Comparative Sun Protection Factors of Essential Oils in Formulation of Natural Sunscreens

Ivan Tan Yu Hao
Dunman High School
Singapore
tan.yuhao.ivan@dhs.sg

Jo Lee Ruo Qi
Dunman High School
Singapore
lee.ruoqi.jo@dhs.sg

Chien Hung Yeh
Dunman High School
Singapore
chien.hungyeh@dhs.sg

Abstract— The aim of this investigation is to evaluate the ultraviolet (UV) absorption ability of herbal oils to develop safer sunscreens with high SPF. 7 herbal oils were selected and suitably diluted in ethanolic solution. Absorbance between 290-320nm was measured using UV-vis spectrophotometry and SPF of the oils were determined using the Mansur equation. All oils tested individually showed UV protection capabilities. Grapefruit oil showed the highest SPF number of 35.28 while eucalyptus oil showed the lowest SPF number of 0.87. All oil combinations tested showed SPF numbers above 25.0. The combination of lavender and grapefruit oils showed the highest SPF number of 29.27.After which, beeswax and shea butter of different concentrations were added to the combination of lavender and grapefruit oils as a base of the sunscreen.

I. Introduction

Ultraviolet (UV) radiation from the sun is divided into three categories: UV-C (200-280nnm), UV-B (280-320nm) and UV-A (320-400nm). UV-C is highly mutagenic and toxic but is fully absorbed by the earth's atmosphere. Most of UV-B and all of UV-A passes through the atmosphere and reaches the ground. Studies have shown that UV-B is directly absorbed by DNA and causes structural damage to DNA. In addition, UV-A causes the formation of reactive oxygen species, which in turn leads to breaks in DNA resulting in damage (Deevya L. Narayanan, 2010; Gerd P. Pfeifer, 2005). DNA damage caused by exposure to UV radiation subsequently results in various adverse effects on the skin such as sunburn, inflammation, photoaging, and even leads to skin cancer (Alena Svobodova, 2006).Photoprotective agents, such as sunscreens, protect the skin by preventing and reducing the damaging effects of UV rays. Sunscreens contain chemical compounds which can absorb,block, reflect or scatter sunlight (M.S. Latha, 2013). Sun protection factor is a laboratory measure of the effectiveness of sunscreen; the higher the SPF, the more protection sunscreen offers against the ultraviolet radiations causing sunburn (Elizângela Abreu Dutra,2004). Active ingredients in commercial sunscreens contain either mineral or chemical filters.Studies show that several frequently used UV filters, such as oxybenzone and octyl-methoxycinnamate (OMC), possess estrogenic activity (Margret Schlumpf, 2001), or cause skin allergies (P. Lenique, 1992). Herbal essential oils have shown to exhibit photoprotective properties and are more suitable for people with hyperallergic skin (AK Mishra, 2011; Chanchal Deep Kaur, 2010). As such, the aim of this investigation is to evaluate the photo protective properties of various herbal oils which can be helpful in the selection of oils and fragrances to develop sunscreens with better safety and high SPF.
Other than the herbal essential oils, the base of the sunscreen will affect its SPF. With only the herbal oils, the sunscreen cannot be formed. Bases of sunscreen have to be photo stable. Photo stability is defined as ability to not degrade when exposed to sunlight. Thus, after finding out the SPF of each essential oils tested, selection of the bases is carried out so to produce a sunscreen with the highest SPF ultimately.

