Determination of Sun Protection Factor (SPF) Number of Some Aqueous Botanical Extracts by Ultraviolet Spectrophotometry

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Abstract: The objective of this study was to determine *in vitro* the ultraviolet absorbance (ABS) in the ultraviolet B range (UVb, 280–320 nm) for botanical aqueous decoctions of some commonly used plants by the UV-VIS Spectrophotometer and then calculate the number of sun protection factor (SPF) for each extract. The aqueous botanical extracts were prepared by soaking the dried botanical sample in boiled distilled water for 20 minutes (decoction). Then, the extract was filtered using filter paper. After dilution, the absorption values of plants aqueous decoctions, which including: peppermint, sage, rosemary, basil, chamomile, cinnamon, dandelion, lavender, clove, and rose, were measured using the single-beam ultraviolet spectrometer in a range of 290-320 nm, with an increase of 5 nm per measurement. The measurement process was repeated twice per wavelength, and then calculated the average absorption using UV-VIS spectrophotometer. Then, the SPF was calculated by applying Mansour's mathematical equation for each extract. All botanical aqueous extracts showed some sun protection properties. Matching the values of SPF, the best SPF value was for rose botanical aqueous extract at 8.2. The SPF value of clove extract was found to be at 5.0. Rosemary aqueous extract revealed SPF at 4.0. These aqueous extracts of plants have revealed absorbency in the UV region. The reason for optical absorbance values of aqueous solutions can be attributed to the content of the organic substances, which including glycosides, tannins, flavonoids, anthocyanins, and other organic materials, that can be extracted in boiling water. Therefore, these extracts can protect the skin from the harmful effects of UV rays so they can be used in the formulation of sunscreens as emollients and sun blockers such as rose extract. Moreover, the aqueous extract of rose petals could be used as an alternative to the chemicals used in cosmetic manufacturing.

Keywords: Sun protection factor, Ultraviolet spectrophotometry, Thyme, Basil, Chamomile, Rose.

1. Introduction

Sunscreens are cosmetic formulations that block UV rays[1]. Ultraviolet light is divided into three areas: Ultraviolet A (UVA) light (290–320 nm), Ultraviolet B (UVB) light (290-320 nm) and Ultraviolet C (UVC) light (290-200 nm)[2]. Ultraviolet B (UVB) light can cause irreversible skin damage, including cancer, hyperpigmentation, and aging, while UVC has no harmful effects on the skin, and UVA is mostly ozone-filtered [1-3].

Plant extracts may represent an important area of research, especially in the areas of prevention of skin cancer and aging caused by ultraviolet (UV) rays[4]. Several plant elements, particularly vitamins and polyphenols, have been shown to influence signal transduction pathways that lead to photo-protective effects[5]. A study of different samples of hydro-alcoholic vegetable extracts has also shown some photo-protective properties[6]. In previous study, the values of the sun protection factor (SPF) were evaluated for water extracts of some common plants, such as watermelon and strawberry, and it was found that most of them have

protective abilities from ultraviolet rays[7]. Also, extracts of black tea leaves have shown efficacy against UV rays[8]. There are many plant extracts that have been proven as sunscreens and used in cosmetics[9-11].

The plants used in this research are summarized in Table 1 with their common and scientific names as well as the family to which the plants belongs, although five plants belong to the same family (Labiatae / Lamiaceae)[12-14].

These plants contain volatile oils, flavonoids, glycosides, lipids, carbohydrates, and steroids. Some of the active substances in these plants are summarized in Table 2, as well as the chemical structures of some of them are shown in Figure 1.

Table 1: Botanical names of used plants.

Family name	Botanical name	Common name
Labiatae	*Rosmarinus officinalis.*	Rosemary
Labiatae	*Ocimum basilicum.*	Basil
Labiatae	*Salvia officinalis.*	Sage
Labiatae	*Lavandula angustifolia*	Lavender
Labiatae	*Mentha piperita*	Peppermint
Compositae	*Matricaria recutita*	Chamomile
Compositae	*Taraxacum officinale*	Dandelion
Mrytaceae	*Eugenia caryophyllus*	Clove
Lauraceae	*Cinnamomum zeylanicum*	Cinnamon
Geraniaceae	*Rose centifolia*	Rose

