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In *vitro* determination of Sun Protection Factor on Clays Used for Cosmetic Purposes in Kenya

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Abstract

Ultraviolet radiation is a real problem to human health and it's said to cause skin cancer and related skin ailments. These diseases are of economic burden in terms of diagnosis, treatment and prevention in low and middle level countries. Commercial sunscreens are considered as the most effective way of preventing the incidences of skin cancer, however they are costly, unavailable and they contain toxic ingredients, which can in the end be cancerous. Sunscreens from natural sources like plants and clay are currently being explored as cheap, reliable, and available and may offer simple alternative health benefits. The purpose of this study was to evaluate the amount of sun protection factor (SPF) offered by cosmetic clays used in Kenya by different communities. The SPF was determined *in vitro* using 3 M transpore adhesive tapes on twelve clay samples collected randomly from sites used in three counties namely Narok, Bomet and Bungoma. Using a spreading protocol of 2 µg/cm^2 transmittances between 280 to 400 nm were measured using a UV 1800 Shimadzu, Japan spectrophotometer. A commercial sunscreen with known SPF was incorporated in the study as a positive control. The SPF values of the clays were found to be between 1.46 and 40.98. The SPF value obtained for the commercial sunscreen differed from the SPF cited by the manufacturer. A second method was used on the commercial sunscreen and values obtained were in close agreement with those used in the first method. This study revealed that clays used for cosmetic purposes offer some form of sun protection to its users. Determination of SPF using Transpore tape is cheap, easy to handle, readily available and rapid.
Keywords: Sun Protection factor, Clays

1. Introduction

Ultraviolet light is the most important environmental risk factor in developing of skin cancer, sunburns, actinic keratosis and seborrheic warts. (WHO, 2012). Skin cancer can be treated by use of x-ray therapy, surgery, chemo therapy, and hormone therapy (WHO, 2008). It can also be prevented by use of sunscreens (Hoang-Minh *et al*., 2011). However resources for diagnosis and treatment of cancer in low and middle level countries are limited or non existent thus such countries can adopt prevention of skin cancer using sunscreens (WHO, 2008)

Sunscreens can be in form of cream, oil, gel or spray and it is placed in contact with the human skin with a view exclusively or mainly to protect it from UVR through absorbing, scattering or reflecting radiation (Mishra *et al*., 2011). For sunscreens to be effective they must be used correctly and be re-applied after some time especially after sporting activities such as swimming (WHO, 2012). The recommended level of use is 2 mg/cm^2 of skin (Haywood *et al*., 2003).

The use of clay in cosmetic applications has been widely studied (Matike *et al*., 2011; Dlova, *et al*., 2013). Apart from UV radiation protection, it is also used for cleansing the skin, emulsification, beauty, adsorption, detoxification, ion exchange with the skin and trans-dermal nutrient supplementation of elements such as calcium, iron, magnesium and potassium. Ability of clays to perform these various functions are influenced by their colour, particle size, specific surface area and cation exchange capacity (CEC) (Ngole *et al*., 2010; Matike, *et al.*, 2011). Clay has been found to contain physical protectors such as TiO_2, ZnO, SiO and Fe_2O_3. UV-protection ability varies with the concentration of Fe_2O_3 content on them (Hoang-Minh *et al.*, 2010; Ngole *et al.*, 2010).

Clay minerals are beneficial to human health by serving as active principles or excipients in pharmaceutical preparations and in beauty therapy medicines. The value of medicinal clays as antibacterial has been studied and proven (Katende-Kyende, 2011). Clays can also eliminate excess grease and toxins from skin thus preventing dermatological diseases such as boils, acnes, ulcers, abscess, and seborrhea (Carretaro *et al.*, 2006). Clays mostly used as dermatological protectors are kaolinite, talc and smectites. This is due to their adsorbent power and presence of substances capable of adhering to the skin forming a film, which protects it mechanically against physical and chemical agents (Carretaro *et al.*, 2006). Communities in Africa still use clays for other purposes, which include cleansing, initiation, funerals, tribal wars, and love festivals (Matike *et al*., 2011). The main objective of this study was to determine the amount of sun protection factor offered by clays found and used in different counties in Kenya.

2. Materials and Methods

2.1 Study Area - The study involved collecting clay samples from three counties namely; Bomet, Bungoma and Narok counties. The counties were purposively selected since the communities living there still apply clays on their skins on several occasions for different purposes and occasions.

