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Study on the extraction of the local Portulaca oleracea plant and evaluation of the sun protection factor (SPF)of both aqueous and ethanolic extracts.

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Abstract

Ultraviolet (UV) radiation is the primary cause of skin damage, premature aging, and skin cancer. Due to safety concerns regarding synthetic sunscreens, interest in natural plant ingredients has increased as safe alternatives to chemical sunscreens. Purslane (Portulaca oleracea) is known for its richness in phenolics and flavonoids, which possess excellent UV-absorbing properties.

This study evaluated Portulaca oleracea leaf and stem extracts (aqueous and alcoholic) via UV-vis spectroscopy (200–400 nm). Sun protection factor (SPF) values were calculated Using a reference method. The alcoholic leaf extract showed the highest SPF (40), followed by the aqueous leaf extract (SPF = 30). The stem extracts showed lower, but still good, activity (alcoholic: SPF = 20; aqueous: SPF = 12).

The results highlight purslane's potential as a natural sunscreen ingredient, particularly in alcoholic leaf extracts. Improved formulations could provide safer and more synergistic UV protection compared to chemical filters.

KEYWORDS: Portulaca Oleracea, Sun Protection Factor, UV, Extract.

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1. Introduction

Proper exposure to sunlight has numerous benefits, including stimulating the body's production of vitamin D and strengthening the immune system, as well as potentially reducing the risk of cancer [1]. However, excessive exposure has many negative effects on human health [2]. The sun's ultraviolet rays reaching the Earth's surface are the main cause of these negative effects. which is divided into three categories based on wavelength, namely UVA (315–400 nm), UVB (280–315 nm), and UVC (100–280 nm) [3]. The epidermis of the skin serves as a barrier to protect the body from the external environment [4]. Nonetheless, chronic exposure or intermittent overexposure of human skin to UV rays leads to various skin diseases, including immunosuppression, irreversible skin photoaging, and dermal pathologies, including tumorigenesis [2]. Sunscreen is the most important strategy, apart from sun avoidance, to prevent UV damage [5]. Available sunscreens are materials applied topically that reflect the rays, which are physical sunscreens, or absorb them and emit them in the form of lower-energy rays, which are chemical sunscreens [6]. The evaluation of the effectiveness of sunscreen in protection is based on the sun protection factor (SPF), which is the UV energy required for producing a minimal erythema dose (MED) on protected skin, divided by the UV energy required for producing an MED on unprotected skin. MED is defined as the lowest time interval or dosage of UV light irradiation sufficient for producing minimal, perceptible erythema on unprotected skin [7]. Sunscreens must be safe during use [8]. Recently, chemical sunscreens have become controversial due to their potential health and environmental risks. They have been found to have endocrine activity and can be carcinogenic, neurotoxic, bioaccumulative, or allergenic [9]. Consequently, there has been increasing interest in the incorporation of natural ingredients, particularly plant extracts, in sunscree formulations. Over the past two decades, significant research has investigated plant-derived compounds with photoprotective properties. Flavonoids, phenolic acids, tannins, and carotenoids have demonstrated UV-absorbing capacities, along with antioxidant properties that mitigate oxidative stress from UV exposure. These compounds also inhibit enzymes responsible for collagen degradation, contributing to the prevention of photoaging [10] [11]. Several botanical extracts have shown the ability to enhance SPF values in cosmetic formulations. Notable examples include the extract of Moringa oleifera, which demonstrated moderate SPF values comparable to commercial sunscreens in the study by Baldisserotto et al. (2018) [12]. Similarly, Centella asiatica extract has been shown to possess UV-absorbing and antioxidant properties (Lee et al., 2020) [13]. Chanchal et al. (2023) reported that Azadirachta indica extract exhibited promising UV-protection capabilities [14]. Other plants such as Camellia sinensis, Aloe vera, Curcuma longa, and Eclipta prostrata have also been recognized for their SPF-enhancing and skin-soothing properties when incorporated into topical products [15], [16]. Among these botanicals, Portulaca oleracea L., commonly known as purslane, has emerged as a potential natural sunscreen agent. This succulent herb is widely distributed across tropical and temperate regions and is both consumed as a vegetable and utilized in traditional medicine. Purslane is rich in bioactive constituents including flavonoids (e.g., quercetin), phenolic acids, tannins, omega-3 fatty acids, and vitamins C and E, all of which contribute to its antioxidant and skin-protective effects [17], [18]. Recent

