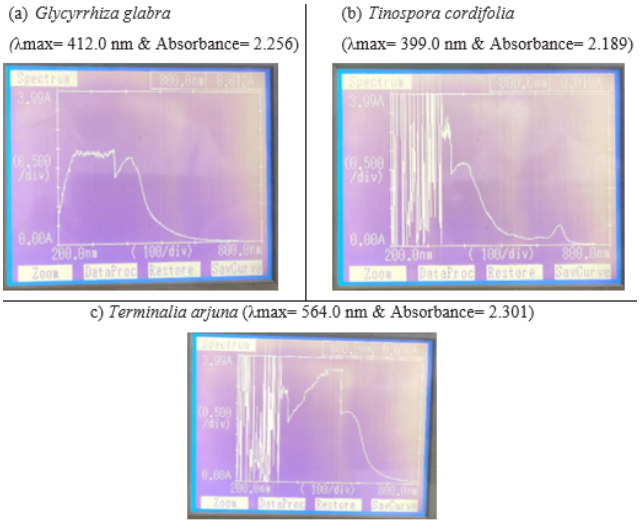

Fig. 3: UV spectrum of plant extracts **(a)** UV spectrum of *Glycyrrhiza glabra* in ethanol **(b)** UV spectrum of *Tinospora cordifolia* in ethanol **(c)** UV spectrum of *Terminalia arjuna* in ethanol

6.3. Preliminary phytochemical evaluation

Preliminary phytochemical evaluation tests were used to detect the presence of different chemical constituents present in plant extracts and their results have been shown in Table 4.

6.4. Determination of total polyphenolic content

Standard solution (Gallic acid): The absorbance of the resultant solutions containing Gallic acid as a standard was performed at 765 nm. Results are shown in Table 5 and the calibration curve obtained thereafter is shown in Figure 4.

Test solution: The value of total polyphenolic content in different plant extracts is shown in Table 6.

6.5. Determination of total flavonoid content

Standard solution (quercetin): The absorbance of the resultant solutions containing quercetin as a standard was performed at 451 nm. The results are shown in Table 7 and the calibration curve obtained thereafter is shown in Figure 5.

Table 4: Preliminary phytochemical evaluation of plant extracts

Test	Glycyrrhiza glabra	Tinospora cordifolia	Terminalia arjuna
a. Fehling test (Carbohydrate)	+	-	+
b. Foam test (Saponins)	+	-	+
c. Sodium hydroxide test (Flavonoids)	+	+	+
d. Lead acetate (Flavonoids)	+	+	+
e. Salkowski test (Phytosterols)	+	+	+
f. Hager's test (Alkaloids)	+	+	+
g. Ferric chloride test (Phenolic compounds)	+	+	+

Table 5: Calibration data of Gallic acid

Concentration (μg/ml)	Absorbance
4	0.356
6	0.519
8	0.639
10	0.759
12	0.822
14	0.953

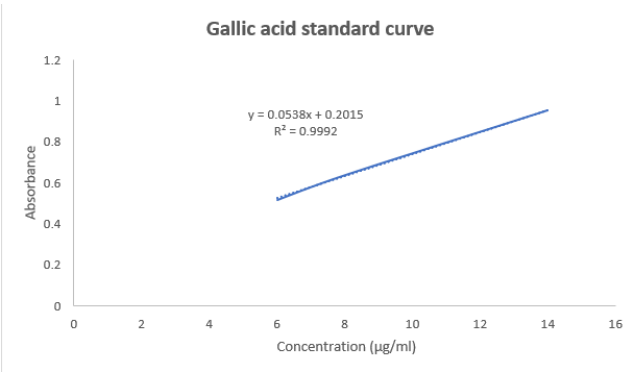

Fig. 4: Standard curve of Gallic acid

Table 6: Total polyphenolic content of plant extracts

	Total polyphenolic content
Glycyrrhiza glabra	49.71 mg of GAE/gm
Tinospora cordifolia	17.28 mg of GAE/gm
Terminalia arjuna	135 mg of GAE/gm

Table 7: Calibration data of quercetin

Concentration (μg/ml)	Absorbance
3	0.576
4	0.656
6	0.76
7	0.826
8	0.869

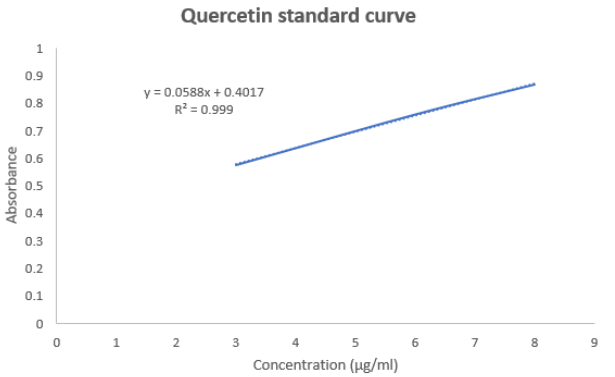

Fig. 5: Standard curve of quercetin

Test solution: The value of total flavonoid content in different plant extracts is shown in Table 8.

