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Evaluation of Anti-tyrosinase, Anti-collagenase, and *In Vitro* Sun Protection Factor (SPF) of Ajwa Date Fruit (*Phoenix dactylifera* L.)

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Abstract

This research explores the potential of Ajwa date fruit extract as a bioactive component in cosmeceutical formulations, with particular emphasis on its anti-tyrosinase, anti-collagenase, and ultraviolet (UV) protection capabilities. The antioxidant activity was determined using the design of response surface methodology, considering the factor of sample-to-water-as-solvent ratio, extraction time, and size of the sample. This factor possesses the capacity to exert an influence on the production of antioxidants and enhance the efficacy of the extraction procedure. The Ajwa date fruit extract was obtained using the Soxhlet method. The extract showed notable inhibition percentages of 67.77 and 49.12 for anti-tyrosinase and anti-collagenase activities, respectively. Additionally, it revealed a sun protection factor value of 17.09. Previous research has indicated that Ajwa dates exhibit significant inhibitory properties against tyrosinase and collagenase enzymes, making them potentially valuable in cosmetic applications. Therefore, research has demonstrated this study's promise in skin pigmentation, elasticity, and UV protection. The study places significant importance on exploring natural alternatives in cosmetics. It highlights the encouraging outcomes obtained from using Ajwa date fruit extract, emphasising its potential for future advancements in cosmeceuticals. The

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present study offers a valuable opportunity to produce skincare formulas that are both safer and more effective.

Keywords: Ajwa date fruit extract, anti-collagenase, anti-tyrosinase, sun protection factor

INTRODUCTION

The cosmetics industry has witnessed substantial expansion and is presently flourishing worldwide. Cosmetic products are used daily by a great number of people, no matter their gender or age. The increasing significance of self-care among consumers globally has resulted in a notable growth of over 15% in the beauty sector market compared to the previous year (Petruzzi, 2024). The cosmetics market, known for its ever-changing nature, has witnessed a significant increase in interest towards novel products targeting skin pigmentation and collagen enhancement.

Advanced formulations have been developed to address hyperpigmentation, providing consumers with efficient remedies for achieving a glowing and uniform complexion. Tyrosinase is a copper-containing monooxygenase enzyme that is essential in the production of melanin. Tyrosinase transforms L-tyrosinase to I-3,4-dihydroxyphenylalanine (L-DOPA), which is then oxidised to generate dopachrome, which causes melanin pigment synthesis (Zengin et al., 2015). Melanin protects human skin from harmful UV rays, removes reactive oxygen species (ROS), and scavenges dangerous medicines. However, excessive melanin production can lead to larger pigmented areas on the skin, melanogenesis, and neurological illnesses, which are adverse to human favour, especially in the Asian continent (Momtaz et al., 2008; Vujanović et al., 2020). Because of their potential to decrease cutaneous melanin synthesis, tyrosinase inhibitors like kojic acid have been employed as whitening agents in human cosmetic goods.

Collagen is a very prevalent structural protein in mammals and is a type of protein found in abundance. A structural protein is a protein that helps to build the structure or framework of cells and tissues. It was discovered in the skin, bones, muscles, and tendons. Collagenase is an enzyme that aids in the breakdown of collagen. Collagen is the most important component, accounting for 70% to 80% of total skin weight (Utami et al., 2018). The skin is composed of three distinct layers: the epidermis, dermis, and subcutaneous tissue. These three skin components go through degenerative changes because of the ageing process, with alterations to the dermis being the most noticeable of these. The dermis mostly comprises the extracellular matrix (ECM) and fibroblasts. Collagen, a significant component of ECM, becomes fragmented and coarsely dispersed, reducing its total amount. It mostly results from increased matrix metalloproteinase (MMP) activity and decreased transforming growth factor-β-signalling caused by ROS produced during ageing (J.-W. Shin et al., 2019; Vijayakumar et al., 2017). This occurrence leads to the fragmentation of collagen molecules and a decrease in the production of new collagen.

Ultraviolet A (UVA) and ultraviolet B (UVB) radiation have the potential to induce several adverse effects on the skin, including sunburn, photoaging, erythema, and inflammation. Sunscreens offer protection to the human skin against damage caused by UV radiation by including active substances, categorised as either organic or inorganic, referred to as UV filters. These UV filters possess unique action modes responsible for the protective effects they confer. The necessity of applying sunscreen to human skin arises from the need to minimise skin exposure and safeguard it against harmful UV radiation. The date fruit is known to possess phenolic and flavonoid components, which have inherent antioxidant properties. According to Alharbi et al. (2021), those substances possess the capacity to penetrate both the superficial layer of the skin (epidermis) and the underlying layer (dermis), thus protecting against the harmful consequences of UV-induced oxidation and premature ageing of the skin.

