Comparative Analysis of Sun Protection Factor (SPF) of Randomly Selected Branded Sunscreens Manufactured in the Philippines

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Abstract –UV radiation is a type of radiation emitted by the sun, alongside infrared and visible light. It is used by the body to help mediate natural synthesis of vitamin D and endorphins used by the body, but excessive UV radiation has adverse effects to the skin, like sunburns (erythema), premature skin aging, photosentivity, suppression of the immune syste, and even skin cancers. With the rise of temperatures due to global warming, demand for sunscreens - cosmetic products used to reduce the amount of UV radiation that reaches the skin - has also risen. Some studies have experimentally measured discrepancies between labeled and measured SPF values for the sunscreens. This study compares the labeled and measured SPF of some of the sunscreens manufactured in the Philippines, and has found major differences between the labeled and measured SPF values of the sunscreens.

Introduction. – UV radiation is a type of radiation emitted by the sun, alongside infrared and visible light. UV radiation is used by the body to help mediate natural synthesis of vitamin D and endorphins in the skin, but excessive UV radiation has adverse effects to the skin. Overexposure to UV rays may cause many skin defects, like sunburns (erythema), premature skin aging (wrinkles), photosensitivity, suppression of the immune system or even skin cancers.. For many years, sunscreens have been recommended by dermatologists, not only as a protective measure against excessive amounts of sunlight, but also because of their contribution to the prevention of skin photodamage. All of cosmetic products with sunscreen properties are designed to absorb or reflect the suns UV radiation in order to protect the skin cells from damage [1, 2].

Sunscreen companies use advertisements that show the SPF values of their products. But other SPF analysis studies done in other countries using their marketed local products show that the true SPF values are inconsistent with the SPF values advertised by sunscreen companies [1–4]. Similar studies are done in other countries and regions such as Brazil [1] and the Kurdistan region of Iraq [2]. However, their regulations for sunscreen products are different in comparison to the sunscreen regulations followed by the Philippine companies [5]. To date, there has been no published studies done in SPF analysis of sunscreens in the Philippines. This paper thus seeks to verify the labelled SPF values in common brands of sunscreens manufactured in the Philippines.

Adulteration refers to a product failing to meet state standards. Conventional cosmetics such as personal care products are typically provided to consumers as predetermined formulations on a basis that they either purchase the product from the inventory or they forgo the purchase. A drawback of this method of doing business is that the cosmetic product may not be optimized to accommodate a consumer's needs and preferences. The formulation may have a fragrance that is either too strong, excessive or insufficient moisturizers, allergens or some other problematic ingredient, concentration or deficiency [6]. It could also provide insufficient protection from the intended cause of problem such as a sunscreen failing to provide enough SPF values as marketed. If a product wasnt able to deliver on their promised performance, the company that created the product is liable to be sued for product adulteration.

Thus the researchers want to determine if the selected sunscreen lotions are able to meet the required standards that is the SPF levels that are indicated in their labels.

This study aims to determine and compare the labeled

SPF values of five sunscreen lotions manufactured in the Philippines to the SPF values measured using UV-Vis spectrophotometry. Specifically, this study aims to:

- Determine the absorbance of the randomly selected five white-colored sunscreen body lotions using UV-Vis spectrophotometry
- Solve for the SPF values of the lotions using their absorbance properties; and
- Compare the experimental SPF values of the sunscreen lotions to the SPF values listed in their labels.

Significance. This study could be used to provide information to the consumers and serve as basis for the Food and Drug Administration to initiate proper regulations and provide correct labeling of sunscreen products.

Limitations. This study was limited to five sunscreen lotion brands locally produced in the Philippines which is available in the countrys local commercial outlets. Only five brands were used to conserve cost in the study. The samples used in the research were white body lotions with SPF of 30 to ensure uniformity.

Materials and Methods. – The study was conducted in Philippine Science High School- Western Visayas Campus Chemical Instrument Lab and in West Visayas State University's University Research and Development Center.

Materials and Equipment. Five different brands of sunscreen, all of which were white sunscreen lotions with SPF of 30, were bought from various stores in Iloilo City; they were labeled A to E. The absolute-grade ethanol required was partly bought by the researchers and partly supplied by the laboratories. The research facilities lent the researchers the necessary laboratory equipment: test tubes, pipettes, parafilm for sealing the test tubes, the centrifuge, the vortex mixer, and the UV-Vis Spectrophotometer.

Preparation of samples for UV-Vis spectrophotometry. 0.05g of sunscreen was dissolved in 5mL of ethanol in a test tube with the assistance of a vortex mixer. The solution was allowed to stand for 5 minutes to let any insoluble compounds settle, before being spun at 6,000 RPM for 5 minutes in a centrifuge. Transferring the solutions from the centrifuge required great care so as not to disturb the settled particulates at the bottom. Serial dilution was then carried out; 0.5mL of stock solution was taken and poured to a test tube that contained 4.5mL of ethanol, making this the first dilution. Succeeding dilutions were performed by taking 0.5mL of the previous dilution and mixing it with 4.5mL of ethanol in another test tube; two such additional dilutions were performed, with mixing done in between dilutions using a vortex mixer.