Table 2: Some active substances in the plants under study

Common name	Main components
Rosemary	Flavonoids: diosmetin **1**, luteolin **2**, genkwanin **3**; phenolic acids: chlorogenic 5, neochlorogenic **6**, caffeic **7**, rosmarinic **8**; volatile oils: camphor **9** (20–50% of the oil); terpenoids: carnosol **10**, rosmanol **11** (diterpenes), oleanolic **12**, ursolic acid **13** (triterpenes).[12,15.]
Basil	Flavonoids, monoterpene glycosides, volatile oils, vitamin A, potassium, vitamin C, sodium, phosphorus, calcium, iron, folic acid and manganese.[12]
Sage	Flavonoids, monoterpene glycosides, volatile oils, diterpenes, phenolic acids and tanins.[12]
Lavender	Volatile oils: linalool **14** (25–38%) and linalyl acetate **15** (25–45%); flavone glycosides; hydroxycinnamic acid **16** esters, rosmarinic acid **8** and chlorogenic acid **5**; coumarins and 7-methoxycoumarin (herniarin) **17**.[16]
Peppermint	volatile oils, carotenes; gum; minerals; resin, and tocopherols; squalene triterpenes.[17]
Chamomile	Volatile oils 0.24–1.9%; coumarins: umbelliferone **18** and its methyl ether, heniarin **17**; flavonoids: apigenin **18** , apigetrin **19**, apiin **20** and luteolin **3**.[12]
Dandelion	Coumarins, flavonoids, minerals: (Potassium 4.5% in leaf, 2.45% in root.), phenolic acids and resins.[12]
Clove	Volatile oils: (15–18%), campesterol **21**, carbohydrates, lipids, oleanolic acid **12**, sitosterol **22**, stigmasterol **23** and vitamins.[12]
Cinnamon	Volatile oils Up to 4%: cinnamaldehyde **24** (60–75%), benzaldehyde **25** and cuminaldehyde **26**; phenols (4–10%).[12]
Rose	The volatiles consisted mainly of 2-phenylethanol **27** (69.7–81.6%), linalool **14** (1.5–3.3%), citronellol **28** (1.8–7.2%), nerol **29** (0.2–4.2%), geraniol **30** (0.9–7.0%) along with rose oxides and all other characteristic minor rose compounds.[18]

A simple, rapid and reliable in vitro method for calculating the SPF is to screen the absorbance of the product between 290-320 nm at every 5 nm intervals. SPF can be calculated by applying Mansur equation (1)[19-21].

Furthermore, UVB radiation (290–320 nm) is more carcinogenic than UVA radiation (320–400 nm) in experimental induction of skin cancer[22]. UVB irradiation can cause severe damage such as sunburn, or photoaging and melanoma, all of which are major health extortions[23]. Moreover, "UVB, can damage DNA and protein structures in the cells of the skin, particularly in the epidermis"[24]. The impact of UVB radiation is huge (Figure 2).

There are many studies on calculating the sun protection factor for plant extracts, and most of them using Mansour's equation to calculate SPF[26-28].

