ORIGINAL RESEARCH

Investigation of Sun Protection Factor (SPF) of Raspberry Seed Oil, Niacinamide and Zinc Oxide in Combination for their Possible Use in a Sunscreen Formulation

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ABSTRACT

Introduction: The Ultraviolet (UV) radiations emitted from the sun have several negative effects on the skin of humans. Some of the harmful effects of the UV rays are redness, skin inflammation, rashes, sunburn, wrinkles, photoaging and skin cancer. It is very important to block or reflect UV rays due to the rising cases of skin cancers secondary to UV damage. Sunscreens are presently one of the preferred and predominant modes of sun protection and must be broad spectrum to be able to block both Ultraviolet A (UVA) and Ultraviolet B (UVB).
Objectives: The primary objective of our project is to assess the Sun Protection Factor (SPF) of a combination of three active ingredients: Zinc Oxide (ZnO), Niacinamide, and Raspberry Seed Oil (RSO).
Methods: Seven samples were prepared, where sample 1 - 6 contains different combinations of these three active ingredients and sample 7 which contains only Raspberry Seed Oil (10%). The SPF of the seven samples was measured according to the standard procedure using an UV-Visible spectrophotometer. The SPF values were then calculated using the Mansur equation.
Results: The result revealed that the SPF of the formulation were below 30 therefore average photoprotective activity was observed.
Conclusions: It can be concluded that the formulations were not able to provide sufficient protection from the UV rays.

INTRODUCTION

The skin is the largest organ of our body. It also serves as a major protective organ of the body. It is well known that over exposure of skin to Ultraviolet (UV) radiation results in oxidative stress, inflammation, immune suppression and Deoxyribonucleic acid (DNA) damage, which can lead to skin ageing and skin cancer.[1] The UV rays that reach the earth are divided into Ultraviolet B (UVB) (280-315 nm), and Ultraviolet A (UVA) (315-400 nm). Thus, broad spectrum sunscreens are used to prevent damage from both UVA and UVB irradiation and reduce the risk of skin cancers.

Many oils extracted from fruit and vegetable seeds contain natural tocopherols, carotenoids and essential fatty acids, which make them highly valuable for penetrating and carrying properties.[2] Raspberry Seed Oil (RSO) is gaining increasing attention by cosmetics industry. It is used as an ingredient in body and face moisturizers because it contains high concentrations of Vitamins A and E.[3] These vitamins are essential for the maintenance and repair of keratinocytes. Raspberry seed oil is also known to possess a Sun Protection Factor (SPF) value (29-50) and thus can be applicable in sunscreen formulation.[4,5] Niacinamide or Vitamin B_3 can lock in moisture, help build proteins in the skin and can also be used as an anti-oxidant and anti-inflammatory agent.[6,7] Zinc Oxide (ZnO) is considered as one of the best choices for UV protection as it offers a broad-spectrum coverage by blocking both UVA and UVB. Besides protecting against the UV radiation, it also possesses antimicrobial properties.[8] We are piloting sunscreen formulations containing Raspberry seed oil, Niacinamide and Zinc Oxide to assess the SPF in various combinations of these three ingredients.

METHODS

Preparation of Formulations

Sample 1: Low dose: RSO (5%) + Niacinamide (2%) + Zinc Oxide (5%); Sample 2: High dose: RSO (10%) + Niacinamide (5%) + Zinc Oxide (10%); Sample 3: Low dose: RSO (5%) + Zinc Oxide (5%); Sample 4: High dose: RSO (10%) + Zinc Oxide (10%); Sample 5: Low dose: RSO (5%) + Niacinamide (2%); Sample 6: High dose: RSO (10%) + Niacinamide (5%); Sample 7: RSO (10%).

Raspberry seed oil, Niacinamide and Zinc oxide were purchased from local pharmacies. The experiments were performed according to Kaur and Saraf, 2010 [2] with a few modifications. The solubility of oils was determined in different ratios of ethanol and distilled water. The maximum solubility was observed in 40% ethanol and 60% distilled water solution. Initial stock solution of RSO (5%, 10%), Niacinamide (2%,5%) and ZnO (5%, 10%) was prepared in ethanol and water solution (40:60). Zinc oxide was first made soluble by addition of a base Sodium hydroxide (NaOH) to form the stock solution. For making sample 1 – 6, the stock solutions were mixed in equal ratios per defined formulation. Then, a 0.1% solution was prepared from each of the sample. Then the prepared aliquots were scanned for measuring the absorbance using UV-Visible spectrophotometer. Three readings of the absorbance were taken and the mean absorbance was calculated.