Analysis of samples. The absorbance characteristics of each sunscreen sample in the 320-290nm wavelengths were analyzed at every 5nm intervals using UV-Vis spectrophotometry. SPF was calculated using the Mansur equation:

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

Where:

- EE(λ) = Erythemal effect spectrum
- I(λ) = Solar intensity spectrum
- Abs(λ) = Absorbance of sunscreen product
- CF = Correction factor of 10

Note: EE(λ)xI(λ) are constants [7] (see Table **??**)

Data analysis. The determined SPF values of each sunscreen lotion were compared to its labeled SPF values by determining their percent difference. The percent difference will show if the determined SPF values are consistent with their respective SPF values if they fall within 10% of the labelled SPF values.

Results and Discussion. – All of the tested sunscreens had SPF values that fell short of their labeled SPF values, with sample E (75.09%) having the largest difference between the labeled and measured SPF values, and sample C with the smallest percentage of difference (55.17%). Other studies [1,2] have also measured discrepancies between the labeled and measured SPF values; percentage differences of 97.89% have been reported [2].

Table 1: Labeled and measured SPF of sunscreens used in the study

Sample	Active Ingredients	Labeled SPF	Measured SPF	Percentage Difference
A	TiO_2	30	10.00	66.65%
B	Octisalate, Ensulizole Avobenzone	30	7.31	75.64%
C	Oxybenzone, Homosalate	30	13.45	55.17%
D	TiO_2	30	10.79	64.02%
E	TiO_2	30	7.47	75.09%

Data variation and validity can be affected by the use of non-validated spectrophotometric methodology used to determine the absorption characteristics of the sunscreens; of note would be readings of negative absorbance for the sunscreen samples. One possible source of problems in the data gathering is the addition of other additives in

the sunscreens, the most readily known being whitening agents, compounds used to lighten skin tone, in the sunscreen, since 4 of the 5 of the sunscreens in the study had whitening agents and these may have caused significant interference in the measurement of absorbance. Another possible source would be the nature of the active ingredients, specifically how they work as an active ingredient it is important to note that in 3 of the 5 tested sunscreens, titanium dioxide, TiO2, was used as an active ingredient; TiO2 as a sunscreen active ingredient works by reflecting and scattering sunlight [8], and the reflection and scattering of UV rays due to the TiO2 particles may have affected the variation of data. Octisalate, ensulizole, avobenzone, octibenzone, and homosalate are examples of chemical absorbers where they work by absorbing the UVA and/or UVB radiation. Sunscreen B in particular is a broad-spectrum sunscreen since octisalate and ensulizole absorb UVB radiation while avobenzone absorbs UVA radiation. Avobenzone may have affected the data since it exclusively absorbs UVA radiation. The combination and concentration of ingredients in the sunscreens can affect absorption data [1].

Other factors that may have affected data variation and validity would be the use of different concentration of ethanol that is used as the solvent to dissolve the sunscreens; the combination and concentration of ingredients in the sunscreens; the effect of various components of the vehicle; and the pH system of the sunscreen and emulsion rheological properties. This effect is reflected in a finished formulation, especially for lotions with an SPF greater than 15. The effect of a solvent is only readily apparent at higher percentage [1]. While the method has been confirmed to be accurate [9], the spectrophotometric in-vitro method has its own limitations: it is challenging to extrapolate from the results of in-vitro back to the biology of the intact organism - in layperson's terms, it is challenging to know or determine whether or not the results of the in-vitro test will also apply when the same treatment is tested on the intact organism.

Summary of Findings. – There was a large inconsistency between the labeled and measured SPF values, and this may be due to the interactions between the ingredients in the sunscreens.

Conclusion. – This study concludes that the selected sunscreens manufactured in the Philippines that were selected for the study have their measured SPF values inconsistent with their labeled SPF values. This however does not conclude that the selected sunscreens did not deliver on the labeled SPF level since the ingredients in the sunscreens may have affected the measured SPF.

Recommendation. – This study recommends the following:

- Alterations in the sample preparation; examples of alterations would be different solvents, different dilution factors, and using additional steps;
- Further in-depth studies about manufacturing practices in the Philippines with respect to sunscreens;
- Further in-depth studies about the interactions between ingredients in sunscreens and how these interactions affect the sunscreens' protective ability;
- The effect of emulsion type (such as water-based or oil-based) on the sunscreens' protective ability;
- Other methods of testing can be tried, such as spreading the sunscreen samples on a substrate, ex. a quartz plate [3], or an epidermal membrane [4].
- Larger sample size.
- Usage of only one cuvette, as individual defects unique to every cuvette may have contributed to the variance of data.

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