Research Article

Assessment of *in-vitro* Sun protection factor and rheological profile of some marketed sunscreen formulation in East Vidarbha area

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Abstract

Objective: The aim of this study was to determine the in vitro SPF values along with P^H and rheological assessment of five selected sunscreen formulation having labeled SPF, used in east vidharbha region. **Material and methods:** The Sun Protection Factor (SPF) is a very popular factor in assessment of sunscreens product. Unfortunately, there is no proper data available on the study of those cosmetic products mainly on SPF. In fact, among much kind of sun screen products used daily in east vidharbha area, only on a few numbers the SPF is labeled. Five different marketed sunscreen formulation having labeled SPF values in range of 15 to 30 were selected, named as F1 to F5 and assessed for in vitro SPF, pH and rheological analysis. It can be observed that the SPF values found for all F1 to F5 are not in close agreement with the labeled SPF. **Results and discussion:** Formulation F1, F2, F3 and F5 have found more than 80% while F4 have found 73.33% when compared with labeled SPF. Rheological profiles indicated that the all sunscreens formulation have pseudo plastic properties and exhibited pH in the range 6.2 to 7.9 Also during collection of sunscreen products it has been observed that, peoples are less aware about protective spectrum of sunscreens, their correct method of application in vidharbha region. **Conclusion:** Study we want to suggest the attention of the scientific community for and also legal authorities that should control the sunscreens industry in order to supervise and prevent this kind of in corrections, maybe creating legal limits for SPF labeled and the correct amount to apply.

***Keywords*:** Sun protection factor (SPF), rheological profile, pH measurement

Introduction

The skin is the body's first line of defense for external exposure. The signs of ageing skin are most visible in the skin. Although, ageing skin is not a threat of a person, it can have a detrimental effect on the psychology of a person. Much of the premature ageing occurs as a direct or indirect result of skin's interaction with environment. Every year, about one million people are diagnosed with skin cancer and about 10.000 die from malignant melanoma. Most skin cancer occurs on the areas of the body that are most frequently exposed to the sun, such as the face, neck, head and back of the hands (Allen et al., 2014; Dutra et al., 2004; More et al., 2013). The harmful effects of solar radiation are caused predominantly by the ultraviolet (UV) region of the electromagnetic spectrum, which can be divided into three regions: UVA, from 400 to 320 nm; UVB, from 320 to 290 nm and UVC, from 290 to 200 nm. UVC radiation is filtered out by the atmosphere before reaching earth. UVB radiation is not completely filtered out by the ozone layer and is responsible for the damage due to sunburn and pyrimidine dimmers. UVA radiation reaches the deeper layers of the epidermis and dermis and provokes the premature ageing of the skin and is responsible for the generation of free radicals. UVB radiation is involved in 65% damage of all skin. Exposure to ultraviolet radiation has pronounced acute and chronic effects on the skin. People are conscious of the possible dangers of photo ageing, sunburn and skin cancer, occurring as a result of sun overexposure (Malsawmtluangi et al., 2013; Mishra et al., 2001; Osterwalder et al., 2009). To prevent those

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harmful sun effects, scientists formulated body creams and lotions where they added sunscreen like active ingredients to protect peoples through absorbing, scattering or reflecting radiation. The molecules in sunscreen absorb most of UVB and prevent it from reaching the skin just as the atmosphere molecules absorb UVC and prevent it from reaching the ground. Thus, physical and/or chemical sunscreen are now incorporated into everyday products such as moisturizers, creams, lotions, shampoos, mousses, and other hair and skin formulations. Sunscreens incorporate a wide variety of chemicals like organic compounds and their derivatives, organic esters, salt and inorganic compounds (mineral) which has particular absorbance (Bernerd et al., 2003; Fonseca et al., 2013; Kale et al., 2011; Shenekar et al., 2014).

The efficacy of a sunscreen product has been recognized as an important public health issue and it is usually expressed by the sun protection factor (SPF), which is defined as the UV energy required producing a minimal erythema dose (MED) on protected skin, divided by the UV energy required to produce a MED on unprotected skin. The minimal erythemal dose (MED) is defined as the lowest time interval or dosage of UV light irradiation sufficient to produce a minimal, perceptible erythema on unprotected skin.

$$SPF = \frac{\text{Minimal erythemal dose in sunscreen protected skin (MED)p}}{\text{Minimal erythemal dose in unprotected skin (MED)u}}$$

