Quim. Nova, Vol. 32, No. 5, 1321-1323, 2009

UVA I-PROTECTION EFFECTIVENESS OF BIOACTIVE COMPOUND AND ORGANIC UV FILTERS: AN *IN VITRO* ASSESSMENT

André Rolim Baby*, Tatiana Santana Balogh, Carla Aparecida Pedriali, Telma Mary Kaneko and Maria Valéria Robles Velasco
Departamento de Farmácia, Faculdade de Ciências Farmacêuticas, Universidade de São Paulo, Av. Prof. Lineu Prestes, 580, 05508-900 São Paulo - SP, Brasil

Recebido em 30/5/08; aceito em 30/10/08; publicado na web em 15/4/09

This research work aimed at determining the UVA effectiveness (UVA I/UV ratio), by diffuse transmittance analysis, of sunscreens developed with a bioactive substance, the rutin, associating or not with organic UVB-UVA filters incorporated at a phosphate-base O/W emulsion. Sunscreens provided conflicting and unpredictable results concerning the anti-UVA protection, specially, at the UVA I region. Possible interactions among the organic UV filters and the polyphenolic bioactive substance may have accounted with improvement or reduction of UV protection by a complex and not yet elucidated mechanism, probably regarding wavelength delocalization to superior or inferior values, by resonant molecule stabilization or destabilization.

Keywords: rutin; sunscreen; UVA.

INTRODUCTION

The knowledge of the effects of UVB and UVA radiation on human skin has increased significantly[1,2] and the authentic necessity of human skin protection against solar radiation has led to the concerning and upgrading of the development of broad spectrum sunscreens highly effectives over the UVB-UVA absorbing range.

Sunscreens are mainly used to prevent erythema formation from sun exposure and solar radiation at the Earth's surface is approximately 90-99% UVA and 1-10% UVB.[3,4] UVB (290-320 nm) radiation primarily causes photocarcinogenesis due its direct interaction with cellular DNA but there are several reasons why investigation of the role of UVA is also relevant. Major consequence of cumulative UVA (320-400 nm) radiation is the generation of reactive oxygen species and the alteration of tumor suppressor genes, like p53. UVA radiation is additional subdivided into UVA II (320-340 nm) and UVA I (340-400 nm).[2,5,6]

UVA radiation directly affects the dermal compartment and is thought to be the major factor responsible for photoaging of human skin. It had been shown that the UVA I accounts for damaging effects in human dermal fibroblasts, as induction of cytokines, matrix metalloproteinases, and mtDNA mutations. Of these, the induction of matrix metalloproteinase-1 which degrades collagen type I is of particular significance since the extent of collagen I reduction correlates with photodamage in skin.[6,7]

This research work aimed at determining the *in vitro* UVA effectiveness of sunscreens developed with a bioactive substance, the rutin, associating or not with organic UVB-UVA filters incorporated at a phosphate-base O/W emulsion. Mainly, UVA effectiveness was obtained by the UVA I/UV ratio with diffuse transmittance analysis.

EXPERIMENTAL

Isolated rutin (99.1%, Henrifarma, Brazil), ethylhexyl methoxycinnamate (EHMC) (UVB organic filter, Uvinul® MC 80, Basf, Brazil) and benzophenone-3 (BZP) (UVA organic filter, Uvinul® M 40, Basf, Brazil) were incorporated into emulsified systems in accordance with the following associations: *CB* – no active substances; *CR* – 0.1% w/w rutin; *CMF* – 3.5% w/w EHMC + 1.0% w/w BZP; *CMFR* – 0.1% w/w rutin + 3.5% w/w EHMC + 1.0% w/w BZP; *CF* – 7.0% w/w EHMC + 2.0% w/w BZP; and *CFR* – 0.1% w/w rutin + 7.0% w/w EHMC + 2.0% w/w BZP.

Emulsified system was previously developed by Velasco and co-workers[8] as a phosphate-base O/W emulsion, containing: cetearyl alcohol (and) dicetyl phosphate (and) ceteth-10 phosphate (Crodafos® CES); disodium EDTA (Uniquelan® NA2S); dimethicone (DC® 200/350); propylene glycol; paraben-type preservatives (Phenova®) and aqua (distilied water).

Absorbance spectra of the samples were measured by diffuse transmittance analysis (UV1000S Ultraviolet Transmittance Analyzer coupling to an integrating sphere, Labsphere®) in 5 nm increments from 290 to 400 nm. Prior to the UVA I effectiveness assessment, the substrate (Vitro-Skin®) composed of collagen was hydrated (24 h) and, then, 70.0 mg of the samples were homogeneously spread over it with circular movements, edges to center, by a saturated gloved finger. Samples were allowed to rest and to dry at room temperature until absorbance recording.[9-11]

UVA I/UV ratio was calculated according to the following equations, as described by US Food and Drug Administration:[11]

$$aUVA\ I/\lambda = 5/3 \times [A290 + A400 + 4(A345 + \ldots + A395) + 2(A350 + A360 + \ldots + A390)]/60 \quad (1)$$

UVA I area per unit wavelength (aUVA I/λ). *A:* absorbance.

$$aUV/\lambda = 5/3 \times [A290 + A400 + 4(A295 + A305 + A315 + \ldots + A395) + 2(A300 + A310 + \ldots + A390)]/110 \quad (2)$$

UV area per unit wavelength (aUV/λ). *A:* absorbance.

$$\text{UVA I/ UV ratio} = \frac{aUVA/\lambda}{aUV/\lambda} \quad (3)$$

UVA I/UV ratio.

