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Original Article

Sun-Protective Potential of *Morinda citrifolia*: Formulation and Evaluation of Herbal Gel

Lakshmi Thabaj, Rashmi Surve*, Shweta Myagadeyavar, Udaykumar Bolmal

Department of Pharmaceutics, Rani Chennamma College of Pharmacy, Belagavi, Karnataka, INDIA.

ABSTRACT

Background: This study aimed to formulate and evaluate a sunscreen gel containing *Morinda citrifolia* (Noni) fruit extract, focusing on its Sun Protection Factor (SPF). Sunscreens are primarily used for photo protection and the experiment explored the efficacy of herbal alternative. **Materials and Methods:** Noni fruit was authenticated and extraction was carried out using aqueous, ethanolic and methanolic solvents. The extracts underwent phytochemical screening to identify bioactive compounds. Various polymers were used to formulate sunscreen gels and their physicochemical properties, including color, texture, appearance, spreadability, extrudability, pH, viscosity and SPF, were assessed. **Results and Discussion:** The ethanolic extract of *Morinda citrifolia* fruit showed a rich phytochemical profile with alkaloids, flavonoids, phenols and tannins. Formulations F1, F2 and F3 exhibited desirable physical properties, including optimal pH (5.8-7.0), good spreadability, extrudability and viscosity. These formulations demonstrated strong UV absorption (290-320 nm) with SPF values comparable to the marketed product, confirming effective sunscreen activity. **Conclusion:** This study successfully demonstrated the potential of *Morinda citrifolia*-based herbal gel as an effective sunscreen formulation. With its favorable SPF, compatibility with human skin and excellent physical properties, the gel represents a promising alternative to synthetic sunscreens. The increasing global demand for herbal products underscores the relevance and market potential of such formulations, paving the way for further research and development in this field.

Keywords: Sun protection factor, Noni fruit, Sunscreen, Gel.

Correspondence:
Mrs. Rashmi Surve
Department of Pharmaceutics, Rani Chennamma College of Pharmacy, Belagavi-590010, Karnataka, INDIA.
Email: rashmisurve08@gmail.com

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INTRODUCTION

Ultraviolet (UV) rays are a form of radiation produced by sunlight and are categorized into UV-A (320-400 nm), UV-B (290-320 nm) and UV-C (200-290 nm) (Morita, 2018). Among these, UV-A and UV-B rays significantly contribute to skin aging. Sunscreens either block, absorb or filter UV radiation, which have a number of immunosuppressive effects on the body. Using skin care products, in particular Sunscreens may be a useful strategy for lowering UV-generated Reactive Oxygen Species (ROS)-mediated photoaging (Margar *et al*., 2020). Sunscreen effectiveness against UV rays is measured by the Sun Protection Factor (SPF), which ranges from 0 to 100. An SPF value above 15 is considered to provide sufficient protection (Hanrahan, 2012).

Noni, also referred to as *Morinda citrifolia*, grows in south eastern Asia to Australia. Noni is renowned for having a very broad tolerance for environmental factors. It thrives in extremely dry conditions and may grow in infertile, acidic and alkaline soils to drenched areas. Traditional and modern uses exist for every part of the plant including the roots, bark, trunks, fruits and leaves. The traditional and contemporary medical uses of noni cover a wide range of ailments and disorders. Although, via a variety of health and cosmetics created in recent years, it has achieved great economic relevance globally. Fruit juices and powders derived from the fruit or leaves are among them (Nelson, 2003).

The noni plant's main constituents have been identified as asperuloside, scopoletin, octanoic acid, potassium, vitamin C, terpenoids, alkaloids, anthraquinones and other iridoids, citrifolinin, citrifoside, dehydroepoxymethoxygaertneroside, asperulosidic acid and deacetylasperuloside. The Noni fruit is the main source of the iridoid, a flavonoid component, which is very important antioxidants (Setyani and Setyowati, 2018).