The higher the SPF, the more effective is the product in preventing sunburn (Colipa et al., 2007). The regular use of these sunscreen formulations can help to reduce the chance of the harmful effects of ultraviolet radiation. However, it is necessary that a very efficient sunscreen substance be used in the cosmetic formulation. An ideal sunscreen agent has to be safe, chemically inert, nonirritating, nontoxic, photo stable, and should provide complete protection to the skin. The choice of the adequate sunscreen is influenced by the prototype of the individual (Bernerd et al., 2003; Fonseca et al., 2013). The photo protection afforded by topical sunscreen against solar ultraviolet radiation exposure can be determined in vivo or in vitro. The in vivo determination is ideally evaluated by photo testing in human volunteers. This type of determination has been used for many years and although useful and precise, is a time consuming process, complex and expensive, particularly when information concerning to the protection against long wavelength (UVA) is required (Allen et al., 2014; Dutra et al., 2004). As consequence, much effort has been devoted to the development of in vitro techniques for assessing the photo protection of sunscreen compounds. Thus, for economical, practical and ethical considerations, a suitable method for in vitro determination of SPF is used more often. SPF is primarily a measure of UV protection, as UVB is 1000 times more erythemogenic than UVA (Kale et al., 2011). The in vitro methods are in general of two types. Methods which involve the measurement of absorption or the transmission of UV radiation through sunscreen product films in quartz plates or biomembranes, and methods in which the absorption characteristics of the sunscreens agents are determined based on spectrophotometer analysis of dilute solutions (More et al., 2013).

The assessment of SPF in vitro can be done by two methods. The first method is measuring of absorption or the transmission of UV radiation through sunscreens product films in quartz plates or biomembranes, and the second method is determining absorption characteristics of sunscreen agent based on spectrophotometric analysis of dilute solutions (Mansur et al., 1986; Pissavini et al., 2003). By UV spectrophotometric technique and employing a simple formula developed by Mansur equation. The in vitro SPF can be calculated by following equation:

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

Where EE (λ): erythemal effect spectrum,

I(λ): solar intensity spectrum,

Abs: Absorbance of sunscreen product.

CF: correction factor=10

The value of EE (λ) are constant and predetermined (Arun et al., 2011) as shown in Table 1.

As being Vidharbha is part of tropical southeastern India, the exposure to UVA and UVB (sunlight) rays is a regular phenomenon especially in summer season. It becomes imperative that one takes adequate measures to protect their skin from burns/radiation, especially during the day time when solar radiation is at its peak. In Vidharbha region of Maharashtra state, major town, more than the half of people spends their time outdoor, under the sun at an average temperature of about 30°C. There are concerns of sun over exposure and skin damaging results into sunburn and skin

Table 1. Normalized product function used in the calculation of SPF

Wavelength (λ nm)	EE x I (normalized)
290	0.051
295	0.0817
300	0.2874
305	0.3278
310	0.1864
315	0.0839
320	0.018

cancer also. This leads to rapid growth of commercially available cosmetic products of different manufacturers. Unfortunately, there is no proper data available on the study of those cosmetic products mainly on SPF. In fact, among many kind of sunscreen products used daily in east Vidharbha region, only on a few numbers the SPF is labeled. At the light of their composition and their importance for the human health, those cosmetic products should satisfy at the quality control. The aim of this study was to determine the in vitro SPF values along with P^H and rheological assessment of five marketed sunscreen formulation having labeled SPF, used in east Vidharbha area.

Material and Methods

Reagent and sample

Commercial sunscreen product of different brand having labeled spf value in between 15 to 30 were purchased from local market of Gondia and Bhandara (M.S) & Ethanol (analytical grade) was purchased from Standard scientific company Nagpur.

Instrumentation

UV-Visible double beam spectrophotometer (Systronic-2201), Brookfield viscometer (model-LVDV-I prime), E.I. Digital PH meter (model- 381), Digital balance, Sonicator

Material and methods

The five marketed sunscreens formulation were named as F1, F2, F3, F4 & F5. They were selected to assess for in vitro SPF, pH and rheological study.1.0 g of each formulation was weighed individually, transferred to 100ml volumetric flask and finally diluted to volume with ethanol. Further, it was kept for the ultrasonication for 15 min. and filtered through Whatman filter paper no. 1 ,discarded the initially 10 ml. Afterwards 5 ml aliquot was transferred to a 25ml volumetric flask and the volume was adjusted with ethanol (Dutra et al., 2004). The absorption spectra of six formulations in solution were obtained in the range of 290 to 320 nm, every 5 nm using uv-visible double beam spectrophometer equipped with 1 cm quartz cell and a computer. Three determinations were made at each point using ethanol as a blank. Further SPF values were determined using Mansur equation.

The pH was measured with a Digital pH meter. The combination electrode was introduced into each six formulation and the reading performed after stabilization. The rheological profile was assessed with a Brookfield L-V viscometer by taking a 150 ml of each sunscreen at 25°C.

Results and discussion

The SPF values of six marketed formulation found in east Vidharbha area were evaluated by UV-Visible spectrophotometer by applying Mansur mathematical equation. The average absorbance for each formulation has been mentioned in table 2.