Sun Protection Factor Determination

The prepared aliquots were scanned between 290 and 320 nm at 5-nm intervals using a Shimadzu UV-Visible spectrophotometer, with a 40% ethanol and 60% distilled water solution serving as the blank. SPF was calculated using Mansur equation (**Figure 1**).

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

Figure 1. Mansur Equation, where CF = correction factor (10), EE (λ) = erythmogenic effect of radiation with wavelength λ, Abs (λ) = spectrophotometric absorbance values at wavelength λ. The values of EE × I are constants.

RESULTS

The UV absorbance was measured at different wavelengths for the prepared samples (Sample 1-7) using a UV spectrophotometer. The wavelengths included 290, 295, 300, 305, 310, 315, and 320 nm. **Table 1** gives the normalized product function which was used in the

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

Wavelength (λ nm)	EE*I (normalized)
290	0.0150
295	0.0817
300	0.2874
305	0.3278
310	0.1864
315	0.0839
320	0.0180

calculation of SPF of the different samples and **Figure 2** illustrates the calculated SPF of all the samples in a graphical format. The recorded absorbance and the calculation of SPF for the samples are given in **Table 1S – 7S** (Supplementary Data set).

The SPF of a combination of Raspberry seed oil (5%), Niacinamide (2%), and Zinc Oxide (5%) was evaluated at low dose and the obtained results shows that the SPF of sample one has a value of 14.885. In sample two SPF of the Raspberry seed oil (10%), Niacinamide (5%) and Zinc Oxide (10%) at high dose showed a value of 24.405.
The SPF of sample three containing RSO (5%) and Zinc Oxide (5%) in low doses was 13.357. The SPF of sample four containing RSO (10%) and Zinc Oxide (10%) in high doses was 23.236.

The SPF of sample 5 containing Raspberry seed oil (5%) and Niacinamide (2%) in low doses was 12.939, and sample 6 which contained Raspberry seed oil (10%) and Niacinamide (5%) in high doses was 22.796. The SPF of sample 7 containing Raspberry seed oil (10%) was 19.930.

DISCUSSION

Many factors such as the combination and concentration of the sunscreens, the use of different solvents, interaction of vehicle components, type of emulsion, emulsifiers and pH used in the formulation affects the determination of SPF values.[9] Therefore, to develop sunscreens with better safety and high SPF, the formulator needs to take into consideration multiple physical and chemical properties of ingredients.

Herbal ingredients can be considered in sunscreen for their photoprotective properties. Besides providing SPF, RSO is also considered a very gentle and lightweight moisturizing solution. RSO encourages natural water retention in the skin cells which helps prevent skin ageing. RSO will not clog any pores therefore it is non-comedogenic.[3] Niacinamide or Vitamin B_3 can lock in moisture, act as an anti-oxidant and anti-inflammatory agent, and would serve as a valuable component in sunscreen formulations.[7]

Zinc oxide is widely used to treat a variety of skin conditions, including itch, atopy/eczema, diaper rash etc. It is the broadest spectrum