2.2 Sampling Design - The clay samples used as cosmetics in the above-mentioned counties were collected randomly from sites normally used by communities living in this region. The samples were dug out using paint less shovel and put in labeled paper bags after which they were transported to a laboratory at Chemistry Department of Egerton University.

2.3 Sample Preparation - The clay was air dried in shallow trays in a well-ventilated area and clay clods were broken. The plant materials and any stones present were also removed. The dry clay samples were crushed using a mortar and pestle and sieved using a 45 µm sieve.

2.4 Sun protection factor (SPF) Determination - About 2 g of cosmetic clay sample was transferred to a beaker and 10 g of liquid paraffin added and homogenized to make a paste. The paste was applied on a (2.5 × 3.5 cm^2) 3 M Transpore tape mounted on a glass slide support to achieve a spreading density protocol of 2 mg/cm^2. This was done by spotting the sunscreen on several sites over the application area (13.75 cm^2) and with circular light rubbing motion for 10 seconds, using a gloved finger the sample was spread to get uniform thickness. Transmittance was determined for a tape with and without the cosmetic clay sample between 280 to 400 nm with bandwidth fixed at 1.0 nm. Transmission measurements were repeated three times on different spots.

The SPF of the cosmetic clay was determined by recording the intensity of transmitted photocurrent in 5 nm steps from 290 to 400 nm and applying the Eqn. 1

SPF = $\sum_{290}^{400} E(\lambda)\varepsilon(\lambda) \;/\; \sum_{290}^{400} E(\lambda)\varepsilon(\lambda)/MPF(\lambda)$ ---Equation 1

(Diffey and Robson, 1989; Bleasel and Aldous, 2008)

Where - $\boldsymbol{E(\lambda)}$ is the spectral irradiance of terrestrial sunlight under defined conditions representing midday summer sunlight for Southern Europe (latitude 40^0 N; Solar zenith angle 20^0; Ozone layer thickness of 0.305 cm. $\boldsymbol{\varepsilon(\lambda)}$ is the relative effectiveness of UVR at wavelength λnm in producing delayed erythema in human skin. *MPF(λ)* is the mean monochromatic factor and is determined by transmittance of the blank substrate divided by transmission through the substrate with the applied sunscreen (Bleasel and Aldous, 2008).

The control was further subjected to another method proposed by Mansur, *et al*., (1986) for confirmation purposes. One gram of the control was transferred to 100 mL volumetric flask and topped with ethanol to the mark. The sample was ultra-sonicated for 30 minutes and filtered discarding the first 10 mL (Mishra *et al*., 2011). The absorption spectrum of the solution was obtained in the range of 290 to 400 nm using 1 cm quartz cell. Three determinations were made. The absorption data from 290 to 320, every 5 nm was used to predict SPF value with the help of Mansur equation:

$\text{SPF spectrophotometric} = \text{CF} \times \sum_{290}^{320} EE(\lambda) \times I(\lambda) \times Abs(\lambda)$---Equation 2

Where - ***EE*** is the erythemal effect spectrum; I is solar intensity spectrum. ***Abs*** is absorbance of sunscreen product and ***CF*** is the correction factor (= 10).

3.0 Results and Discussion

Sun protection factor (SPF) - SPF is a number given to sunscreen formulations, which is determined in a laboratory as to its effectiveness. It has become a worldwide standard for measuring the effectiveness of sunscreen when applied at an even rate of 2 milligrams per square centimeter (mg/cm^2). SPF is an estimate of how long one can stay in the sun before getting sunburn compared with when not wearing a sunscreen. In order to protect the skin against harmful Ultra Violet Radiation (UVR), the formulation must be having enough SPF and also the product must be having wide range of absorbance between 290 and 400 nm (Mishra *et al*., 2011).

In this study, twelve clay samples randomly obtained from the study areas were applied on a 3 M transpore tape before SPF evaluation by UV spectroscopic method as proposed by Diffey and Robson (1989). In Eqn 1, the numerator describes the ability of solar radiation to produce erythema in unprotected skin whereas the denominator describes the ability of solar radiation to produce erythema in sunscreen protected skin (Bleasel and Aldous, 2008).