studies have further highlighted purslane's therapeutic properties. Budiawan et al. (2023) demonstrated that purslane exhibits potent anti-inflammatory and antioxidant activity, accelerates wound healing, and reduces skin inflammation [19]. Li, Yanxi Xiao et al. corroborated these findings, indicating that purslane extracts confer protection against oxidative stress in skin cells. However, the specific SPF properties of purslane remain underexplored, representing a promising avenue for further investigation [20]. To evaluate the photoprotective efficacy of plant extracts, a range of methodologies have been employed. The most commonly used is the in vitro spectrophotometric method, which estimates SPF based on UV absorbance data over defined wavelength ranges, often calculated using the Mansur equation [21]. Additional assessments, such as the determination of critical wavelength (λc) and UVA/UVB absorbance ratios, provide insight into the spectrum of protection offered [22]. The spectrophotometric method, due to its simplicity and reproducibility, is widely adopted in sunscreen research for SPF determination. While some studies incorporate in vitro skin models or synthetic membranes, more advanced research may involve in vivo testing on human volunteers to obtain precise SPF measurements [23].

In this context, the present study aims to assess the potential of Portulaca oleracea extract as a natural sunscreen agent, focusing on the in vitro determination of its SPF using validated spectrophotometric methodologies. This investigation builds upon existing literature on the pharmacological properties of purslane and contributes to the expanding domain of plant-based sunscreens and natural photoprotection strategies.

2. Methodology

2.1. Devices and Materials

analytical balance with a precision of 0.0001g (Precisa), Ultrasonic Bath (JENEK / PS-80), Rotary Vacuum Evaporator (STUART), Drying Oven (Memmert), UV-Visible Spectrophotometer (Rigol 3660), Pipettes, Burettes and Beakers.

Solvents: Distilled Water, 70:30 (v/v) ethanol:distilled water mixture

Phytochemical Test Reagents: Ferric Chloride ($FeCl_3$), Mayer's Reagent (Mercuric chloride ($HgCl_2$), Potassium iodide (KI)) ,1% Aluminum Chloride ($AlCl_3$), Chloroform, Acetic Anhydride, Concentrated Sulfuric Acid (H_2SO_4), 1% Lead Acetate Solution,10% Sodium Hydroxide (NaOH) Solution.

2.2. Sample collection

In this research, we used parts of the Portulaca oleracea plant (leaves, stems). The leaves and stems of the purslane plant were obtained from the local market of Homs Governorate. The plant materials were washed twice with tap water and then with distilled water. They were then dried at room temperature in the shade. After ensuring their dryness, the samples were crushed using an electric grinder and stored in an airtight container till further use.

2.3. Preparation of Plant Extracts

2.3.1. AQUEOUS EXTRACTS

The aqueous extracts of Portulaca oleracea (purslane) leaves and stems were prepared following a modified maceration technique. Five grams of dried plant material (leaves or stems) were placed into a 250 mL glass beaker, to which 100 mL of distilled water was added. The mixture was subjected to ultrasonic treatment for 5 minutes to enhance the extraction process, then allowed to macerate for 48 hours at room temperature. The resulting solution was sequentially filtered through three layers of medical gauze and subsequently through Whatman No. 1 filter paper to remove particulate matter. The filtrate was then concentrated under reduced pressure using a rotary vacuum evaporator to obtain a thick viscous residue, which was further dried in a drying oven to yield the solid extract. The extraction yield was measured gravimetrically and recorded accordingly.