The date palm is the primary agricultural crop in regions such as the Arabian Peninsula, North Africa, the Middle East, and Southwest Asia (Alharbi et al., 2021). There exists a vast assortment of about 2,000 distinct varieties of dates (Al-Shahib & Marshall, 2003). The Ajwa variety is recognised for being rich in nutrients and possessing healing properties, making it known as "super date" (Alharbi et al., 2021). Ajwa dates contain various antioxidants, including flavonoids and phenolic acid compounds. Natural compounds from plants exhibit significant potential as relatively unexplored opportunities for safe application in the beauty industry. Consumer demand for ecologically friendly products has drawn attention to using plant extracts in skin care products (Ribeiro et al., 2015). Antioxidants can complement the effectiveness of sunscreen. While sunscreens primarily act as physical or chemical barriers to UV rays, antioxidants can provide an additional layer of defence by neutralising free radicals that may escape the sunscreen's protection. Moreover, antioxidants help protect collagen by neutralising free radicals contributing to collagen degradation. Some antioxidants also stimulate collagen synthesis, promoting the maintenance of skin elasticity and firmness.

While prior research has extensively explored the antioxidant capabilities of Ajwa dates, a significant gap in our understanding exists concerning their potential functional applications. Considering the acknowledged lack of knowledge in this area, our research aims to explore new ground by examining the anti-elastase, anti-collagenase properties, and *in vitro* sun protection factor (SPF) of Ajwa dates extract. The objective is to gain fresh insights into the potential incorporation of Ajwa dates extract into cosmetic and medicinal products, specifically those with whitening and anti-ageing properties. In contrast to previous research that primarily focused on their antioxidant properties, this study pioneers an examination into the anti-elastase, anti-collagenase activities, and *in vitro* SPF of Ajwa dates extract.

Furthermore, the phytochemical screening was systematically conducted using gas chromatography-mass spectrometry (GC-MS) and ultra-high-performance liquid chromatography-quadrupole time-of-flight (UHPLC-QTOF). This screening is an analytical technique to identify compounds in Ajwa dates extract. GC-MS is well-suited for volatile and semi-volatile compounds and is widely applied in various industries. At the same time, UHPLC-QTOF is advantageous for analysing a broad spectrum of compounds in liquid samples, providing high-resolution and accurate mass measurements for precise identification. It was conducted to prove and elucidate the diverse chemical constituents in the Ajwa dates extract, aiming to pinpoint the specific functional component responsible for the observed biological activity.

MATERIALS AND METHODS

Sample Preparation and Chemicals

Fruits of *Phoenix dactylifera* were purchased from Madinah, Saudi Arabia, through a local supplier. The fruits and pits were manually separated and dried in a laboratory oven at 60°C for 2 weeks. Following the drying process, the flesh of the samples was crushed into smaller sizes, sieved into several sizes, and kept in air-tight bottles for subsequent processes. All chemicals were of analytical grade. Collagenase Kit and Tyrosinase Activity Kit were purchased from BiTA Lifesciences Sdn. Bhd. (Malaysia). The other solvent and apparatus, such as gallic acid and microplate, were purchased from Life Science of BioVision Inc. (USA).

The extraction of dates was performed using the Soxhlet extraction method, with distilled water employed as the solvent. This process is carried out repeatedly. Accordingly, the response surface methodology (RSM) design controlled the sample-to-water-as-solvent ratio, extraction time, and sample size. The proportion of a sample to the amount of water used as a solvent (ratio), extraction time (hr), and size of the sample (mm) in experimental produce were 1:10, 1:20, 1:30; 1.00, 2.87, 4.75, and 3.00, 4.50, 6.00. Next, the collected aqueous extraction sample was subjected to drying using a freeze dryer. The crude extract was collected and stored in air-tight bottles at -4°C until further experimentation. The present study utilised the antioxidant qualities of crude extract to determine the anti-tyrosinase, anti-collagenase, and *in vitro* SPF characteristics of Ajwa date fruit.

