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Determination of Sun Protection Factor (SPF) of Some Body Creams and Lotions Marketed in Kinshasa by Ultraviolet Spectrophotometry

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Abstract: *The purpose of this study was to determine in vitro the sun protection factor (SPF) of somebody creams and lotion sunscreens formulations marketed in Kinshasa containing physical and/or chemical sunscreen by ultraviolet spectrophotometry. The calculated sun protection factor of ten different commercially available formulations of body creams and lotions founded in Kinshasa's market were evaluated using Mansur equation. The labeled SPF values were in the range of 15 to 60. The outcome of the study indicated that out of the ten different marketed formulations, 40% sunscreen samples were in close agreement of their labeled claim SPF while 60% sunscreen samples had lower SPF values than labeled claim. The proposed spectrophotometric method is rapid, simple and cost effective for the in vitrodetermination of SPF values of body creams and lotions containing physical and/or chemical sunscreens.*

Keywords: *Sunscreens, Sun Protection Factor, Cream, lotion, Ultraviolet spectrophotometry.*

1. 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 [1-3].

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 dimers. 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 photoageing, sunburn… and skin cancer, occurring as a result of sun overexposure [4-6].

To prevent those 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 [7-10].

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. The higher the SPF, the more effective is the product in preventing sunburn [1-3,5,11].

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, photostable, and should provide complete protection to the skin. The choice of the adequate sunscreen is influenced by the prototype of the individual [6,8].

The photoprotection 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 phototesting 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 [1,2]. As consequence, much effort has been devoted to the development of *in vitro* techniques for assessing the photoprotection 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 [9].

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 spectrophotometric analysis of dilute solutions[1,2,4].

In a tropical country like Democratic Republic of Congo (DRC), the exposure to UVA and UVB (sunlight) rays is a regular phenomenon. It becomes imperative that one takes adequate measures to protect their skin from burns/radiation, especially during the daytime when solar radiation is at its peak.

In Kinshasa, major town of (DRC) where there are more than ten million people, more than the half of people spend their time outdoor, under the sun at an average temperature of about 28°C. They are concern of sun overexposure and skin damaging. This town knows a rapid growth of commercially available cosmetic products of different manufacturers. The body creams and lotions used are made in Kinshasa and one quantity comes from foreigner. Unfortunately, there is no data available on the study of those cosmetic products mainly on SPF. In fact, among many kind of body creams and lotions used daily in Kinshasa, 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 of ten selected body creams and lotions having labeled SPF, used in Kinshasa containing physical and/or chemical sunscreens through UV-Vis spectrophotometry and the application of the Mansur mathematical equation [2,5].

2. MATERIAL AND METHODS

2.1. Samples Preparation

Ten commercially available body creams and lotions of various manufacturers having labeled SPF were purchased from Kinshasa market (samples A-J). 1.0 g of all samples was weighed, transferred to a 100 ml volumetric flask, diluted to volume with ethanol (Merck product, analytical grade), followed by ultrasonication for 5 min and then filtered through cotton, rejecting the ten first ml. A 10 ml aliquot was transferred to 100 ml volumetric flask and diluted to volume

with ethanol. Then a 10 ml aliquot was transferred to a 50 ml volumetric flask and the volume completed with ethanol.

2.2. Spectrophotometric measurement and SPF determination

The absorption spectra of samples in solution were obtained in the range of 290 to 320 nm, every 5 nm using a Hitachi U-3900 H. UV/Visible spectrophotometer,equipped with 1 cm quartz cell and a computer. Three determinations were made at each point using ethanol as a blank.

SPF values were determined using Mansur equation (equation 1)[2,5].Indeed, Mansur *et al.* [12], developed a very simple mathematical equation which substitutes the *in vitro* method proposed by Sayre *et al.*, [13], utilizing UV spectrophotometry and the following equation 1[2,5]:

$$SPF_{spectrophotometric} = CF \times \sum_{290}^{320} EE(\lambda) \times I(\lambda) \times Abs(\lambda) \quad (1)$$

Where EE: erythemal effect spectrum; I : solar intensity spectrum; Abs: absorbance of sunscreen product ; CF: correction factor (= 10).

The values of EE x I are constants and predetermined by Sayre *et al.*,[13], and are showed in Table 1.

Table 1. *Normalized product function used in the calculation of SPF [2, 3, 5].*

Wavelength (nm)	EE X I (normalized)
290	0,0150
295	0,0817
300	0,2874
305	0,3278
310	0,1864
315	0,0837
320	0,0180
Total	1

Legend :

EE :erythemal effect spectrum; I: solar intensity spectrum

3. RESULTS AND DISCUSSION

3.1. Results

Table 2 give active ingredients and labeled and calculated SPF values of ten of the commercially available formulations found at the Kinshasa's market.