2.3.2. ETHANOLIC EXTRACTS

The ethanolic extracts were prepared using the same procedure as the aqueous extracts, substituting the solvent system with a 70:30 (v/v) ethanol:distilled water mixture. This hydroethanolic solvent system is widely reported to be effective for the extraction of both polar and semi-polar phytoconstituents [24]. After the same sequence of ultrasonic treatment, maceration, filtration, concentration, and drying, the final extract was weighed and its yield recorded.

2.4. Extraction Yield Calculation

The extraction yield was calculated using the following formula:

$$\text{Yield (\%)} = (\text{Weight of dried extract}) / (\text{Weight of starting plant material}) \times 100 \quad \ldots\ldots (1)$$

2.5. Determination of Sun Protection Factor (SPF)

The SPF of the extracts was determined via a spectrophotometric method as described by Mansur et al. (1986) [21]. A solution of the dried extract (1 mg/mL) was prepared using distilled water for aqueous extracts and ethanol:water (70:30) for ethanolic extracts. The absorbance of each solution was measured using a UV-Vis spectrophotometer across wavelengths from 290 nm to 320 nm at 5 nm intervals. All measurements were conducted in triplicate to ensure accuracy and reproducibility. The SPF value was then calculated using the Mansur equation:

$$SPF_{\text{spectrophotometer}} = CF \cdot \sum_{290}^{320} [EE \cdot I] \cdot Abs \quad \ldots\ldots (2)$$

where CF is the correction factor (CF = 10), EE(λ) is the erythemal effect spectrum, I(λ) is the solar intensity spectrum, and Abs(λ) is the absorbance of the sample at wavelength λ. The constants for EE(λ) × I(λ) were adopted from Sayre et al. (1979) (Table 1), as normalized in Mansur's study [25].

TABLE(2): NORMALIZED PRODUCT FUNCTION USED IN THE CALCULATION OF SPF.

Wavelength (nm)	EE x I (normalized)
290	0.0150
295	0.0817
300	0.2874
305	0.3278
310	0.1864
315	0.0839
320	0.0180
Total	1.0000

2.6. Phytochemical Screening

Qualitative phytochemical tests were conducted to identify various secondary metabolites present in the extracts:

• Phenols: Confirmed by adding 1 mL ferric chloride ($FeCl_3$) to 1 mL of extract. Blue, purple, red, or green coloration indicated phenols [26].

• Alkaloids: Detected by adding Mayer's reagent to 2 mL of extract; formation of a white precipitate confirmed alkaloid presence [27].

• Flavonoids: Identified using 1% aluminum chloride ($AlCl_3$); a yellow coloration indicated flavonoids [26].

• Steroids and Terpenoids: Treated with chloroform, acetic anhydride, and concentrated H_2SO_4. Green solution indicated steroids; red color signified terpenoids [27].

• Tannins: A white gelatinous precipitate formed with 1% lead acetate indicated tannins [28].

• Coumarins: Yellow coloration upon addition of 10% sodium hydroxide (NaOH) confirmed coumarins [28].

3. Results and discussion

3.1. Total extraction yield

Extracts from both leaves and stems of Portulaca oleracea were obtained using maceration with two solvents: distilled water and 70% ethanol. The choice of solvents was guided by their differing polarities and extraction capabilities for specific classes of bioactive compounds.