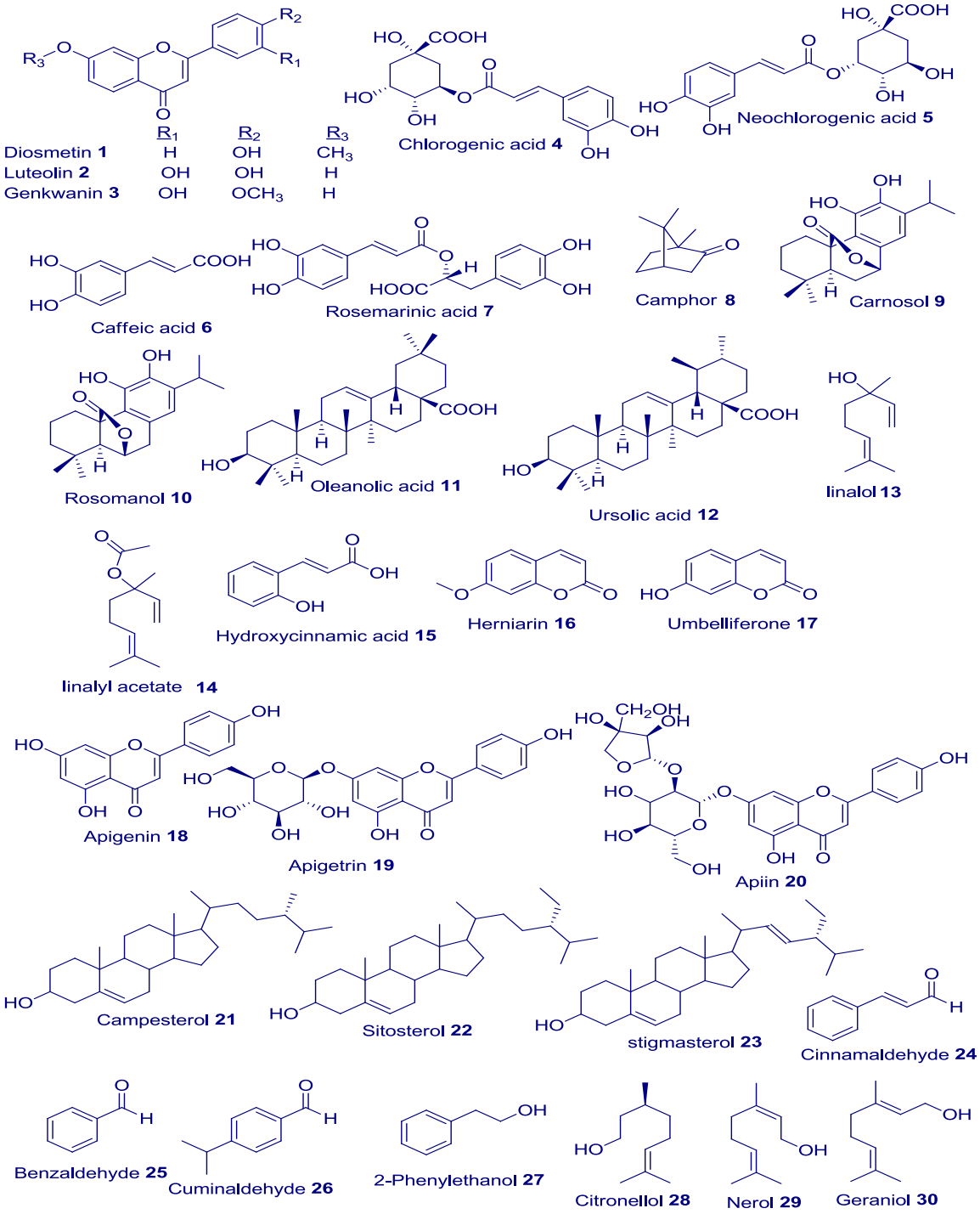

Figure 1: Chemical structures of main components of used plants

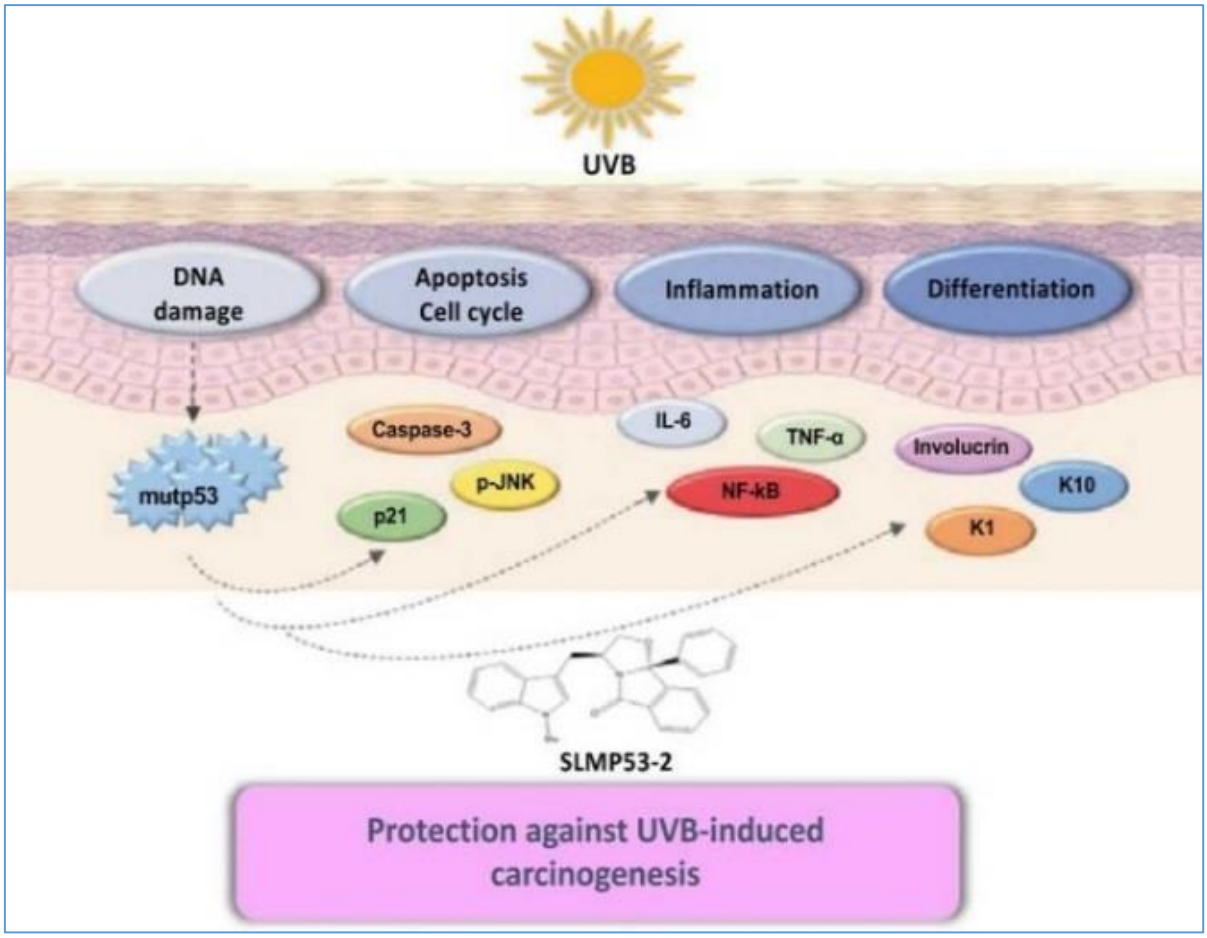

Figure 2: The impact of VB radiation on skin[25].

2. MATERIALS AND METHODS

2.1 Plant material

In this research, ten different commercially available plants, including peppermint, rosemary, sage, lavender, basil, chamomile, cinnamon, clove, and rose, were purchased from the local market in Sirte (Libya).

2.2 Apparatus

A JENWAY6305 UV/Visible spectrophotometer (single beam) was used.

2.3 Preparation of the plant extracts

The aqueous botanical extract was prepared by soaking 2.0 grams of the dried botanical sample in boiled distilled water (50 mL) for 20 minutes (infusion). Then, the extract was left at room temperature for either 20 minutes to become cold. The extract was then filtered using filter paper to remove any solid particles. Then, the filtrate was used as a stock solution for each sample with concentration of 4 x 10^4 ppm.

2.4 Sample preparation for absorbance measurements

1 mL of the filtrate of stock solution was taken and transferred to a standard 50 mL volumetric flask, diluted to volume with distilled water, so that the sample concentration was 800 ppm.

2.5 Calculations of solar protection factor (SPF)

After dilution, the UV absorbance values were measured between 290-320 nm using a UV-vis spectrophotometer, and then the Mansour equation (1) was applied to calculate the SPF values for each extract.

$$\mathbf{SPF} = \mathrm{CF} \times \sum_{290\ nm}^{320\ nm} EE(\lambda) \times I(\lambda) \times ABS(\lambda) \quad (\mathbf{1})$$

Where: CF is the correction factor (=10); “EE”, the erythemal effect of radiation at wavelength λ; “I”, the intensity of the solar spectrum; and “ABS”, the absorbance at wavelengths 290-320 nm. “EE”, “I”,

and "ABS" are values obtained or applied for every wavelength (λ). The values for each of the [EE(λ) x I(λ)] are constants have been reported by the authors as normalized on the basis of the work by Sayre et. al., and are shown in Table 4[4,11,12].

UV absorption for botanical aqueous extracts were shown in Table 5. Appling absorbance values in Mansur equation (1) to calculate the SPF values for these analysed samples as shown in Table 5.

Table 4: Normalized product function used in the calculation of SPF.