Table 2. Average absorbance of six marketed sunscreen formulation in range 290-320 nm

Range	F1	F2	F3	F4	F5
290	1.801	2.521	1.701	1.744	1.712
295	1.822	2.263	1.724	1.856	1.725
300	1.814	2.536	1.820	1.857	1.736
305	1.820	2.589	1.801	1.896	1.845
310	1.801	2.437	1.714	1.789	1.895
315	1.714	2.411	1.745	1.752	1.896
320	1.703	2.402	1.736	1.723	1.899

Table 3. Labeled and Calculated SPF values of the five marketed formulation

Code	Marketed Sample	Labeled SPF	Calculated SPF	Calculated SPF/Labeled SPF
F1	Oshea Herbal Phytolight	25	22.43	89.7%
F2	Suncote Gel	30	25.29	84.3%
F3	Oriflamme Sun Care Photo stable	20	16.4	82%
F4	Vaseline Healthy White Lotion	24	17.6	73.33%
F5	Lotus Herbals Safe Sun	20	17.4	87%

Table 4. Rheological behavior shear stress vs shear rate

Shear stress	Shear rate	Formulations			
0	**F1**	**F2**	**F3**	**F4**	**F5**
0.002	0.01	0.04	0.03	0.02	0.05
0.08	1.2	3.2	3.1	1.9	3.4
0.1	1.8	3.7	3.8	2.5	3.9
0.2	2.1	4.8	4.2	2.9	4.9
0.5	3.4	5.4	4.9	3.7	5.7
1	3.8	6.1	5.6	4.9	6.4

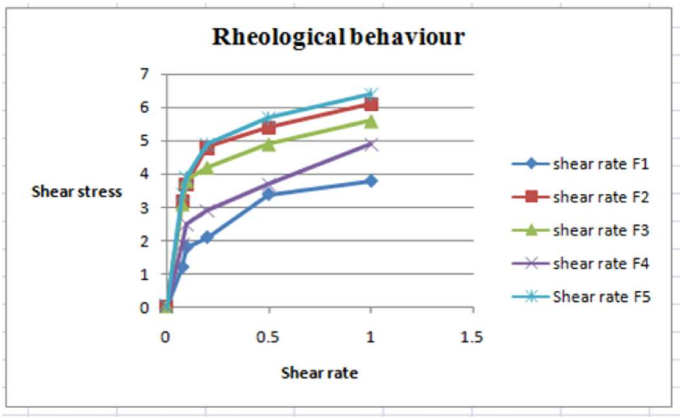

Figure 1. Rheological behavior of sunscreens of five marketed formulation

The % comparison of labeled and calculated SPF has been expressed in table 3. It can be observed that the SPF values found for all F1 to F5 are not in close agreement with the labeled SPF. Formulation F1, F2, F3 and F5 have found more than 80% while F4 have found 73.33 when compared with labeled SPF.

It has been important to study among other things, the effect of the vehicle on the thickness and uniformity of sunscreen films. In this study, we determined viscosity and rheological behavior of the formulations by using a Brookfield rheometer. The formulation F2 has found higher thixotropy with SPF (25.29) .The F5 formulation presented the close SPF with F4 formulation, but had a least high thixotropy.The formulationF1 and F3 has been found least highest and least lowest SPF but have been nearest thixotropy.The above rheological study of different sunscreen formulation was tested in different shear rate and 25°C. All five marketed sunscreens were showed pseudoplastic or shear thinning behavior because of decreasing viscosity with an increasing shear rate as shown in figure 1. The sunscreen formulations with a pseudoplastic flow produce a coherent protective film covering the skin surface and this activity is important for adherence to skin.

The pH of commercial sunscreen samples was found almost a close to neutral i.e. around pH 7 and compatible with human's skin as shown in. The variation of emulsion used in the formulations by interaction of vehicle components such as esters, emollients and emulsifiers used in the formulation, the pH system and viscosity and emulsion rheological properties, which can be increased and decrease UV absorption of each sunscreen (Dutra et al., 2004).

Conclusion

It can be observed that the SPF values found for all F1 to F5 are not in close agreement with the labeled SPF. Formulation F1, F2, F3 and F5 have found more than 80% while F4 have found 73.33% when compared with labeled SPF. There are many factors affecting the determination of SPF value like no applicability of proper methods for evaluation of sunscreen products, the use of different solvents the effects and interactions of vehicle with the skin, pH, viscosity and rheological properties. The rheological profiles indicated that the all formulations are pseudo plastic as the shear rate shows inverse relation with viscosity. The pseudo plastic is desirable property needed by all types of sunscreens to produce a coherent protective film covering the skin surface and distributed active ingredients. The assessed pH indicated that all formulation have almost close to neutral pH, which is compatible human skin.

Also during collection of sunscreen products it has been observed that, peoples are less aware about protective spectrum of sunscreens, their correct method of application in east vidharbha region. We have an obligation to alert the population for the correct use of sunscreens, to provide correct and precise advice to prevent skin damages caused by UV radiation. With this study we want to suggest the attention of the scientific community for and also legal authorities that should control the sunscreens industry in order to supervise and prevent this kind of in corrections, maybe creating legal limits for SPF labeled and the correct amount to apply.

Conflict of interest

None

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