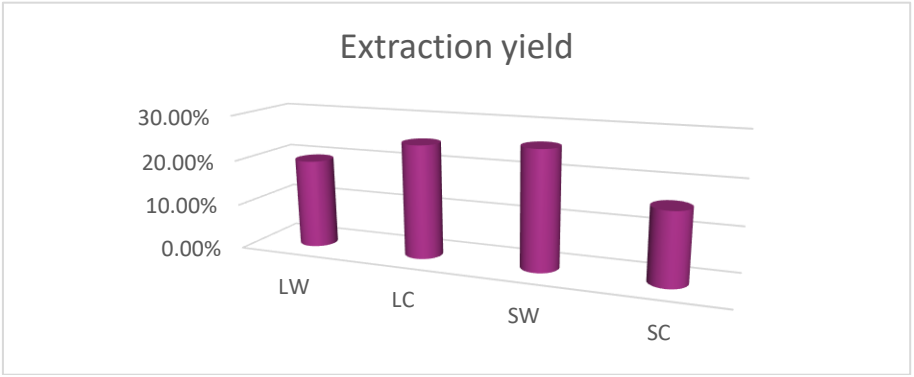
Distilled water is a highly polar solvent, ideal for extracting hydrophilic compounds such as sugar-bound flavonoids, simple phenols, tannins, and glycosides—all of which are known for their antioxidant and UV-absorbing properties [29]. Its safety, non-toxicity, affordability, and ease of handling make it a suitable option for applications involving sensitive skin or natural cosmetic formulations.

Ethanol 70%, a semi-polar solvent, offers superior penetration through plant cell walls and can extract both polar and moderately non-polar compounds. It is particularly

effective at dissolving aglycone flavonoids and semi-polar polyphenols, resulting in higher extraction efficiency for UV-protective compounds [30].

As illustrated in Figure 1, extraction yields varied significantly depending on the plant part and the solvent used. The highest yield (26%) was obtained from the aqueous stem extract, followed by the ethanolic leaf extract (25%). The lowest yield (15.8%) was recorded for the ethanolic stem extract, while the aqueous leaf extract produced a moderate yield (19.6%).

These differences are primarily attributed to the distinct structural and biochemical properties of each plant part. The stems of P. oleracea are structurally fibrous and contain high levels of hydrophilic polysaccharides, making water a more effective solvent for their extraction. In contrast, leaves are richer in flavonoids, phenolic acids, and other UV-absorbing secondary metabolites, which are better solubilized by ethanol [31].



FIGURE(1):EXTRACTION YIELD OF PURSLANE PLANT

LW: THE AQUEOUS EXTRACT OF THE LEAVES, LC: THE ETHANOLIC EXTRACT OF THE LEAVES, SW: THE AQUEOUS EXTRACT OF THE STEMS, SC: THE ETHANOLIC EXTRACT OF THE STEMS

3.2. Determine the sun protection factor value:

TABLE(3): ABSORBANCES OF SAMPLES AT A CONCENTRATION OF 1 MG/ML

S_C	S_W	L_C	L_W	UV (nm)
2.236	1.46	4.087	3.059	290
2.124	1.348	4.091	3.056	295
2.08	1.316	4.095	3.053	300
1.984	1.232	4.099	3.05	305
1.92	1.2	4.101	3.047	310
1.868	1.184	4.099	3.047	315
1.836	1.168	4.004	3.048	320

FIGURE(2): SPF OF EXTRACTS OF LEAVES AND STEMS OF THE PURSLANE PLANT

The UV-absorption properties of four Portulaca oleracea extracts—ethanolic and aqueous extracts from both leaves and stems—were assessed using a UV-visible spectrophotometer, with absorbance recorded at wavelengths ranging from 290 to 320 nm (Table 2). These measurements were used to calculate the Sun Protection Factor (SPF), a metric that indicates the ability of a substance to absorb ultraviolet B (UVB) radiation, which is primarily responsible for skin erythema and photodamage.
The SPF values were calculated using the Mansur equation, which incorporates absorbance data across multiple UVB wavelengths to estimate photoprotective efficacy. The results, depicted in Figure 2, show distinct differences between plant parts and solvent systems.