A commercial sunscreen with an SPF of 40 as indicated by the manufacturer was used as a positive control. The commercial sunscreen was further subjected to the method as per Mishra *et al* (2011) to confirm the values obtained using the initial method. A UV spectrophotometer (UV1800-Shimadzu; Japan) controlled with a computer installed with UV-Prope software was used to determine transmittance and absorbance of all samples.

The clay samples used for cosmetic purposes from Narok County had SPF values between 4.5 and 40.98, and the mean was found to be 19.25 ± 17.96. Samples from Bomet County ranged from 1.46 to 5.59 with a mean of 4.11 ± 1.91. The clay samples from Bungoma County varied from 2.55 to 4.61 with a mean of 3.34 ± 0.94. The commercial sunscreen was found to have a SPF value of 29.88, which was also confirmed using method proposed by Mansur *et al* (1986) and found to be 29.84, these values were way below the manufacturers' value of 40. Data obtained for monochromatic protection factor and sun protection factor are given in table 1, 2 and 3.

The SPF values of cosmetic clays in this study were in close range to those obtained from white and red clays of South Africa as shown in a study by Dlova *et al.,* (2013)

Table 1: Monochromatic and sun protection factors obtained for each cosmetic clay samples from Narok county

	Sunscreen clay sample application thickness, 2 mg/cm ^{2}.			
Wavelength (nm)	N1	N2	N3	N4
290	0±0.0	0±0.0	0±0.0	0±0.0
295	0±0.0	0±0.0	0±0.0	0±0.0
300	0±0.0	0±0.0	0±0.0	0±0.0
305	0±0.0	3.33±1.1	3.33±1.2	0±0.0
310	20.0±0.0	3.5±0.8	3.4±06	15.6±7.7
315	25.4±5.5	3.9±0.9	3.7±0.6	14.3±4.8
320	26.2±5.7	4.2±1.1	3.8±0.5	15.4±5.1
325	26.7±6.6	4.4±1.21	4.02±0.6	15.9±6.0
330	25.9±6.5	4.5±1.25	4.1±0.6	16.3±5.8
335	27.4±6.7	4.6±1.2	4.2±0.6	16.1±5.5
340	27.6±6.6	4.7±1.3	4.2±0.6	16.3±5.7
345	27.0±6.3	4.7±1.32	4.2±0.6	16.8±6.2
350	27.2±6.6	4.7±1.3	4.2±0.6	16.7±6.0
355	27.7±7.1	4.8±1.4	4.2±0.6	16.3±5.7
360	28.3±7.8	4.6±1.2	4.2±0.6	15.9±5.8
365	28.5±8.0	4.4±1.0	4.2±0.62	15.9±6.4
370	28.9±8.2	4.4±1.0	4.2±0.6	15.7±6.14
375	29.0±8.2	4.4±1.0	4.2±0.6	15.7±6.2
380	29.0±8.2	4.4±1.0	4.1±0.6	15.5±6.2
385	29.2±8.7	4.3±1.0	4.1±0.6	15.3±6.0
390	28.5±7.4	4.3±1.0	4.1±0.6	15.2±5.9
395	28.7±8.2	4.3±1.0	4.1±0.6	14.9±5.7
400	28.9±8.2	4.3±1.0	4.1±0.6	14.8±5.9
SPF	40.98	4.50	4.50	27.05

Table 2: Monochromatic and sun protection factors obtained for clay samples from Bomet County

	Sunscreen clay sample application thickness, 2 mg/cm ^{2}.			
Wavelength (nm)	BT1	BT2	BT3	BT4
290	0±0.0	0±0.0	0±0.0	0±0.0
295	0±0.0	0±0.0	0±0.0	0±0.0
300	0±0.0	0±0.0	0±0.0	1±0.0
305	3.3±1.2	4±0.0	1.3±2.3	1.2±0.2
310	5±1.7	5±1.7	8.89±1.9	1.5±0.1
315	5.3±1.8	5.05±1.9	8.65±0.8	1.6±0.1
320	5.7±1.7	4.95±1.8	8.52±1.2	1.7±0.1
325	5.92±1.7	5.0±1.79	8.3±0.9	1.8±0.2
330	6.1±1.7	4.98±1.8	8.05±0.9	1.9±0.2
335	6.2±1.8	4.92±1.7	7.95±0.9	1.9±0.2
340	6.2±1.8	4.9±1.7	7.8±0.8	1.9±0.2
345	6.3±1.8	4.9±1.7	7.7±0.8	1.9±0.1
350	6.3±1.8	4.9±1.7	7.7±0.7	1.9±0.2
355	6.3±1.8	4.9±1.7	7.5±0.7	1.9±0.1
360	6.0±1.6	4.8±1.6	7.4±0.8	1.9±0.2
365	5.7±1.3	4.7±1.6	7.3±0.8	1.9±0.2
370	5.7±1.3	4.7±1.6	7.3±0.8	1.9±0.2
375	5.7±1.3	4.7±1.6	7.1±0.7	1.9±0.2
380	5.6±1.3	4.7±1.6	7.0±0.7	1.9±0.2
385	5.6±1.2	4.6±1.5	7.0±0.7	1.8±0.2
390	5.6±1.3	4.6±1.5	6.8±0.7	1.9±0.2
395	5.6±1.3	4.6±1.5	6.7±0.7	1.8±0.2
400	5.6±1.3	4.6±1.5	6.7±0.7	1.8±0.2
SPF	5.41	5.59	3.97	1.46