Wavelength (nm)	EE x I (normalized)
290	0.0150
295	0.0812
300	0.2874
305	0.3278
310	0.1864
315	0.0837
320	0.0180

Table 5: Absorbance of aqueous botanical extracts

Wavelength (nm)	Cinna-mon	Dande-lion	Chamo-mile	Rose	Clove	Sage	Basil	Rosem-ary	Pepper-mint	Lavender
290	0.1300	0.1775	0.1470	0.4845	0.2920	0.0795	0.0695	0.1475	0.0295	0.1090
295	0.1220	0.1150	0.1210	0.4655	0.2645	0.0905	0.0395	0.161	0.2030	0.0985
300	0.1535	0.1155	0.1135	0.4005	0.2495	0.0560	0.0405	0.2175	0.0160	0.0901
305	0.1415	0.1180	0.1080	0.3510	0.2250	0.0475	0.0765	0.1995	0.1460	0.0710
310	0.1745	0.1225	0.1045	0.2200	0.1985	0.0440	0.0465	0.1750	0.0665	0.0635
315	0.1600	0.1275	0.1020	0.2590	0.1750	0.0410	0.0485	0.1675	0.0890	0.0720
320	0.1550	0.1470	0.3075	0.3150	0.1755	0.0430	0.0480	0.0800	0.1060	0.0109

Table 6: The SPF values for the analysed samples.

Botanical name	**Calculated SPF**
Chamomile	1.1 ± 0.02
Dandelion	2.2 ± 0.02
Clove	5.0 ± 0.02
Cinnamon	1.0 ± 0.01
Rose	8.2 ± 0.04
Rosemary	4.0 ± 0.02
Basil	2.2 ± 0.01
Sage	3.3 ± 0.02
Lavender	3.0 ± 0.01
Peppermint	2.3± 0.01

3. Results and discussions

Water is the safest solvent for use on the skin, so it has been selected to make aqueous extracts for different plant samples. It was also chosen to have the aqueous extract in the form of the plant soaked in boiling water (infusion) instead of boiling the plant in water (decoction) because it is considered the most appropriate method. Two grams are used to prepare the decoctions to be relative to standard values that are used in the manufacture of creams and lotions as sunscreens.

Common plants known for their benefits have been selected, five of which belong to the oral family: mint, mermaid, wreath, rye, ceramics, and other plants including chamomile, cinnamon, cauliflower, cauliflower, and rosemary. All these plants are available on the local market at an appropriate price.

The SPF is a numerical sorting system that refers to a product's ability to protect against sunlight. Measuring the values of the SPF is the ultimate way

to determine the effectiveness of the sunscreen. The higher value of the SPF indicates to the higher value, which the sunscreen product provides against UV radiation. In this study, SPF values for different plant extracts were determined using the In Vitro laboratory method. These values were calculated as above using the Mansour equation 1, and the results of the calculated SPF values are shown in table 6.

It was observed that all the tested aqueous botanical extracts showed some UV protection capabilities. The aqueous rose extract showed the highest SPF value of 8.2, followed by clove with a value of 5.0, and then rosemary, which gave 4 while sage gave a value of 3.3. The rest of the SPF values are shown in Table 6 and Figure 3.

The absorbance values of aqueous extracts can be attributed to their content of glycosides, tannins, flavonoids, anthocyanins, and other organic materials that can be extracted in boiling water.

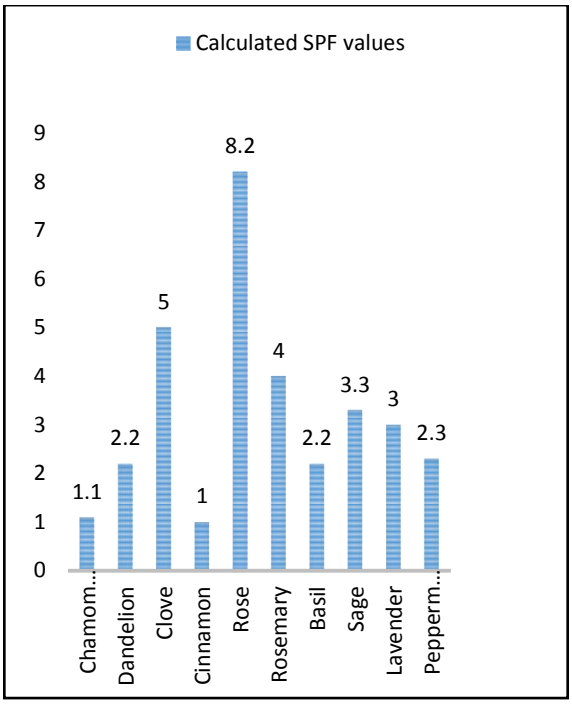

Figure 3: Comparison of the calculated SPF values for aqueous extracts of used plants