---

*e-mail: andrerb@usp.br

RESULTS AND DISCUSSION

Bioactive compounds, such as isolated rutin, are an increasing trend toward to the development of suncare cosmetic products, like sunscreens, effectively active against UV radiation that are composed of decreasing organic UV filter proportions and, yet, appreciating high absorbing properties ranging from UVB to UVA.

Highest values of UVA I/UV ratio were obtained for CB (1.37) and CR (1.59). Table 1 summarizes the UVA I/UV ratios. Rutin alone at the emulsified system and the vehicle active-free reached values in the order of 2 times superior than the systems containing the other associations of the bioactive compound and the organic UV filters (CMF, CMFR, CF and CFR).

Table 1. UVA I/UV ratio values for the sunscreen emulsified systems (n = 5)

	CB	CR	CMF	CMFR	CF	CFR
aUVA I	0.05	0.15	0.42	0.54	0.71	0.71
aUV	0.04	0.10	0.57	0.68	0.84	0.84
UVA I/UV ratio	1.37	1.59	0.73	0.79	0.84	0.84

CB – no active substances; *CR* – 0.1% w/w rutin; *CMF* – 3.5% w/w EHMC + 1.0% w/w BZP; *CMFR* – 0.1% w/w rutin + 3.5% w/w EHMC + 1.0% w/w BZP; *CF* – 7.0% w/w EHMC + 2.0% w/w BZP; *CFR* – 0.1% w/w rutin + 7.0% w/w EHMC + 2.0% w/w BZP

Organic UV filters, from CMF and CF, acquired UVA I/UV ratios of 0.73 and 0.79, respectively. These sunscreens differentiated from each other by the proportions of EHMC and BZP. It was observed that these organic UV filter associations were not as effective against UVA I as CB and CF. It was also verified that the 2-fold increase in UV-filter proportion did not promote augmentation of the UVA I protection, nevertheless, as demonstrated by Velasco and co-workers,[8] there has been the enhancement of the UVB protection effectiveness, by *in vitro* sun protection factor (SPF) estimation, of 7.34 ± 0.24 (CMF) to 14.63 ± 2.05 (CF).

Couteau and co-workers[10] and El-Boury and co-workers[12] established that SPF is a function of UV filter concentration, which we have previous observed[8] and, consistent with our results, we have noticed that the elevation of the UV filter proportion in a sunscreen did not intrinsically provide the respective improvement of the UVA protection. Furthermore, the bioactive association with the organic UV filters decreased the rutin UVA I defense in which CMFR and CFR generated equal UVA I/UV ratio values of 0.84. This observation was not expected to CMFR since the presence of 0.1% w/w rutin enhanced the SPF of 7.34 ± 0.24 to (CMF) to 9.97 ± 0.18 (no SPF improvement was achieved when rutin was associated 7.0% w/w EHMC + 3.0% w/w BZP). This phenomenon might be attributed to an electron stabilization-destabilization mechanism of the UV filter molecules (resonant structures) due to the presence of polyphenolic compound (rutin) in which the UV filter concentration appeared to be a critical factor.[13-15]

Parameters and categories that are employed to classify the UVA effectiveness[11] were reported in Tables 2 and 3. Among them, it is currently used the UVA rating, critical wavelength (λ_c, nm) and, more recently, UVA I/UV ratio. US Food and Drug Administration[1,11] categorized each one of them and in Table 3 we used these categories to classify the sunscreen emulsified systems presented wherein with the addition of previous results.[8] All sunscreens and the vehicle active-free were of, at least, high UVA protection according to UVA I/UV ratio and λ_c. Regarding the UVA rating, systems were of medium (CMF, CMFR, CF and CFR) to high (CB and CR) anti-UVA defensives.

Table 2. Categories of anti-UVA effectiveness in reference to US Food and Drug Administration, with some modification, based on UVA I/UV ratio, critical wavelength (λ_c, nm) and UVA rating[11]

	Low	Medium	High	Highest
UVA I/ UV ratio	0.20 to 0.39	0.40 to 0.69	0.70 to 0.95	greater than 0.95
λ_c (nm)	325 to 335	335 to 350	350 to 370	greater than 370
UVA rating	0.20 to 0.39	0.40 to 0.69	0.70 to 0.95	greater than 0.95

CONCLUSIONS

In summary, sunscreen emulsified systems containing bioactive compounds provided conflicting and unpredictable results, through *in vitro* assessment, concerning the anti-UVA protection, specially, at the UVA I region. Possible interactions among the organic UV filters and the polyphenolic bioactive substance may have accounted with the improvement or reduction of UV protection by a complex and not yet elucidated mechanism, probably regarding wavelength delocalization to superior or inferior values, by resonant molecule stabilization or destabilization.