Morinda citrifolia has antibacterial, antiviral, antifungal, anticancer, anti-tubercular, analgesic, immunological and mental health benefits, as well as anthelminthic properties. Because of its positive properties, the fruit juice of *Morinda citrifolia* is sold widely as a nutraceutical dietary supplement around the world. They include analgesic, hypotensive, anti-inflammatory, immunological boosting, etc., (Ali *et al*., 2016). Traditional practitioners have utilised noni to treat dermatoses like ringworm,

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dry skin, acne, pustules and other skin issues. Additionally, ripe noni fruit juice has been used for aesthetic purposes. The immature noni fruit that has been dried, the leaves, or the seeds that have been combined with coconut oil have all been used externally in some regions (Pande *et al*., 2005). The plant and the fruit are as depicted in Figure 1.

Topical medication delivery is the targeted administration of formulation through the ophthalmic, rectal, nasal, vaginal and cutaneous routes in the body in order to boost bioavailability and decrease negative effects and enhance patient compliance (Kumar *et al*., 2017).

Gels are semisolid systems made up of a dispersion of either big organic molecules or small inorganic particles that are impregnated with liquid. Hydrogels are water in soluble, three dimensional networks of polymer chain capable of holding large amounts of water (Silna *et al*., 2016).

MATERIALS AND METHODS

Materials

Noni fruits were received as a gift sample from Valyou Products Private Limited, Karnataka. All the chemicals used were of analytical grade. The Carbopol 934, Carbopol 940, Carbopol 980, HPMC K 15M, HPMC K 100, Chitosan, EDTA Disodium salt, Trimethanolamine, Propylene glycol, Ethanol, Coconut oil, Diethyl phthalate, Carboxy methyl cellulose were all procured from B. B. Chemicals. Methyl paraben was purchased from Visso traders, Karnataka.

Plant Collection and Authentication

The plant of *Morindra citrifolia* was authenticated at Indian Council of Medical Research (ICMR)-National Institute of Traditional Medicine (NITM), Belagavi, Karnataka, India. The herbarium specimens of the same have been deposited in their herbaria with accession number RMRC-1745.

Preparation of Plant Extract

The fresh noni fruits were washed with running water and cut into pieces with sterile knife and dried it in a hot air oven for 48 hr at 45°C. Fruit that has been dried and powdered are further extracted using ethanol, methanol and distilled water respectively. Each, 50 g of dried powder is extracted with 500 mL of 95% ethanol, 500 mL of 95% methanol and 500 mL of distilled water with vigorous shaking every 1 hr. After 5 days it was filtered using Whatman filter paper No.42 and the filtrate was boiled for 15-30 min till the volume has been reduced to half of its initial volume (Mariya *et al*., 2016; Ranvir *et al*., 2017).

Phytochemical Screening

The extracts were subjected to preliminary phytochemical screening for the detection of various plant constituents by standard procedures (Naganingam *et al*., 2012).

Formulation of Gel Based Sunscreen

The formulation chart is as shown in Table 1. The gel-based sunscreen was formulated in three different steps. Firstly, preparation of gel phase was carried out using polymers then preparation of liquid phase and at last incorporation of liquid phase into gel phase. Carbopol 934, Carbopol 940, Carbopol 980, chitosan, HPMC K 15M and HPMC K 100 were separately dissolved slowly with stirring in 60 mL of distilled water and then disodium edetate and triethanolamine were dissolved in 10 mL of distilled water separately and stirred for 10 min. 5 mL of propylene glycol, 0.1 mL propyl paraben, 0.2 mL of methyl paraben were mixed in 1 mL of coconut oil with the incorporation of extracted noni drug. Disodium edetate and triethanolamine solution were added to the respective polymer solution and the pH was then adjusted to 5-7 by stirring the solution for 10 min then propylene glycol solution was added with stirring for 10 min until a clear consistent gel was obtained (Aiyalu *et al*., 2016).

Evaluation of Formulated Gel

Physical characterization

The prepared gel formulations are inspected visually for their colour, appearance and texture.

pH Test

The pH of the prepared gel was measured using digital pH meter (Rolex India) 1 g of gel was dissolved in 100 mL of distilled water and it was placed for 2 hr and then dip the glass electrode into a gel. The measurement of pH of each formulation was done in triplicate (Mahendra and Rasika, 2019).

