Determination of sun protection factor number: an emerging in–vitro tool for predicting UV protection capabilities

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Abstract

The deleterious effect of ultra-violet rays from the sun on the skin is alarming and agents or substances that can reduce or combat these effects are well sought for. The purpose of this study was to investigate the potential of commonly consumed teas in providing sunscreen protection using the in vitro method. Thirty selected teas (green, black and “others”) were brewed and diluted to produce 20% v/v aqueous solution. The absorbances of the solutions were determined by the UV spectrophotometer between wavelengths of 320 and 290 nm. The sunscreen protection factors (SPF) were then calculated using the Mansur equation. The determined SPF values were between 10.33 and 25.33%. The green teas were observed to have the highest absorbance (2.5) and consequently higher SPF (25.33%) followed by the black teas (24.45%) and then the “others”. Some of the unclassified teas however had values as high as 25.20% while also having very low values (10.33%). Teas have been postulated to have skin protective abilities when consumed orally or applied topically; this work gives further credit to this postulation. The results reveal that these safe and cheap teas have great potential as sun-protective agents.

Keywords: Herbal teas, sun protection factor, in vitro method

1. Introduction

The skin is the largest organ in the body, makes up to 16% of the entire body and covers about 1.8 m². It protects against chemicals and environmental hazards, radiation, infections; it also protects against harmful UV rays. These sunscreen products can be incorporated into oils, creams, gels and lotions. The sunscreens used in the cosmetic industry can either be physical or chemical depending on their mode of action [2]. Consequently, upon the fact that it is practically impossible to be completely shielded from these rays, creams and lotions containing ingredients capable of protecting the skin have been formulated for basic everyday use. Examples of commonly used chemical ingredients used as sunscreen are zinc oxide and titanium dioxide. The naturally occurring compounds like anthocyanins, proanthocyanidin, resveratrol (grapes), quercetin, apigenin, silymarin, curcumin, vitamin E, vitamin C, wheat germ oil, pumpkin seed oil, carotenoids, herbs, teas, fruits and vegetables are also implicated in sunscreen activity [2]. These herbs, fruits, teas also have antioxidant potential, therefore, they are able to scavenge free radicals and have an effect in protecting the skin from the harmful UV radiation. The inclusion of sunscreen products is widely used globally in the cosmetic industry as this ensures adequate protection against harmful UV rays. These sunscreen products can be incorporated into oils, creams, gels and lotions. The sunscreens used in the cosmetic industry can either be physical or chemical depending on their mode of action [2]. Consequently, due to the fact that it is practically impossible to be completely shielded from these rays, creams and lotions containing ingredients capable of protecting the skin have been formulated for basic everyday use. Examples of commonly used chemical ingredients used as sunscreen are zinc oxide and titanium dioxide. The naturally occurring compounds like anthocyanins, proanthocyanidin, resveratrol (grapes), quercetin, apigenin, silymarin, curcumin, vitamin E, vitamin C, wheat germ oil, pumpkin seed oil, carotenoids, herbs, teas, fruits and vegetables are also implicated in sunscreen activity [2]. These sunscreens act by absorbing, reflecting or scattering UV radiations, they also have SPF. There are 3 types of UV radiation namely; UVA which penetrates deep into the epidermis and dermis of the skin and generates free radicals indicated in premature skin ageing, wrinkling and spots on the skin.
The SPF using an equation known as the Mansur equation. Solutions of sunscreens substances and then extrapolation of specimen. It involves determination of absorption of dilute non-time consuming and does not require the use of life method on the other hand is simple, economical, practical, requires ethical clearance and very expensive. The human volunteers and this is time consuming, complex, adverse skin reactions that occur due to exposure to UV radiation. The inclusion of tea extract in cosmetic products has been reported to show evidence of antioxidant and anti-radiation. The effectiveness of substances used as sunscreens is expressed as the protection factor i.e. the UV energy required to produce a minimal erythema on an unprotected skin within a period of time. The sunscreen protection factor (SPF) suggests the length of time you can leave your skin exposed in the sun after application of a sunscreen without getting burnt or the sun-protection ability of substances. The SPF numbers have become a worldwide standard for measuring the effectiveness of sunscreen products and these numbers can be determined by in vitro or in vivo methods. The in vivo method involves testing of creams/lotions containing SPF on human volunteers and this is time consuming, complex, requires ethical clearance and very expensive. The in vitro method on the other hand is simple, economical, practical, non-time consuming and does not require the use of life specimen. It involves determination of absorption of dilute solutions of sunscreens substances and then extrapolation of the SPF using an equation known as the Mansur equation.

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SPF = \frac{CF}{\sum \frac{EE}{\lambda} I(\lambda) Abs(\lambda)}
\]

CF = correction factor (10), EE = erythmogenic effect of radiation with wavelength,
I = solar intensity spectrum, Abs (\lambda) = spectrophotometric absorbance values at wavelength.

The aim of this work was to determine the sunscreen potentials of herbal teas circulating in the Nigerian market with a view to ascertaining the veracity of the Mansur equation as an emerging popular in vitro tool for predicting UV protection capabilities. Literature survey shows that, this is the first time such a large number of samples would be evaluated using this in vitro tool.