Table 3: Monochromatic and sun protection factors obtained for clay samples from Bungoma County

	Sunscreen clay sample application thickness, 2 mg/cm ^{2}.				
Wavelength (nm)	BM1	BM2	BM3	BM4	CONTROL
290	0±0.0	0±0.0	0±0.00	0±0.0	0±0.0
295	0±0.00	0±0.0	0±0.00	0±0.0	0±0.0
300	0±0.00	0±0.0	0±0.00	0±0.0	0±0.0
305	3.3±1.2	2.7±1.2	2±0.00	1.8±0.4	0±0.0
310	3.4±1.1	2.8±0.5	2.24±0.3	2.1±0.4	0±0.0
315	4.3±1.4	3.1±0.7	2.43±0.2	2.4±0.5	8.6±14.8
320	4.3±1.3	3.2±0.7	2.57±0.2	2.5±0.5	16.1±27.9
325	4.3±1.3	3.2±0.7	2.66±0.2	2.6±0.5	59.1±29.3
330	4.3±1.3	3.3±0.7	2.73±0.2	2.7±0.5	40.7±20.1
335	4.2±1.2	3.3±0.7	2.77±0.2	2.7±0.5	33.7±16.7
340	4.2±1.2	3.3±0.7	2.79±0.2	2.8±0.5	26.6±13.5
345	4.2±1.2	3.3±0.7	2.8±0.2	2.8±0.5	22.1±10.1
350	4.2±1.2	3.3±0.7	2.8±0.2	2.8±0.5	17.7±8.0
355	4.1±1.2	3.3±0.7	2.8±0.2	2.8±0.5	14.9±6.5
360	4.1±1.2	3.3±0.7	2.81±0.2	2.8±0.5	12.0±4.9
365	4.1±1.2	3.3±0.8	2.83±0.2	2.8±0.5	9.6±3.7
370	4.1±1.2	3.2±0.8	2.83±0.2	2.8±0.5	7.9±3.0
375	4.1±1.2	3.2±0.8	2.82±0.2	2.8±0.5	6.8±2.5
380	4.1±1.2	3.2±0.7	2.81±0.2	2.8±0.5	6.1±2.1
385	4.1±1.1	3.2±0.7	2.81±0.2	2.8±0.5	4.9±1.6
390	4.0±1.1	3.2±0.7	2.79±0.2	2.8±0.5	3.6±1.1
395	4.0±1.1	3.2±0.7	2.78±0.2	2.8±0.5	3.1±0.9
400	4.0±1.1	3.2±0.7	2.78±0.2	2.8±0.4	2.8±0.7
SPF	4.61	3.46	2.73	2.55	29.88

The SPF values of most of these clays were below five; however, they provide some protection to the users. Samples N1 and N4 from Narok County showed higher SPF values of 40.98 and 27.05 respectively, which are higher than most marketed commercial sunscreens. These clays will provide a substantial amount of protection to the users. It should also be noted that the amount applied to the transpore tape is much lower than what is usually applied hence the protection factor might be higher than what has been calculated here.

Conclusion

The clay cosmetic samples offer sun protection to the users. The sun protection ability is influenced greatly by the concentration of Fe_2O_3 in them. TiO_2 and ZnO also play a role in offering UV protection ability. Particle size also was shown to influence protection ability of the clays. Determination of SPF using Transpore tape is cheap, easy to handle, readily available and rapid.

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