Spreadability

The spreadability was expressed in terms of time in seconds taken by 2 slides to slip off from the gel which was placed in between the slides, under certain load. Lesser the time taken for separation of the 2 slides, better the spreadability. The herbal gel formulation was placed over one of the slides. The other slide was placed on the top of the gel, such that the gel was sandwiched between the 2 slides in an area occupied by a distance of 7.5 cm along the slide. 100 g weight was placed upon the upper slides so that the gel between the 2 slides was pressed uniformly to form a thin layer. The weight was removed and the excess of gel adhering to the slides was scrapped off. The 2 slides in position were fixed to a stand without slightest disturbance and in such a way that only the upper slide to slip off freely by the force of weight tied to it. A 10 g weight was tied to the upper slide carefully. The time taken for the upper slide to travel the distance of 6.8 cm and separated

away from the lower slide under the influence of the weight was noted. The experiment was repeated by three times and the meantime was taken for calculation. Spreadability was calculated using formula (Donglikar and Deore, 2017).

$$S=M*L/T$$

Where,

M=Weight tied to upper slide (1 g),

L=length of glass slide (6.8 cm),

T=Time taken to separate the slides.

Extrudability

It is usual empirical test to measure the force required to extrude the material from tube. More quantity extruded better was Extrudability. The formulation under study was filled in clean, lacquered aluminium collapsible tube with nozzle tube of 5 mm opening and applies pressure on tube by keeping weights.

Extrudability was then determined by measuring amount of gel extruded through the tip when the pressure was applied on tube (Das *et al.*, 2011).

$$\text{Extrudability}=\text{Applied weight to extrude gel from tube (g)}/\text{Area(cm2)}$$

Viscosity

The viscosity of prepared gel was measured by brook field viscometer at 100 rpm 25°C temperature using spindle No. 6 (Dixit *et al.*, 2013).

Sun Protection Factor (SPF) Determination

The equation Mansur is used to calculate the value of SPF. The sample's absorption spectrum was measured using a UV-visible Spectrophotometer with 96% ethanol used as a blank. Absorption value measured between 290 and 320 nm, at intervals of 5 nm. Obtaining the uptake value (Abs) and multiplying it by EE x I. Table 2 displays the EE value x I for each period. The outcomes of EE x I's multiplication were added up. The SPF value of the samples tested is calculated by multiplying the sum by a Correction Factor (CF) with a value of 10. Using the Mansur technique, calculate SPF (Khan, 2018).

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

Where,

CF: Correction Factor (typically 10, but can vary based on the method used).

EE(λ): Erythemal Effectiveness at wavelength λ.

I(λ): Solar Intensity Spectrum at wavelength λ.

Abs(λ): Absorbance of the sample at wavelength λ.

Wavelength-290 and 320 nm, with a tolerance of 5 nm, as indicated in Table 2.

Table 1: Formulation of sunscreen gel (20 g).

Ingredients	F1	F2	F3	F4	F5	F6
Noni extract	15 g	15 g	15 g	15 g	15 g	15 g
Carbopol 934	1 g	-	-	-	-	-
Carbopol 940	-	1 g	-	-	-	-
Carbopol 980	-	-	1 g	-	-	-
Chitosan	-	-	-	1 g	-	-
HPMC K 15M	-	-	-	-	1 g	-
HPMC K 100	-	-	-	-	-	1 g
Disodium edetate	0.005 g	0.005 g	0.005 g	0.005 g	0.005 g	0.005 g
Propyl paraben (0.2%)	0.1 mL	0.1 mL	0.1 mL	0.1 mL	0.1 mL	0.1 mL
Methyl paraben (0.5%)	0.2 mL	0.2 mL	0.2 mL	0.2 mL	0.2 mL	0.2 mL
Propylene glycol (5%)	5 mL	5 mL	5 mL	5 mL	5 mL	5 mL
Coconut oil	1 mL	1 mL	1 mL	1 mL	1 mL	1 mL
Triethanolamine	1 mL	1 mL	1 mL	1 mL	1 mL	1 mL
Distilled water	QS	QS	QS	QS	QS	QS

QS: Quantity Sufficient.

Figure 1: *Morindra citrifolia* fruit.