Determination of Anti-collagenase Inhibition

Collagenase inhibition was measured using a collagenase activity colourimeter assay kit and the technique outlined in the calorimeter (ab196999) #K792-100 (BioVision Inc., USA). Prior to usage, it is necessary to ensure that all materials and produced reagents are brought to room temperature. Reagent background wells, inhibitor test sample wells, positive control wells, inhibitor control wells, and solvent control wells are all set up in reaction wells. The sample extract (2 µl inhibitor test and 98 µl assay buffer) was added to the well. The positive control contained

10 µl collagenase and 90 µl assay buffer. The inhibitor control was prepared with 10 µl collagenase, 2 µl inhibitor control, and 88 µl assay buffer, while the solvent consisted of 10 µl collagenase and 88 µl assay buffer. One hundred (100) µl of the reaction mix consisting of 60 µl collagenase assay buffer and 40 µl collagenase substrate was poured into each well, and the activity was measured immediately. At 345 nm, the absorbance was measured on a microplate reader in kinetic mode for at least 5–15 min at 37°C protected from light.

The calculation of inhibition is as follows:

$$\% \text{ Inhibition} = \text{Activity}_{(\text{enzyme})} - \text{Activity}_{(\text{inhibitor})} / \text{Activity}_{(\text{enzyme})} \times 100\%$$

Determination of Anti-tyrosinase Inhibition

Anti-tyrosinase was driven using the procedure described by (Haliloglu et al., 2017) with minor modifications. The inhibition of mushroom tyrosinase by the tested sample, using L-DOPA as a substrate, formed the foundation for this approach. The experiments were carried out on a 96-well microplate, and the absorbance at 475 nm was measured using a microplate reader. Wells designed and labelled A, B, C, and D, each containing a reaction mixture (160 µl) for each concentration of the sample solution. The wells are labelled as follows: (A) 120 µl of a 0.1 M phosphate buffer (pH 6.8) and 40 µl of mushroom tyrosinase (33.3 units/ml); (B) 160 µl of the same buffer as blank; (C) 80 µl of the same buffer, 40 µl of tyrosinase (33.3 units/ml), 40 µl of the sample-buffer solution containing dimethyl sulfoxide (DMSO), (D) 120 µl of the same buffer, 40 µl sample solution containing DMSO. The content of each well was mixed and preincubated at 23°C for 10 min. Subsequently, 40 µl of L-DOPA (2.5 mM) was added. The well-contained reaction mixture was measured after incubation at 23°C for 15 min. The quantification of dopachrome in each reaction mixture was achieved by measuring the disparity in optical density before and after the incubation period. Kojic acid (Sigma-Aldrich, Germany) was employed as a positive control. The percentage of inhibition of tyrosinase activity was obtained using the equation:

$$\% \text{ Inhibition activity} = [(A - B) - (C - D)]/(A - B) \times 100\%$$

Dates extract anti-tyrosinase activity was reported as kojic acid equivalent (KAE) in mg/g of date extract. Kojic acid dilutions in methanol were made to obtain a calibration curve. Calculation was performed using the $y = -0.0066x + 0.0892$ ($r^2 = 0.9784$). The experiments were conducted repeatedly, presenting the outcomes as mean KAE values.

Determination of *In vitro* SPF

The methodology outlined by de Oliveira et al. (2007) was employed to determine SPF *in vitro*. The ethanol solution diluted the date extract, resulting in 50, 100, 500, and 1,000 g/ml concentrations.

Subsequently, the ethanolic extracts undergo spectrophotometric scanning over a wavelength range of 260 to 400 nm at intervals of 5 nm. The measurements were conducted using a quartz cell with a length of 1 cm, and ethanol was utilised as the blank solution. The SPF was determined using the mathematical equation provided as follows:

$$\text{PF spectrophotometric} = CF \times \sum_{290}^{320} EE(\lambda) \times I(\lambda) \times Abs(\lambda)$$

where, EE (λ) = erythermal effect spectrum; I (λ) = solar intensity spectrum; Abs (λ) = absorbance of sunscreen extract; and CF = correction factor (=10). The value of EE x I is constant. Table 1 shows the standardised extract function that was used to calculate SPF.

Table 1
Standardised extract function used in the calculation of sun protection factor (SPF)

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

Note. It is the standardised formula used in the calculation of SPF, EE (λ) = Erythermal effect spectrum, and I (λ) = Solar intensity spectrum

RESULTS AND DISCUSSION

Anti-collagenase Activity

The anti-collagenase activity was assessed using a standard date extract concentration at 1,000 µg/ml, which exhibited a notable collagenase inhibition percentage of 49.12%. In contrast, the solution of ascorbic acid in its conventional form exhibited a measured value of 77.20%, as depicted in Figure 1. The findings indicated that the extract derived from dates exhibits essential inhibitory effects on collagenase enzymes compared to the standard ascorbic acid. It suggests that dates may serve as a promising source of anti-ageing agents.