II. METHOD AND MATERIALS

A. Phase 1: Determining SPF of Herbal Essential oils:

Materials

Oils:	**Others:**
• Eucalyptus Oil • Lavender Oil • Tea Tree Oil • Coconut Oil • Olive Oil • Jojoba Oil • Watermelon Oil • Rosemary Oil • Basil Oil • Carrot Seed Oil • Thyme Oil • Grapefruit Oil	• Micropipettes • Beakers • Ethanol • Fulcrum tubes • Quartz cuvettes • Spectrophotometer

Procedures

1. A range of pure herbal essential oils will be obtained. The oils will be suitably diluted in 70% ethanol solution.
2. Absorbance spectra of each aliquot of oil will be obtained using a spectrophotometer in the range of 280 to 320nm using a 3ml quartz cuvette and 70% ethanol as blank. Absorption values will also be obtained in the range of 280 to 320nm in 5nm intervals.
3. SPF of herbal oils will be calculated using the Mansur equation (C. Malsawmtluangi, 2013)

B. Phase 2: Combining Herbal Essential Oils to Improve SPF of Oils:

Materials
(i)Oils
Combination 1: Grapefruit Oil + Lavender Oil
Combination 2: Grapefruit Oil + Coconut Oil
Combination 3: Grapefruit Oil + Teatree Oil
Combination 4: Grapefruit Oil + Jojoba Oil
Combination 5: Grapefruit Oil + Watermelon Oil + Lavender Oil

Procedures

1. Using the results from phase 1, herbals oils with high SPF will be combined in an attempt to obtain combinations of oils with higher SPF.
2. The oil combinations will also be diluted in 70% ethanol solution.
3. Absorbance spectra of each oil mixture will be obtained in the range of 280 to 320nm using a 3ml quartz cuvette and 70% ethanol as blank. Absorption values will also be obtained in the range of 280 to 320nm in 5nm intervals.
4. SPF of herbal oils will be calculated using the Mansur equation (C. Malsawmtluangi, 2013)

C. Phase 3: Creating the Final Herbal Sunscreen:

Materials

Oils:	**Others:**
• Watermelon Oil • Lavender Oil • Grapefruit Oil • Coconut Oil	• Micropipettes • Beakers • Fulcrum tubes • Beeswax • Ethanol • Shea butter

Procedures

1. The shea butter, beeswax and coconut oil will be heated slowly in a beaker, over a hotplate, in different proportions
2. The mixture will be stirred constantly and then let cool for 15-30 mins.
3. The combination of oil with the highest SPF is added to the mixture, making up a total of 10% of the total final herbal sunscreen.
4. Herbal sunscreen is stirred well, and then refrigerated until use.

III. RESULTS AND DISCUSSIONS

Table 1: Absorbance of Individual Herbal Oils

Wavelength (nm)	**EE (λ) x I employed**	**Eucalyptus oil**	**Lavender oil**	**Tea tree oil**
290	0.0150	0.372	1.623	2.711
295	0.0817	0.208	1.222	1.569
300	0.2874	0.112	1.008	0.567
305	0.3278	0.064	0.944	0.205
310	0.1864	0.045	0.923	0.117
315	0.0837	0.033	0.875	0.090
320	0.0180	0.027	0.777	0.077

Table 1.1: Absorbance of Individual Herbal Oils

Wavelength (nm)	EE (λ) x I employed	Coconut oil	Grapefruit oil	Olive oil
290	0.0150	0.468	3.024	0.175
295	0.0817	0.411	3.186	0.170
300	0.2874	0.373	3.373	0.162
305	0.3278	0.373	3.360	0.158
310	0.1864	0.388	4.000	0.157
315	0.0837	0.383	4.000	0.155
320	0.0180	0.385	4.000	0.153

Table 1.2: Absorbance of Individual Herbal Oils

Wavelength (nm)	EE (λ) x I employed	Watermelon oil	Rosemary oil	Basil oil
290	0.0150	3.143	0.895	3.067
295	0.0817	3.121	0.326	2.802
300	0.2874	3.196	0.268	2.418
305	0.3278	3.123	0.216	2.048
310	0.1864	4.000	0.172	1.508
315	0.0837	3.786	0.142	1.110
320	0.0180	3.544	0.124	1.002