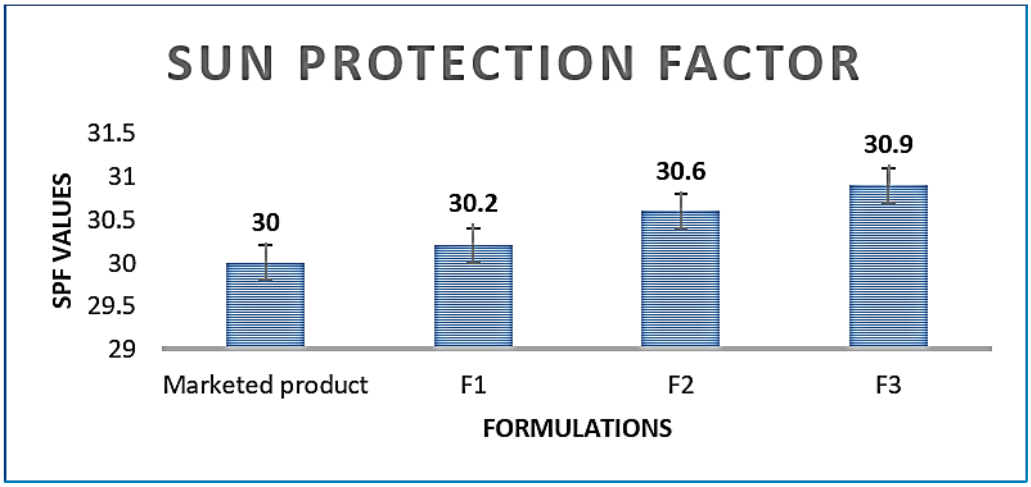

Figure 2: Comparison of Sun Protection Factor across formulations.

Stability Test

The stability test of the gel was carried out by storing the gel in a tightly-closed container for 28 days at 75% Relative Humidity and 30°C temperature. Changes in the physical properties such as organoleptic (color, shape, odor), spreadability, pH and SPF were observed. If there is no significant change during the storage period, its characterization remains within acceptable limits, preparation is said to be stable (Das *et al.*, 2011).

RESULTS

Authentication

Morinda citrifolia fruit was collected and authenticated by Dr. Harsha. V. Hegde (Scientist E). ICMR- National Institute of Traditional Medicine (NITM).

Extraction

As compared to methanolic and aqueous maceration the extract yield for ethanolic maceration was better.

Phytochemical screening

Phytochemical screening result of the ethanolic extract of *M. citrifolia* fruit powder is as represented in Table 3.

Physical examination

As compared to formulations F1, F2 and F3, the formulations F4, F5 and F6 do not meet the expected texture properties as shown in Table 4. Hence only formulation F1, F2 and F3 were considered for further evaluation.

Determination of pH

The pH of the F1, F2 and F3 gels ranged from 6 to 7 which is similar to the pH range of human skin and these 3 formulations

were compared with marketed product. The results are as shown in Table 5.

Spreadability

The therapeutic potential of a gel formulation depends on the spreadability, which describes how far a gel spreads when applied to skin. In this investigation, all the formulations had acceptable Spreadability as shown in Table 5.

Extrudability

All 3 formulations and the marked formulation showed good and acceptable extrudability.

Viscosity

The viscosity of a fluid serves as a proxy for its flow resistance; the higher the viscosity, the higher the flow resistance. Viscosity is a crucial factor to consider when assessing gel preparations. The viscosities of formulations F1, F2 and F3 are listed in Table 5.

Sun protection factor

At 290-320 nm, F1, F2 and F3 gels displayed high absorption. The SPF values for three gels are listed in Table 5. All the 3 formulations had good sunscreen activity as shown in Figure 2.

Stability

The stability test as per ICH guidelines showed no significant changes in physicochemical properties, including color, texture, appearance, spreadability, extrudability, pH, viscosity and SPF after 28 days of storage.