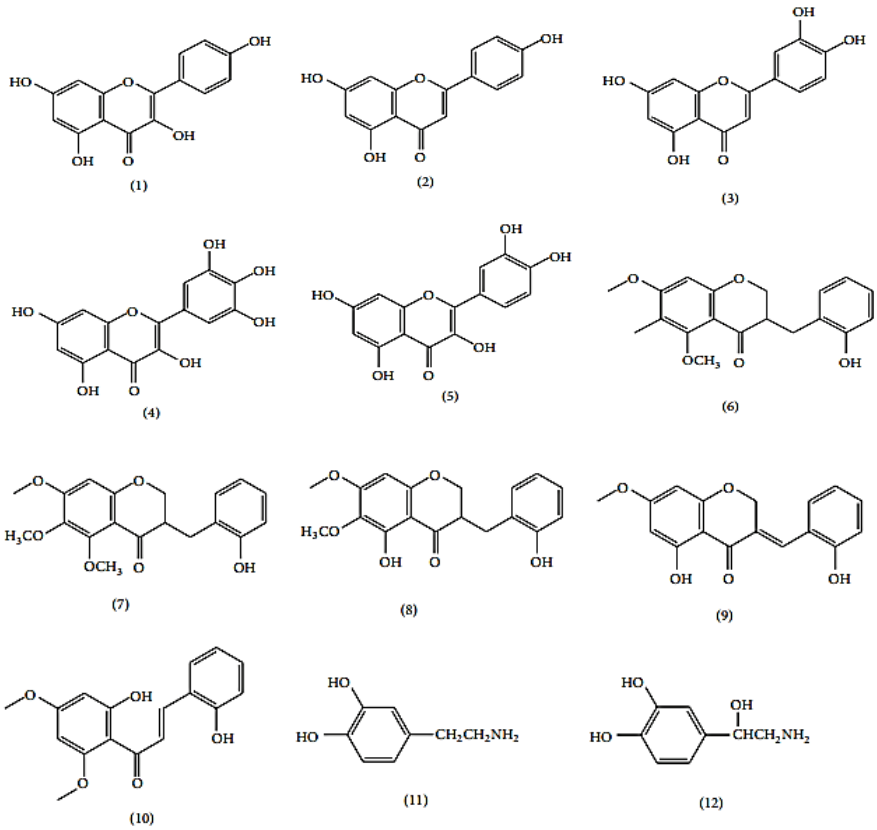
3.2.1. LEAF EXTRACTS

Among all the samples, leaf extracts demonstrated the highest SPF values, indicating a stronger UV-blocking potential:
Ethanolic leaf extract: SPF = 40, Aqueous leaf extract: SPF = 30
The superior SPF of ethanolic extracts is attributed to their higher concentration of flavonoids and phenolic compounds, such as quercetin, kaempferol, and gallic acid, all of which are known to effectively absorb UVB radiation [32]. These compounds act as natural sunscreens by absorbing and scattering harmful UV rays while also exhibiting antioxidant activity that protects skin from photo-induced oxidative stress. Ethanol, particularly at 70% concentration, is a semi-polar solvent that efficiently penetrates plant cell walls and extracts a broad spectrum of polar and moderately polar bioactives, including aglycone flavonoids and low-molecular-weight phenols [33]. This explains the elevated SPF values for the ethanolic leaf extract relative to the aqueous one.

3.2.2. STEM EXTRACTS

Ethanolic stem extract: SPF = 20, Aqueous stem extract: SPF = 12
The lower SPF values observed in stem extracts indicate a reduced concentration of UV-absorbing compounds compared to the leaves. Stems typically contain more

fibrous material and polysaccharides and fewer secondary metabolites like flavonoids or phenolic acids, which are the primary contributors to UV protection [34]. Still, the ethanolic stem extract performed better than the aqueous one, underscoring the importance of solvent polarity in enhancing the yield of active photoprotective compounds. Although ethanol does not extract as much total mass as water in stems, it extracts more targeted, functionally relevant compounds, hence the higher SPF.
The figure shows the structures of some compounds found in purslane that may play a role in protecting against ultraviolet radiation [35].