Table 1.3: Absorbance of Individual Herbal Oils

Wavelength (nm)	EE (λ) x I employed	Carrot seed oil	Thyme oil	Jojoba oil
290	0.0150	2.404	2.352	0.331
295	0.0817	2.251	1.584	0.320
300	0.2874	2.082	1.200	0.318
305	0.3278	1.848	1.033	0.307
310	0.1864	1.565	1.861	0.303
315	0.0837	1.209	0.855	0.299
320	0.0180	0.932	0.794	0.295

Table 2: SPF Values of Individual Herbal Oils

Individual herbal oils	SPF values	Individual herbal oils	SPF values
Grapefruit	35.289	Tea tree	4.297
Watermelon	33.707	Coconut	3.814
Basil	20.332	Jojoba	3.100
Carrot seed	18.338	Rosemary	2.341
Thyme	12.809	Olive	1.599
Lavender	9.826	Eucalyptus	0.874

The absorbance of the 12 individual herbal oils across the wavelengths of 290 to 320 were recorded. The SPF values of the oils were then recorded using the Mansur Equation, which ranged from. 0.874 in eucalyptus to 35.289 in grapefruit (Table 2). SPF value of Grapefruit oil was found to be the highest among all the oils tested, followed closely by watermelon oil which makes them highly suitable for use in our sunscreen formulations.

Table 3: Absorbance of Herbal Oil Combinations

Wavelength (nm)	EE (λ) x I employed	Tea tree/ Grapefruit oil	Coconut/ Grapefruit oil
290	0.0150	2.04	0.896
295	0.0817	1.394	1.022
300	0.2874	1.156	1.142
305	0.3278	1.179	1.27
310	0.1864	1.337	1.461
315	0.0837	1.428	1.566
320	0.0180	1.462	1.592

Table 3.1: Absorbance of Herbal Oil Combinations

Wavelength (nm)	EE (λ) x I employed	Lavender/ Grapefruit oil	Jojoba/ Grapefruit oil
290	0.0150	1.276	0.91
295	0.0817	1.274	1.032
300	0.2874	1.328	1.146
305	0.3278	1.441	1.27
310	0.1864	1.656	1.454
315	0.0837	1.742	1.549
320	0.0180	1.763	1.601

Table 3.2: Absorbance of Herbal Oil Combinations

Wavelength (nm)	EE (λ) x I employed	Grapefruit/ Watermelon/ Lavender	Grapefruit/ Watermelon/ Basil
290	0.0150	3.225	3.312
295	0.0817	3.266	3.264
300	0.2874	3.279	3.190
305	0.3278	3.179	3.266
310	0.1864	3.060	3.078
315	0.0837	2.431	2.298
320	0.0180	1.880	1.735

Table 3.3: Absorbance of Herbal Oil Combinations

Wavelength (nm)	EE (λ) x I employed	Grapefruit/ Watermelon/ Coconut
290	0.0150	3.218
295	0.0817	3.259
300	0.2874	3.272
305	0.3278	3.261
310	0.1864	3.006
315	0.0837	2.266
320	0.0180	1.719

Table 4: SPF Values of Herbal Oil Combinations

Herbal oil combinations	SPF values	Herbal oil combinations	SPF values
Watermelon, Lavender & Grapefruit	62.147	Lavender & Grapefruit	29.269
Watermelon, Coconut & Grapefruit	62.097	Coconut & Grapefruit	25.470
Watermelon, Basil & Grapefruit	62.021	Jojoba & Grapefruit	25.463
		Tea tree & Grapefruit	25.165

Herbals oils with high SPF values were then selected for use in the herbal oil combinations. SPF values of the 7 combinations ranged from 25.165 in tea tree and grapefruit to 62.147 in watermelon, lavender and grapefruit. Out of the 7 combinations tested, the combination of watermelon, lavender and grapefruit gave the highest SPF value.