Table 8: Total flavonoids content of plant extracts

	Total flavonoid content
Glycyrrhiza glabra	65.42 mg of QE/gm
Tinospora cordifolia	6.57 mg of QE/gm
Terminalia arjuna	126 mg of QE/gm

6.6. Data Obtained from calibration curve

Calibration Curve: Glycyrrhiza glabra (at 412 nm)

The calibration curve of the *Glycyrrhiza glabra* extract was done in 90% ethanol at 412 nm and the results are shown in Table 9 the calibration curve obtained thereafter is shown in Figure 6.

Calibration Curve: Tinospora cordifolia (at 399 nm)

The calibration curve of the Tinospora cordifolia extract was done in 90% ethanol at 399 nm and the results are shown in Table 10 the calibration curve obtained thereafter is shown in Figure 7.

Calibration Curve: Terminalia arjuna (at 564 nm)

The calibration curve of the *Terminalia arjuna* extract was done in 90% ethanol at 564 nm and the results are shown in Table 11 the calibration curve obtained thereafter is shown in Figure 8.

Table 9: Calibration data of *Glycyrrhiza glabra* extract

Concentration (μg/ml)	Absorbance			
	1	2	3	Average ± Mean (n=3)
10	0.315	0.312	0.312	0.313 ± 0.0017
20	0.504	0.507	0.510	0.507 ± 0.003
30	0.688	0.693	0.689	0.690 ± 0.0026
40	0.813	0.820	0.815	0.816 ± 0.0036
50	1.124	1.122	1.120	1.122 ± 0.002
60	1.218	1.216	1.217	1.217 ± 0.001
70	1.359	1.358	1.357	1.358 ± 0.001
80	1.525	1.523	1.524	1.524 ± 0.001

Table 10: Calibration data of *Tinospora cordifolia* extract

Concentration (μg/ml)	Absorbance			
	1	2	3	Average ± Mean (n=3)
10	0.050	0.052	0.051	0.051 ± 0.001
20	0.104	0.106	0.105	0.105 ± 0.001
30	0.172	0.170	0.171	0.171 ± 0.001
40	0.276	0.272	0.277	0.275 ± 0.0026
50	0.321	0.328	0.326	0.325 ± 0.0036
60	0.382	0.385	0.382	0.383 ± 0.0017
70	0.443	0.447	0.454	0.448 ± 0.0055
80	0.531	0.526	0.530	0.529 ± 0.0026

Table 11: Calibration data of *Terminalia arjuna* extract

Concentration (μg/ml)	Absorbance			
	1	2	3	Average ± Mean (n=3)
10	0.103	0.099	0.101	0.101 ± 0.002
20	0.146	0.148	0.147	0.147 ± 0.001
30	0.197	0.197	0.200	0.198 ± 0.0017
40	0.264	0.262	0.266	0.264 ± 0.002
50	0.313	0.311	0.312	0.312 ± 0.001
60	0.367	0.365	0.363	0.365 ± 0.002
70	0.417	0.418	0.416	0.417 ± 0.001
80	0.482	0.483	0.487	0.484 ± 0.0026

Table 12: Evaluation data of different formulations

Evaluation parameters	C1	C2	C3	C4
Color	Yellow	White	Light pink	Dark off white
Texture	Smooth and non greasy	Smooth and non greasy	Smooth and non greasy	Smooth and non greasy
pH ± Mean (n=3)	6.82 ± 0.0208	6.73 ± 0.0416	6.94 ± 0.0404	6.73 ± 0.0321
Rancidity	No	No	No	No
Spreadability (g*cm/sec) ± Mean (n=3)	0.64 ± 0.0351	0.58 ± 0.0152	0.54 ± 0.0208	0.61 ± 0.0305
Drug content (%) ± Mean (n=3)	74.31 ± 0.237	86.81 ± 0.036	82.80 ± 0.061	-

Table 13: SPF value of formulations

Wavelength (nm)	C1		C2		C3		C4	
	Absorbance	SPF	Absorbance	SPF	Absorbance	SPF	Absorbance	SPF
290	1.122	0.01683	0.714	0.01071	1.986	0.02979	3.210	0.04815
295	1.275	0.10416	0.599	0.04893	1.796	0.14673	2.865	0.23407
300	1.363	0.39173	0.502	0.14427	1.568	0.45064	2.623	0.75385
305	1.185	0.38844	0.442	0.14488	1.408	0.46154	2.386	0.78213
310	0.879	0.16384	0.362	0.06076	0.896	0.16701	2.238	0.41716
315	0.913	0.07641	0.286	0.02393	0.515	0.04310	1.958	0.16388
320	0.936	0.01684	0.215	0.00387	0.432	0.00777	1.514	0.02725
Total		1.15825		0.43735		1.30658		2.42649
SPF		11.58		4.37		13.06		24.26