FIGURE(3): THE STRUCTURES OF SOME COMPOUNDS FOUND IN PURSLANE THAT MAY PLAY A ROLE IN PROTECTING AGAINST ULTRAVIOLET RADIATION.

(1) KAEMPFEROL, (2) APIGENIN, (3) LUTEOLIN, (4) MYRICETIN, (5) QUERCETIN, (6) PORTULACANONES A, (7) PORTULACANONES B, (8) PORTULACANONES C, (9) PORTULACANONES D, (10) 2,2□ -DIHYDROXY-4□ ,6□ –DIMETHOXYCHALCONE, (11) DOPAMINE, (12) NORADRENALIN [35].

3.3. Phytochemical screening

Phytochemical analysis of Portulaca oleracea extracts revealed the presence of several bioactive secondary metabolites, many of which are associated with UV protection and antioxidant activity.

3.3.1. PHENOLS AND FLAVONOIDS

All samples tested positive for phenolic compounds and flavonoids:
Phenols were detected using ferric chloride ($FeCl_3$), which forms a characteristic blue-green or black coloration in the presence of phenolic hydroxyl groups. Flavonoids were confirmed using aluminum chloride ($AlCl_3$), which forms stable complexes with flavonoids, yielding a yellow fluorescence under UV light. These findings are consistent with previous reports identifying P. oleracea as a rich source of gallic acid, quercetin, and kaempferol—well-documented phenolic and flavonoid compounds with proven antioxidant and UV-absorbing properties [36]. Their ability to absorb UV-B radiation (290–320 nm) contributes significantly to the high sun protection factor (SPF) observed in the extracts, particularly from the leaves.

3.3.2. ALKALOIDS AND TANNINS

Alkaloids were detected in all samples using Mayer's reagent, which containsmercuric chloride ($HgCl_2$) and potassium iodide (KI) dissolved in deionized water. The appearance of a white precipitate confirms the presence of alkaloidal.
Tannins were confirmed by adding lead acetate, which reacts with hydrolyzable or condensed tannins to produce a white, gelatinous precipitate. Tannins are also known to exhibit antioxidant and anti-inflammatory effects that may contribute to skin protection, although their direct UV absorption is less pronounced than that of flavonoids and phenols.

3.3.3. TERPENES AND COUMARINS

Neither terpenes nor coumarins were detected in any of the extracts. This may be due to their actual absence in P. oleracea, or more likely, to the limitations of the solvent system used.
Terpenes and coumarins are typically non-polar or weakly polar compounds that require non-polar solvents—such as hexane, diethyl ether, or chloroform—for effective extraction [37].
Since this study utilized only water and 70% ethanol, both polar solvents, it is reasonable that these less polar metabolites were not extracted or detected at quantifiable levels.

TABLE (3): PHYTOCHEMICAL SCREENING

secondary metabolite	L_W	L_C	S_W	S_C
Phenols	+	+	+	+
Flavonoids	+	+	+	+
Alkaloids	+	+	+	+
Tannins	+	+	+	+
Terpenes	–	–	–	–
Coumarins	–	–	–	–

4. Conclusions

This preliminary study revealed the UV-absorbing and sun-protective properties of Portulaca oleracea extracts. In addition to their numerous therapeutic benefits, these plants could become useful, cost-effective, and readily available ingredients to demonstrate their sun-protective potential. The ethanolic leaf extract, in particular, demonstrated a high SPF value, underscoring the effectiveness of flavonoids and phenolic compounds in providing sun protection. The phytochemical profile further supports these findings, as the plant contains key bioactive metabolites associated with antioxidant activity and UV protection.This study could be a useful tool for quality control during the formulation and analysis of sunscreen products, providing information prior to initiating bio-studies. In the future, these plant extracts could be used alone or in combination with other additives to develop sunscreen formulations, such as creams and lotions with a high sun protection factor (SPF).

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