Table 2. *Active ingredients and labeled and calculatedSPF values of the commercially available formulations found at the Kinshasa's market.*

Commercial sample (function)	**Actives Ingredients**	**Labeled SPF**	**Calculated SPF**
A (Emulsion for body)	Avobenzene, Octylsalycilate, Titanium oxide, Terephthalylidène, Dicamphor sulfonic acid	15.00	15.24 ±0.05
B (Emulsion for body)	benzophenone-3, octylmethoxycinnamate, octyldimethylPABA	15.00	14.65 ± 0.06
C (Emulsion for body)	benzophenone-3, octylmethoxycinnamate, octyldimethylPABA	15.00	14.92 ± 0.03
D (Emulsion for body)	Ethylhexylmethoxycinnamate, titanium dioxide	15.00	15.12 ±0.04
E (Emulsion for body)	non specified, AntiUV SPF_{20}	20.00	17.20 ± 0.06
F (Emulsion for body)	non specified AntiUV SPF_{20}	20.00	16.94 ± 0.04
G	non specified	20.00	17.05± 0.04

(Emulsion for body)	AntiUV SPF_{20}		
H (Facial Emulsion)	benzophenone-3, ethylhexylmethoxycinnamate, ethylhexylsalycilate and titanium oxide	40.00	21.43 ± 0.07
I (Kid's Emulsion)	Alkylbenzoate, titanium dioxide	50+	24.14 ± 0.04
J (Facial Emulsion)	Alkylbenzoate, titanium dioxide, Methoxybenzoylmethane	60.00	23.12 ± 0.05

Seven of ten samples are emulsion for body, two are facial emulsion and only one is a kid's lotion. Ten chemical filters are used and one physical blocker (titanium oxide). The labeled SPF values are in the range of 15 to 60. Samples with SPF_{20} have actives ingredients non specified and claimed antiUV SPF_{20}. Samples have two, three or four actives ingredients. Five samples over seven used titanium oxide. In all samples with SPF more than 20, we used titanium oxide is used as ingredient. Two samples B and C have the same ingredients and SPF.

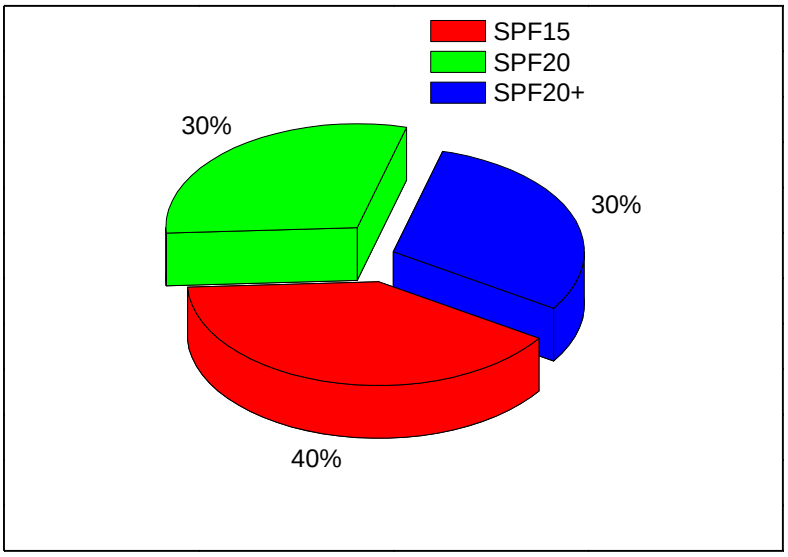

Figure 1. *Proportions of labeled SPF sunscreens formulations*

As it can be noticed from this figure, sunscreen formulations of a labeled SPF value of 15 constitute40% of all formulations. As it can be seen in figure 2, a significant difference is found in labeled and calculated values for SPF higher than 20.

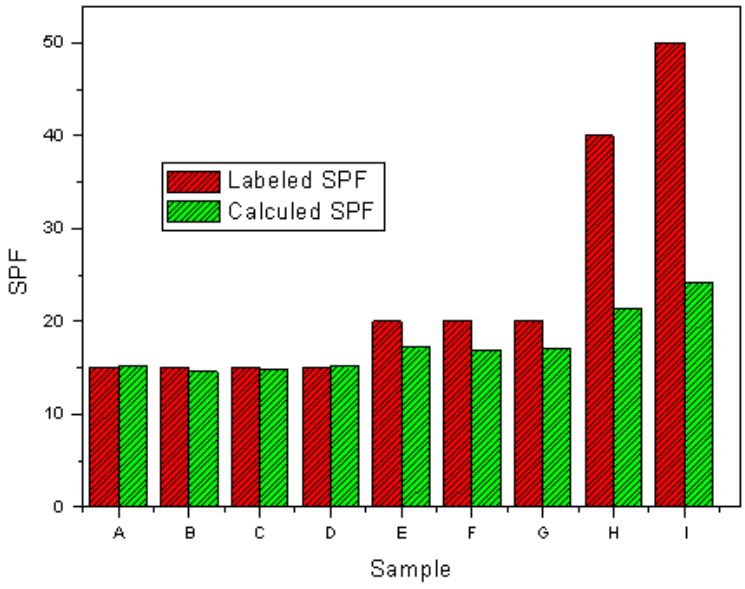

Figure 2. *Labeled SPF and Calculated SPF vs samples*

3.2. Discussion

Measurement of SPF is ultimate way to determine effectiveness of sunscreen formulation. The higher the SPF, the more protection a sunscreen offers against UV-light. Sunscreens are used to aid the body's natural defense mechanisms to protect against harmful UV radiation from the sun. Its function is based on its ability to absorb, reflect or scatter the sun's rays [2,5].