4. Conclusions:

The chemicals used in this procedure are typically used in cosmetic formulations and present no risk of direct contact with the skin. In addition, SPF values showed that a water extract for rose petals showed better protection from sunlight, so it could be used as an alternative to the chemicals that are used in the manufacture of sunblocks, such as zinc oxides, titanium, and other organic chemical filters. Moreover, cosmetics with herbal ingredients are more suitable for highly sensitive skin because they are less irritable and can be easily tuned to the skin as well as they have milder side effects, are easier to use, and are usually less expensive and more readily available.

5. Recommendations:

The method used to measure SPF is simple, easy to use, and inexpensive, so it is possible to calculate SPF values for all preparations containing organic filters. We also recommended that rose water, which has shown the highest absorption value, could be used to prepare skin care formulations, as well as for its wonderful aroma.

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تحديد عامل الحماية من اشعة الشمس (SPF) لعدد من المستخلصات المائية النباتية

عن طريق مطيافية الأشعة فوق البنفسجية

الملخص: تهدف هذه الدراسة إلى قياس الامتصاصية الضوئية (Abs) للأشعة فوق البنفسجية لمستخلصات مائية نباتية في مجال الـ UVB بواسطة جهاز UV-vis spectrophotometer لبعض النباتات شائعة الاستخدام ومن ثم حسلب عامل الحماية من اشعة الشمس (SPF) لكل مستخلص.

تم تحضير المستخلصات النباتية المائية عن طريق نقع العينة النباتية المجففة في ماء مقطر مغلي لمدة 20 دقيقة (botanical decoction)، ثم تم ترشيح المستخلص باستخدام ورقة ترشيح، بعد التخفيف ، تم قياس قيم الامتصاصية لمستخلص مغلي النباتات والتي شملت كل من: النعناع ، والمريمية ، وإكليل الجبل ، والريحان ، والبابونج ، والقرفة ، والهندباء ، والخزامى ، والقرنفل ، والورد ، باستخدام مقياس جهاز طيف الاشعة الفوق بنفسجية أحادي الحزمة في مدى 290-320 نانومتر، ويتم ذلك بزيادة 5 نانومتر في كل قياس وتكرر عملية القياس مرتان للطول الموجي الواحد، ثم حساب متوسط الامتصاصية لكل عينة نباتية، ثم حساب الـــ SPF من خلال تطبيق معادلة منصور الرياضية لكل مستخلص.

أظهرت جميع المستخلصات المائية بعض خاصية الحماية من اشعة الشمس. كانت أفضل قيمة SPF هي للمستخلص المائي لنبات الورد بقيمة قدرها 8.2. تليها قيمة SPF لمستخلص نبات القرنفل الذي كان عند 5.0. مستخلص إكليل الجبل اعطى قيمة SPFقدرها 4.0.

قدمت الدراسة بيانات على ان المستخلصات المائية للعينات النباتية تمتلك خاصية الحماية من أشعة الشمس، ويمكن ان يعزو سبب قيم الامتصاصية الضوئية للمحاليل المائية للمواد العضوية التي تحتويها من جليكوسيدات وتانينات وفلافونيدات والانثوسيانينات وغيرها من المواد العضوية التي يمكن استخلاصها في الماء المغلي. ولذلك فهي قادرة على حماية الجلد من التأثير الضار للأشعة فوق البنفسجية. البيانات أظهرت ان مستخلص مائي لبتلات نبات الورد أظهر حماية أفضل من أشعة الشمس لذلك يمكن استخدامه كبديل للمواد الكيميائية المستخدمة في صناعة مستحضرات الواقيات الشمسية.

الكلمات المفتاحية: عامل الحماية من أشعة الشمس، مطيافية الاشعة فوق البنفسجية، زعتر، ريحان، بابونج، ورد.