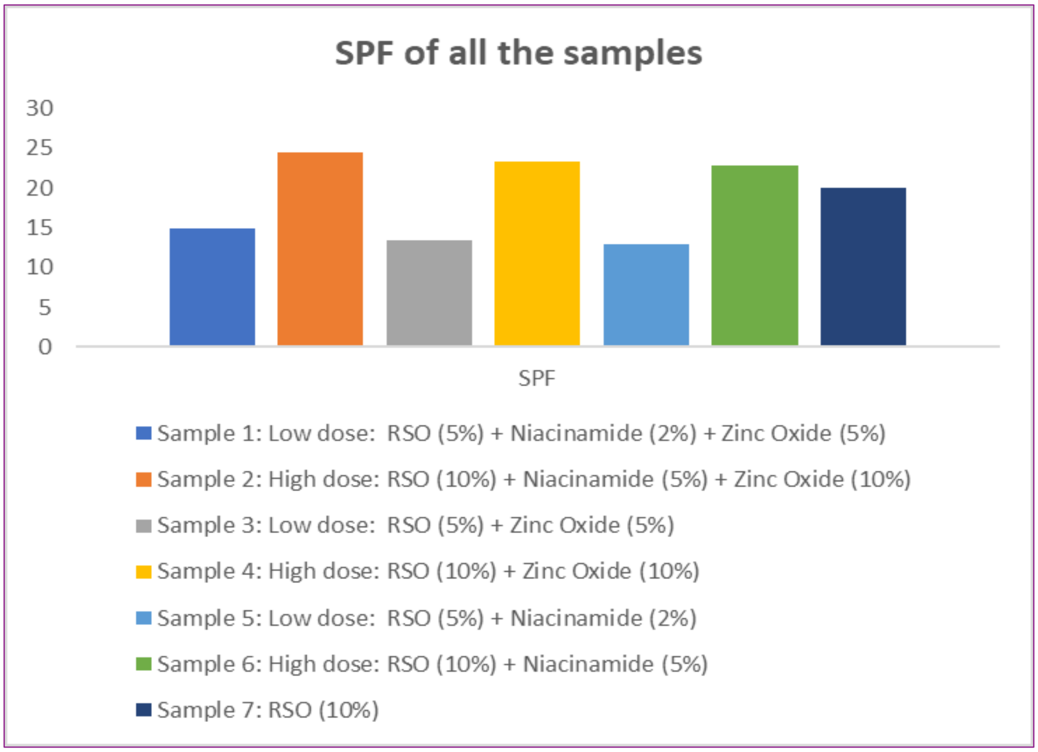

Figure 2. SPF of all the samples (1-7).

UVA and UVB absorber that is approved for use as a sunscreen by the U.S. Food and

Drug Administration (FDA).[10,11] Moreover, it is completely photostable.[10] It is a physical UV blocker that is deemed safe even in pediatric patients. Therefore, addition of Zinc oxide may contribute to increase in the SPF of the formulation without compromising with the overall safety profile.

Our study shows that the SPF of raspberry seed oil is 19.930 at a high dose of 10%, and when used in combination with Niacinamide and Zinc oxide the SPF increases. This increase in SPF value might be due to the synergistic effect of the combination. The highest SPF was found to be of Sample 2 which contains Raspberry seed oil (10%), Niacinamide (5%) and Zinc Oxide (10%) in high doses. It was previously mentioned that Raspberry seed oil contains an SPF of 29-50 which is slightly higher in compared to our study showing an SPF activity of 19.930 at a dose of 10%.[4,5] Our study showed that the SPF values of the combined samples (i.e. sample numbers 2, 4, and 6) in high doses were close to 30. The American academy of Dermatology suggests using sunscreens with at least 30 SPF.[12] Our formulations in

combined form came close however did not reach the minimum SPF requirement for making sunscreens. SPF determination is

considered an important test for screening ingredients widely used in the cosmeceutical industry. The higher the SPF is, the more protection offered by phytoconstituents against UV light.[13] If correctly mixed, the seed oils with other sunscreens like ZnO should absorb UV radiations (290–400 nm) to give enough SPF greater than 30 for photoprotection.

One of the limitations we found is the formulations in our method did not produce the minimum requirement for SPF. Sample 2 came closest to reaching the required amount of SPF needed for protection. The other limitations we found is that addition of ZnO did not lead to high enough SPF as expected. This may be because ZnO is insoluble in water/alcohol and made soluble through addition of NaOH. This may have resulted in degradation of the ZnO through formation of zincates, as ZnO reacts with NaOH.[14] To overcome this problem, we recommend adding the zinc oxide powder directly into a cream or lotion base and then measure the SPF of the total cream formulation.

Addition of NaOH is not required for sustaining solubility of ZnO in ointment, lotion or cream formulations and suggests higher concentrations of ZnO in these vehicles can be mixed with Niacinamide and Raspberry seed oil. By eliminating NaOH we hope to obtain higher SPF values in future studies.

CONCLUSION

The current study aimed to assess the SPF of a combination of three active ingredients. This combination has the potential to offer broad-spectrum UV protection while maintaining a favourable safety profile. Raspberry Seed Oil provided average UV protection by absorbing the harmful UV-rays and ensured consumer safety and avoidance of harmful organic UV filters with potential toxic effects. When the raspberry seed oil was used in combination with Niacinamide and Zinc oxide the SPF values increased slightly which shows the synergistic activity of the active ingredients. More research with different vehicles needs to be done to increase the SPF value without compromising safety.