2. Materials and Method
The twelve black teas assessed include; Lipton tea, Top tea, Typhoo (English breakfast tea), Ketapa Pride, Alwazah tea, Hillwaytea, Richmond tea, PG tips, Al - ameer tea, Dilmah, Loyd, Impra, Ahmad
The following were the green teas assessed; Legend green tea, Mustika Ratu, Twinings, Highland, Qualitea, 3 Ballerina

The absorbance of the tea samples are shown in Tables I, II and III while the SPF values calculated through UV-Spectrophotometric method are shown in Table IV. The SPF values of the aqueous herbal teas range between 10.33 and 25.33. The green teas; Mustika ratu, Twinings, Qualitea and Ballerina were found to have the highest SPF values among all the teas studied. The implication is that these teas may protect the skin from harmful effects of the sun when consumed orally or applied topically. However, two of the unclassified (others); teas Earl Grey tea and Moringa tea and one of the black teas; Loyd tea were observed to have SPF below 15% indicating their relative inability for skin protection. Almost all the teas in the same category have the same or similar SPF values as calculated from Mansur equation.
Table I: Absorbance of black teas (B1 - B13)

<table>
<thead>
<tr>
<th>nm</th>
<th>EE*I</th>
<th>B1</th>
<th>B2</th>
<th>B3</th>
<th>B4</th>
<th>B5</th>
<th>B6</th>
<th>B7</th>
<th>B8</th>
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<th>B10</th>
<th>B11</th>
<th>B12</th>
<th>B13</th>
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<tbody>
<tr>
<td>290</td>
<td>0.0150</td>
<td>2.516 ± 0</td>
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<td>2.492 ± 0</td>
<td>2.445 ± 0</td>
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<td>295</td>
<td>0.0817</td>
<td>2.475 ± 0</td>
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<td>2.444 ± 0</td>
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<tr>
<td>300</td>
<td>0.2874</td>
<td>2.447 ± 0</td>
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<td>305</td>
<td>0.3278</td>
<td>2.443 ± 0</td>
<td>2.433 ± 0</td>
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<tr>
<td>310</td>
<td>0.1864</td>
<td>2.439 ± 0</td>
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<tr>
<td>315</td>
<td>0.0837</td>
<td>2.436 ± 0</td>
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<tr>
<td>320</td>
<td>0.0180</td>
<td>2.433 ± 0</td>
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Previous reports have expounded the potential of natural and safe materials as sun-protective agents; for example, Patel et al. [10] reported the incorporation of *Pongamia pinnata* leaf and *Punica granatum* peel extracts in sunscreen formulations with antimicrobial properties, the SPF value was found to be 5 and transmittance of less than 2%. The authors concluded that, the information was critical in the selection of oils that could be incorporated into sunscreen formulations. Aqueous solutions of citrus juices have also been investigated for sun-protective potential having the highest value and suggested that, the SPF values ranging between 0.25 and 7.5 with olive oil was found to be beneficial. On their part, Ratnasooriya et al. [12] reported the highest SPF values for their samples which incidentally were black teas. The authors observed that Sri Lankan black tea which has high antioxidant potential also possesses SPF greater than 15 indicating their potential for good sunscreen activity. Although our observation on the behavior of different teas herein investigated are not significantly different from previous reports by other researchers, our study is larger in scope than all previous studies and unlike previous researchers, except Ratnasooriya et al. [13] who reported on two black teas, our study focused on all teas already approved by the regulatory agency (National Agency for Food and Drug Administration and Control; NAFDAC) and circulating in the Nigerian market. It is significant to note here that, most of these teas are imported and command high patronage. According to Gayer et al. [13]
“even though several synthetic sunscreens are available, they have limited applications in cosmetics due to their potential toxicity in humans and ability to interfere only in selected pathways of carcinogenesis.

Botanical and herbal agents are known to be safe and have been widely accepted by consumers. They also work in various ways by stimulating immune response, inducing gene suppression, detoxifying carcinogens, blocking oxidative damage to DNA, initiating selected pathways or by other mechanisms [5, 14]. Thus, these herbal teas play significant and multiple roles in ameliorating the process of carcinogenesis. Therefore, these herbal teas at optimum concentrations could contain water extractable polyphenolic compounds which possess antioxidant, anti-inflammatory and anti-carcinogenic properties, these compounds destroy free radicals implicated in skin damage and thus, repair the skin. One of such polyphenolic compounds; epigallocatechin gallate which is present in green tea is said to be about 100% more potent than vitamin C as an antioxidant and 25% more effective than vitamin E as a sun-protection agent. Epigallocatechin gallate is thought to be responsible for the sun-protection ability of teas [5, 14]. The presence of these polyphenolic compounds in the different types of teas differs and as such determines their effectiveness in skin protection. The topical and even oral use of these teas has proved to be effective for photo-protection of the skin. Consumption of green teas has been reported to reduce skin redness after exposure to UVB radiation and they also repair the skin because of the presence of anti-oxidants. The green teas were observed to have the highest SPF (25%) followed by some of the uncategorized teas and then black teas (24%). Values between 15 and 30% have been suggested as good, as it implies that these agents can block 93-97% UVB radiation while also offering protection against UVA radiation, whereas values > 50% are capable of blocking about 98% UVB, but they offer minimal protection against UVA, which is responsible for accelerated skin aging.

4. Conclusion
The SPF values of the aqueous extracts of some commonly found teas were evaluated. It was found that most of them have the UV protection capabilities. Along with their many beneficial effects and safety, these botanicals could become good, cheap and easily available formulation ingredients in sunscreen products.

5. References