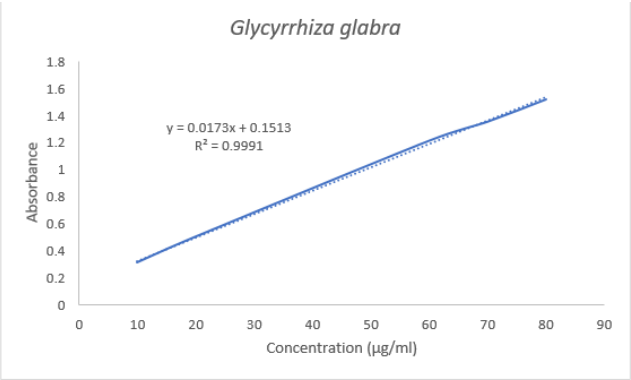

Fig. 6: Calibration curve of *Glycyrrhiza glabra*

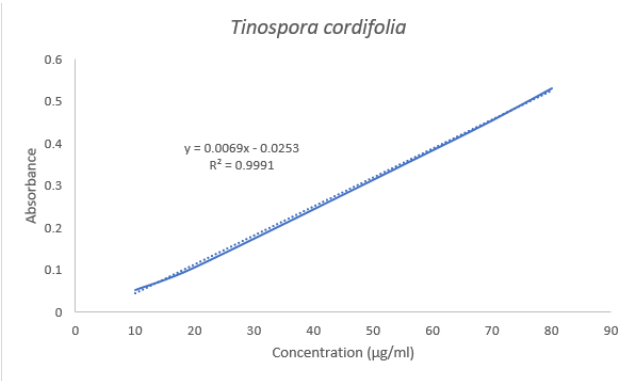

Fig. 7: Calibration curve of *Tinospora cordifolia* extract

6.7. Characterization and evaluation of herbal sunscreen creams

The result of the evaluation parameters of different cream formulations is shown in Table 12.

6.8. Determination of sun protection factor (SPF)

The value of the Sun Protection Factor of cream formulations is shown in Table 13.

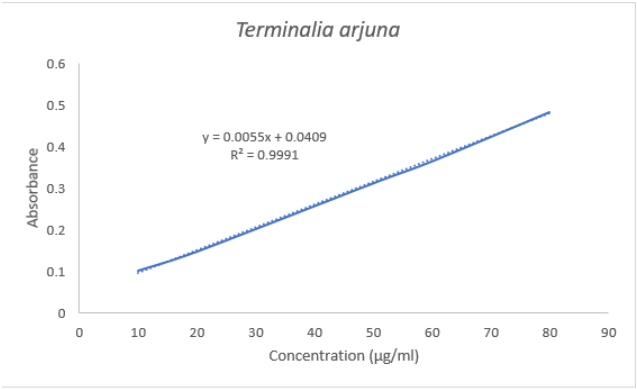

Fig. 8: Calibration curve of *Terminalia arjuna* extract

7. Conclusion

The study aimed to formulate and develop herbal sunscreen creams using extracts of *Glycyrrhiza glabra, Tinospora cordifolia* and *Terminalia arjuna* both individually and in combination. The formulations C1, C2, C3 and C4 were prepared by varying the composition and evaluated for their physicochemical properties and SPF. The study showed that formulation C4 having all three extracts of *Glycyrrhiza glabra, Tinospora cordifolia* and *Terminalia arjuna* was found to be of highest SPF value. The sunscreen property of all above-mentioned extracts is due to the presence of flavonoids and phenols present in *Glycyrrhiza glabra, Tinospora cordifolia* and *Terminalia arjuna.* All the compositions from C1 to C4 have shown SPF ranging from 4.37 to 24.26. From the observation in Table 13, it is concluded that the C4 has a higher amount of phenolic and flavonoid contents due to the combination of all three extracts. Therefore, it shows the highest SPF value. All the formulations are found to be suitable as sunscreen in day-to-day use based on their SPF value. The pH of all the compositions was nearer to skin pH. The homogeneous and non-greasiness of the formulations show that they can be effectively used by all age groups.

8. Source of Funding

None.

9. Conflict of Interest

None.

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Author biography

Yamini Shah, Associate Professor and Former HOD

Rajvee Mewada, Student Bachelor of Pharmacy https://orcid.org/0000-0002-2630-8113

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