Conflict of Interest Disclosures: None

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Supplement

Table 1S: Determination of SPF value for Sample 1.

Wavelength (λ nm)	EE*I (normalized)	Mean Absorbance	CF × EE (λ)× I (λ)× Abs (λ)	SPF
290	0.0150	2.342	0.351	14.885
295	0.0817	2.240	1.830	
300	0.2874	1.715	4.928	
305	0.3278	1.507	4.939	
310	0.1864	1.071	1.996	
315	0.0839	0.876	0.734	
320	0.0180	0.598	0.107	

Sample 1: Low dose: RSO (5%) + Niacinamide (2%) + Zinc Oxide (5%)

Table 2S: Determination of SPF value for Sample 2.

Wavelength (λ nm)	EE*I (normalized)	Mean Absorbance	CF × EE (λ)× I (λ)× Abs (λ)	SPF
290	0.0150	3.807	0.571	24.405
295	0.0817	3.322	2.714	
300	0.2874	2.811	8.079	
305	0.3278	2.497	8.185	
310	0.1864	1.796	3.347	
315	0.0839	1.605	1.346	
320	0.0180	0.906	0.163	

Sample 2: High dose: RSO (10%) + Niacinamide (5%) + Zinc Oxide (10%)

Table 3S: Determination of SPF value for Sample 3.

Wavelength (λ nm)	EE*I (normalized)	Mean Absorbance	CF × EE (λ)× I (λ)× Abs (λ)	SPF
290	0.0150	2.074	0.311	13.357
295	0.0817	1.929	1.575	
300	0.2874	1.536	4.414	
305	0.3278	1.402	4.595	
310	0.1864	0.932	1.737	
315	0.0839	0.764	0.640	
320	0.0180	0.476	0.085	

Sample 3: Low dose: RSO (5%) + Zinc Oxide (5%)

Table 4S: Determination of SPF value for Sample 4.

Wavelength (λ nm)	EE*I (normalized)	Mean Absorbance	CF × EE (λ)× I (λ)× Abs (λ)	SPF
290	0.0150	3.360	0.504	23.236
295	0.0817	3.014	2.462	
300	0.2874	2.729	7.845	
305	0.3278	2.294	7.520	

310	0.1864	1.866	3.478	
315	0.0839	1.525	1.279	
320	0.0180	0.826	0.148	

Sample 4: High dose: RSO (10%) + Zinc Oxide (10%)

Table 5S: Determination of SPF value for Sample 5.

Wavelength (λ nm)	EE*I (normalized)	Mean Absorbance	CF × EE (λ)× I (λ)× Abs (λ)	SPF
290	0.0150	2.157	0.323	12.939
295	0.0817	2.002	1.635	
300	0.2874	1.510	4.339	
305	0.3278	1.276	4.182	
310	0.1864	0.957	1.783	
315	0.0839	0.716	0.600	
320	0.0180	0.428	0.077	

Sample 5: Low dose: Raspberry seed oil (5%) + Niacinamide (2%)

Table 6S: Determination of SPF value for Sample 6.

Wavelength (λ nm)	EE*I (normalized)	Mean Absorbance	CF × EE (λ)× I (λ)× Abs (λ)	SPF
290	0.0150	3.274	0.491	22.796
295	0.0817	3.031	2.476	
300	0.2874	2.655	7.632	
305	0.3278	2.281	7.477	
310	0.1864	1.756	3.273	
315	0.0839	1.515	1.271	
320	0.0180	0.982	0.176	

Sample 6: High dose: RSO (10%) + Niacinamide (5%)

Table 7S: Determination of SPF value for Sample 7.

Wavelength (λ nm)	EE*I (normalized)	Mean Absorbance	CF × EE (λ)× I (λ)× Abs (λ)	SPF
290	0.0150	2.989	0.448	19.930
295	0.0817	2.556	2.088	
300	0.2874	2.367	6.802	
305	0.3278	1.975	6.476	
310	0.1864	1.605	2.992	
315	0.0839	1.177	0.987	
320	0.0180	0.766	0.137	

Sample 7: Raspberry seed oil (10%)