ACKNOWLEDGEMENTS

Authors are thankul to CAPES; I. M. N. Salgado-Santos and C. R. G. S. Peron from Evic Brazil – Institute of Skin Bioengineering; C. A. S. de O. Pinto and F. D. Sarruf from Laboratory of Cosmetology, FCF-USP.

Table 3. Anti-UVA categories of the sunscreen emulsified systems: UVA I/UV ratio, critical wavelength (λ_c, nm) and UVA rating (n = 5) [8,11]

	CB	CR	CMF	CMFR	CF	CFR
UVA I/UV ratio	1.37	1.59	0.73	0.79	0.84	0.84
Category of UVA protection	Highest	Highest	High	High	High	High
λ_c (nm)*	386	385	359	363	361	363
Category of UVA protection	Highest	Highest	High	High	High	High
UVA rating*	0.77	0.95	0.44	0.46	0.49	0.50
Category of UVA protection	High	High to highest	Medium	Medium	Medium	Medium

CB – no active substances; *CR* – 0.1% w/w rutin; *CMF* – 3.5% w/w EHMC + 1.0% w/w BZP; *CMFR* – 0.1% w/w rutin + 3.5% w/w EHMC + 1.0% w/w BZP; *CF* – 7.0% w/w EHMC + 2.0% w/w BZP; *CFR* – 0.1% w/w rutin + 7.0% w/w EHMC + 2.0% w/w BZP; *(*):* Velasco and co-workers (2008) [8]

REFERENCES

1. US Food and Drug Administration (FDA); *21 CFR Parts 310, 352, 700 and 740. Sunscreen Drug Products for Over-the-Counter Human Use,* Final Monograph*,* 1999.
2. Seité, S.; Moyal, D.; Verdier, M.-P.; Hourseau, C.; Fourtanier, A.; *Photodermatol. Photoimmunol. Photomed.* **2000**, *16*, 3.
3. Verschooten, L.; Declercq, L.; Garmyn, M.; *Int. J. Cosmet. Sci.* **2006**, *28*, 1.
4. Faurschou, A.; Wulf, H. C.; *Br. J. Dermatol.* **2007**, *156*, 716.
5. Heinrich, U.; Tronnier, H.; Kockott, D.; Kuckuk, R.; Heise, H. M.; *Int. J. Cosmet. Sci.* **2004**, *26*, 79.
6. Vielhaber, G.; Grether-Beck, S.; Koch, O.; Johncock, W.; Krutmann, J.; *Photochem. Photobiol. Sci.* **2006**, *5*, 275.
7. Persson, A. E.; Edström, D. W.; Bäckvall, H.; Lundeberg, J.; Pontén, F.; Ros, A.-M.; Williams, C.; *Photodermatol. Photoimmunol. Photomed.* **2002**, *18*, 287.
8. Velasco, M. V. R.; Balogh, T. S.; Pedriali, C. A.; Sarruf, F. D.; Pinto, C. A. S. O.; Kaneko, T. M.; Baby, A. R.; *Lat. Am. J. Pharm.* **2008**, *27*, 23.
9. Diffey, B. L.; Tanner, P. R.; Matts, P. J.; Nash, J. F.; *J. Am. Acad. Dermatol.* **2000**, *43*, 1024.
10. Couteau, C.; Pommier, M.; Paparis, E.; Coiffard, L. J. M.; *Pharmazie* **2007**, *62*, 449.
11. US Food and Drug Administration (FDA); *21 CFR Parts 347 and 352*. *Sunscreen Drug Products for Over-the-Counter Human Use; Proposed Amendment of Final Monograph,* Proposed Rule 2007.
12. El-Boury, S.; Couteau, C.; Boulande, L.; Paparis, E.; Coiffard, L. J. M.; *Int. J. Pharm.* **2007**, *340*, 1.
13. Martins, H. F. P.; Leal, J. P.; Fernandez, M. T.; Lopes, V. H. C.; Cordeiro, M. N. D. S.; *J. Am. Soc. Spectrom.* **2004**, *15*, 848.
14. Flor, J.; Davolos, M. R.; Corrêa, M. A.; *Quim. Nova* **2007**, *30*, 153.
15. Velasco, M. V. R.; Sarruf, F. D.; Salgado-Santos, I. M. N.; Haroutiounian-Filho, C. A.; Kaneko, T. M.; Baby, A. R.; *Int. J. Pharm.* **2008**, *363*, 50.