In the present research work, the SPF of ten different commercially available sunscreen products found at the Kinshasa market were evaluated in vitro by UV spectrophotometry applying Mansur mathematical equation . The labeled SPF values were in the range of 15 to 60. The calculated SPF values of marketed formulations obtained using the UV spectrophotometric method were shown in figure 2. It can be observed that the SPF values found for samples A, B, C and D are in close agreement with the labeled SPF. All other samples presented calculated SPF values lower than labeled SPF. Samples A,B,C and D have a difference of -0,24; 0,35; 0,08 and -0,12 respectively, when compared to SPF 15 labeled. Samples E,F and G have a difference of 2,80; 3,06 and 2,95 respectively, when compared to SPF 20 labeled.

Samples H,I and J have a difference of 18,57; 25,86 and 36,88 respectively, when compared to SPF 40; 50+ and 60 labeled.In their works,Dutra et al.[2] ; Fonseca and Rafaela, [8];Mishra et al. [5] and Sudhahar and Balasubramanian [14] obtained similar results at the light of sunscreens formulations having SPF higher than 20.

Among samples analyzed, sample I exhibits a maximal absorbance higher than all samples of sunscreens formulations (figure 2). This is probably due to the fact that sample I have more sunscreens substance amount than the other samples, presenting thus, a calculated SPF higher than the others.

Samples A, B, C and D presented nearly the same calculated SPF values (SPF~ 15.0). They have different sunscreen perhaps in different amount. Sample B and C have the same sunscreen, the sunscreen amount in the sample C can be enough like reflected in the obtained calculated SPF value. Thus, sample B presented a calculated SPF value lower than the one of sample C. Samples E, F and G have calculated SPF closer and all formulations sunscreen contained the same sunscreens may be not in the same quantity.

For the samples having the same labeled SPF (samples A, B, C and D, samples E, F and G), data variation can be due to the composition of those formulations.

As can be seen the higher differences observedbetween labeled and calculated values were in sunscreens with labeled SPF 40, 50+ and 60. This should be an alert since sunscreens SPF 40,50 and 60 are greatly used in phototype I that includes babies, children, persons with clear skin, persons who cannot be exposed directly to the sunlight and also professionals of outdoor exposure like fisherman, building workers, street sellers, policeman and lifeguards. [8].

There are many factors affecting the determination of SPF values, as for example, no applicability of proper methods for evaluation of sunscreen products,the use of different solvents in which the sunscreen are dissolved; the combination and concentration of the sunscreen; the type of emulsion; the effects and interactions of vehicle components, such as esters, emollients and emulsifiers used in the formulation; the interaction of the vehicle with the skin; the addition of other active ingredients; the pH system, viscosity and the emulsion rheological properties, among other factors, which can increase or decrease UV absorption of each sunscreen [2,5].

The effect that different solvents and emollients have upon the wavelength of maximum absorbance and upon the UV absorbance of several sunscreens chemical, alone or in combination is well known and documented [1-3,4,13-16]. Excipients and other active ingredients can also produce UV absorption bands, thus interfering with those of UVA and UVB sunscreen. This effect is reflected in a finished formulation, especially for the six creams and lotions with a SPF greater than 15. The effect of a solvent is only realized at high percentages. According to Pissavini*et al.* [15], a high SPF values are more difficult to measure. A high SPF normally leads to a greater uncertainty also in the final *in vivo* result, due to the biological variations of the volunteers[2].

Therefore, to develop sunscreens with better safety and high SPF, the formulator must understand the physicochemical principle, not only the UV absorbance of the actives, but also vehicle components, such as esters, emollients and emulsifiers used in the formulation, since sunscreen can interact with other components of the vehicle, and these interactions can affect sunscreen efficacy[4,13].

To be effective in preventing sunburn and other skin damage, a sunscreen product should have a wide range of absorbance between 290 and 400 nm. Evaluation of the efficiency of a sunscreen formulation has for a long time been assessed through *in vivo* testperformed with human Volunteers. *In vivo* test is time- consuming, is normally subject to certain degree of variability, not mention the ethical problems of testing with human. The *in vitro* SPF is useful for screening test during product development, as a supplement of the *in vivo* SPF measure. SPF numbers are an estimate of how long one can stay in the sun before burning compared with not using sunscreen [2,5].

4. CONCLUSIONS

The calculated SPF values of the 40% of the analyzed samples are in close agreement with the labeled SPF and 60% presented SPF values lower than labeled SPF. The proposed UV spectrophotometric method is easy, rapid, employs low cost reagents and can be used for the *in vitro* determination of SPF values in many cosmetic formulations. The proposed methodology may be useful as a rapid quality control tool. It can be used duringthe production process, in the analysis of the final product, and can give important information before proceeding to the *in vivo* tests.

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