DISCUSSION

The study aimed to develop and evaluate herbal gel formulations containing *Morinda citrifolia* (Noni fruit) extract for their potential use as sunscreens. The findings highlight several significant aspects of the formulation process, phytochemical composition and evaluation outcomes. The successful authentication of *M. citrifolia* fruit ensures the botanical source's credibility, a critical step in herbal product development. Among the solvents tested, ethanolic maceration yielded the highest extract recovery, demonstrating ethanol's effectiveness in extracting bioactive compounds from Noni fruit. The ethanolic extract of *M. citrifolia* demonstrated the presence of essential bioactive compounds, including alkaloids, flavonoids, glycosides, phenols and tannins. These constituents are known for their antioxidant and photoprotective properties, which support the rationale for using *M. citrifolia* in sunscreen formulations (Ranvir *et al.*, 2017; Naganingam *et al.*, 2012).

Out of six formulations, F1, F2 and F3 demonstrated acceptable physical characteristics, including good consistency, non-greasy texture and appropriate pH levels (5.8-7.0), compatible with human skin. The exclusion of F4, F5 and F6 highlights the critical role of formulation optimization in achieving desired properties. F1, F2 and F3 showed excellent spreadability and extrudability, comparable to the marketed product. These properties are essential for consumer acceptability and ease of application, ensuring even coverage on the skin. The viscosity values of the formulations were within acceptable ranges, which is crucial for achieving optimal adherence to the skin without being overly thick or runny (Das *et al.*, 2011). The SPF values of F1, F2 and F3 were comparable to the marketed formulation (SPF~30), confirming their effectiveness as sunscreens. The high absorbance in the UVB range (290-320 nm) supports the gel's photoprotective

Table 2: Value of EE*I at wavelength 290-320 nm.

Wave length	EE*I
290	0,0150
295	0,0817
300	0,2874
305	0,3278
310	0,1864
315	0,0839
320	0,0180
Total	1

Table 3: Results of phytochemical analysis. (+++ PRESENT in more amount, --- ABSENT).

Phytochemicals	Tests applied	Inference
Alkaloids	Hager's test	+++
	Wanger's test	+++
	Mayer's test	+++
	Dragendroff's test	+++
Glycosides	1. Cardiac glycosides	+++
	Killer killani test	
	2. Saponin glycosides	+++
	Forth test test	
	3. Anthraquinine glycosides	---
	Brontranger's test	
Carbohydrates	Molish test	+++
	Benedict test	+++
	Fehling's test	+++
Steroids and terpenoids	Libermann burchard test	+++
Proteins	Biuret test	+++
Amino acids	Ninhydrin test	+++
Flavonoids	Shinoda test	+++
Phenols and tannins	Ferric chloride test	+++
Lipids and fats	Powder drug is rubbed on filter paper	+++

Table 4: Physical characterization of gel.

Physical examination	Marketed product	F1	F2	F3	F4	F5	F6
Colour	Pale yellow	Brown	Brown	Brown	Brown	Brown	Brown
Texture	Non greasy	Non greasy	Non greasy	Non greasy	Liquid	Liquid	Liquid
Consistency	Good	Good	Very good	Good	Watery	Not good	Not good

Table 5: Evaluation of sunscreen gel.

Evaluation Parameter	Marketed product	F1	F2	F3
pH	6.2±0.2	6.6±0.3	7±0.2	6.3±0.2
Spreadability	24.5±0.1	23.5±0.2	24.2±0.1	25.06±0.1
Viscosity (cps)	24.5±0.1	23.5±0.2	24.2±0.1	25.06±0.1
SPF	30±0.5	30.2±0.3	30.6±0.5	30.9±0.4

properties, attributed to the phytochemical constituents of the *M. citrifolia* extract (Dixit *et al*., 2013; Khan, 2018).

CONCLUSION

In conclusion, the development of an herbal sunscreen gel using *M. citrifolia* extract aligns with the growing demand for natural, skin-friendly formulations. This study establishes a strong foundation for advancing herbal sunscreens as effective and safer alternatives to synthetic products. The idea that natural medicines are safer and have fewer side effects than synthetic ones make them more acceptable. The demand for herbal formulations is rising on the global market. Establishing the herbal gel with *M. citrifolia* fruit extract is a trending approach. However further *in vivo* studies are highly recommended to prove the efficacy of our developed sunscreen formulation.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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