Sunscreens play an important role in photoprotection. Studies have shown that regular use of sunscreen is effective in reducing the incidence of sunburn, pigmentation and skin cancer (Deevya L. Narayanan, 2010; Latha MS, 2013) as they are able to prevent the skin from absorbing the harmful UV rays. SPF is generally used as a measure of UVB absorption. Research has shown that as SPF values increase, the percentage of UVB absorbed by the product also increases (Brummitte Dale Wilson, 2012; Aruna Chintaginjala, 2012). An SPF 15 product correlates to 93.3% UVB absorption, indicating that 93.3% of UVB rays are blocked from the skin (Table 4). A product with minimum SPF 15 is usually recommended for use outdoors daily. All 7 herbal oil combinations provide a minimum of SPF 25, which enables them to block out at least 95% of UVB rays and making them ideal for daily use.

Table 5: Percentage change in sunscreens placed at 3 different locations

Sunscreen	Initial SPF	After 24 hours under sunlight	After 24 hours refrigerated	After 24 hours exposed to Room Temperature and Pressure (RTP)
0% Beeswax Sunscreen	146.192	94.774 (-35.2%)	98.458 (-32.7%)	84.890 (-41.9%)
10% Beeswax Sunscreen	70.851	51.712 (-27.0%)	58.306 (-17.7%)	54.315 (-23.3%)
20% Beeswax Sunscreen	59.413	29.591 (-50.2%)	51.769 (-12.9%)	15.035 (74.7%)

In relation to the purpose of our research which is to create a sunscreen with natural ingredients, sunscreens of 3 different beeswax percentages (0%, 10% & 20%) were created. Each sunscreen is divided into 3 portions and placed in the fridge, sun and at room temperature. Out of the 3 sunscreens, the 20% beeswax sunscreen had the highest percentage change in spf when placed in the sun, followed by the 0% beeswax sunscreen. It is thus shown that 10% beeswax is the optimum percentage of beeswax that is suitable for a natural sunscreen, for it not only has a relatively high SPF value, but is also durable.

These results, however follows a general pattern as although the SPF value decreases with the increase in concentration of Beeswax, the Beeswax extract is able to retain the SPF of osunscreen for longer periods of time and should therefore still be an integral component in the sunscreen mixture. Although the SPF of the 20% Beeswax sunscreen drop the most significantly, with the highest percentage change, when exposed to the three different conditions, this can also be attributed to the low initial SPF of the sunscreen, as the drop in SPF values is the least among the 3 sunscreens tested.

Therefore, apart from the initial herbal oil mixture, the herbal oil sunscreen should also contain both the Shea Butter, to ensure the sunscreen offers UV protection for the skin, as well as Beeswax extract, to ensure that this SPF value can also be retained for long periods of time for sustainable commercial use.

All herbal oils tested in this investigation do not cause adverse effects on the skin, which is an important consideration in the making of a topical sunscreen. These oils are also easily absorbed by the skin and spread easily. The herbals oils used in this investigation have their own benefits which may bring about therapeutic effects for consumers, in addition to their photoprotective abilities. For example, Jojoba oil has been shown to be effective for the treatment of eczema, psoriasis and dry skin and is commonly used as a moisturiser (Priyanka Kantivan Goswami, 2013). Tea tree oil possesses antioxidant activity and has also been reported to have broad-spectrum antibacterial activity against skin and mucosa infections (Nader Pazyar, 2013).

Furthermore, the natural ingredients used in this investigation are safe for the skin, and have their individual benefits to creating a natural sunscreen. For instance, when applies to the skin, beeswax forms a protective barrier that helps protect it from environmental assaults, while also holding in the moisture and reducing dryness. Also, beeswax is rich in vitamin A and helps exfoliate the skin, and can rejuvenate one's look (Ann Marie Gianni, 2016). Shea butter on the other hand, is moisturizing and hydrating and provides immediate softness and smoothness. It is also suitable for relieving sunburns (Dr. Josh Axe, 2016). The use of natural ingredients hence enhances the effects of the essential oils, and make a suitable sunscreen which can be customised according to the needs of the consumer.

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