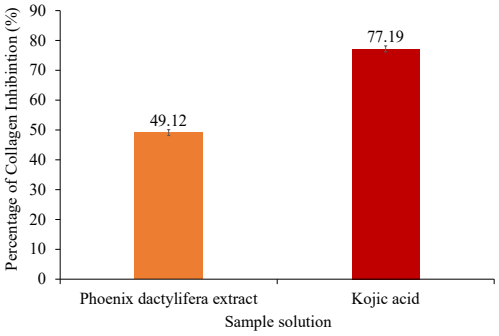

Figure 1. The percentages of collagenase inhibition on kojic acid and *Phoenix dactylifera* fruit extract

The production of ROS during the ageing process increases MMP expression while simultaneously inhibiting transforming growth factor beta (TGF-β) signalling, which results in collagen fragmentation and decreased collagen manufacturing. MMPs are a class of proteinases that contain zinc (Zn). MMP-1, or matrix metalloproteinase-1, is an enzymatic protein responsible for initiating degradation processes targeting Types I, II, and III collagens. These collagens are widely distributed throughout the dermis, making them the predominant interstitial collagens in this tissue. Matrix metalloproteinase-2

(MMP-2) is responsible for the degradation of Type I-III, IV, and VII collagens, with the latter two being prominently present in the dermal-epidermal junction (Vijayakumar et al., 2017).

Collagen production declines as people become older, whereas collagenase levels rise. However, undesired ageing can be delayed by using antioxidants to scavenge free radicals and suppress collagenase activity. The findings revealed that date extract can inhibit collagenase, implying that it could be used as an anti-inflammatory medication. Hydroxyl groups in the polyphenol compounds present in date extracts may interact with the collagenase backbone or other functional group side chains. The alteration in collagenase conformation, induced by hydrophobic contact with the benzene ring of polyphenol, reduces the enzyme's catalytic efficiency (Vijayakumar et al., 2017).

Another plausible consequence is the involvement of the Zn ion active site in collagenase. The involvement of a structural Zn ion in the active region of collagenase is crucial for enabling interaction with an inhibitor (Bigg et al., 1994). Hence, it is plausible that polyphenol compounds have the capability to bind to the active site of the Zn ion, thereby obstructing the substrate's ability to undergo enzymatic digestion. This mechanism potentially plays a role in date flesh extracts observed collagenase inhibitory function.

Anti-tyrosinase Activity

The anti-tyrosinase assay relies on suppressing the tyrosinase enzyme by applying mushroom extract. Tyrosinase is commonly acknowledged as a pivotal enzyme involved in the synthesis of melanin and in the pathogenesis of dermatological disorders characterised by abnormal melanin deposition. Melanin is the principal pigment accountable for human skin pigmentation. In recent years, the significance of tyrosinase inhibitors has expanded considerably due to their clinical efficacy in treating skin conditions and their widespread use in the cosmetic industry for skin whitening and depigmentation.

Tyrosinase is pivotal in melanin formation and dermatological conditions characterised by excessive melanin accumulation. The anti-tyrosinase activity was assessed using kojic acid as the reference standard. The results indicated that the extract derived from P. dactylifera with the highest concentration of 1,000 µg/ml demonstrated a moderate inhibition percentage of 67.76% against tyrosinase. In comparison, the standard solution of kojic acid exhibited a higher inhibition percentage of 76.03%. These findings are visually represented in Figure 2.

A strong correlation exists between the biological activities exhibited by plants and the presence of phytochemicals in their extracts (Vijayakumar et al., 2017). The significant inhibition of tyrosinase seen in the Ajwa dates extract could potentially be primarily attributed to the presence of many bioactive substances, including but not limited to vitamin C, B-complex, antioxidants, and other bioactive constituents (Alharbi et al., 2021; Al-Shahib & Marshall, 2003; Ribeiro et al., 2015). The research

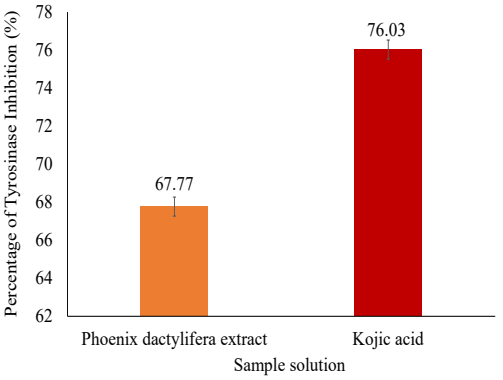

Figure 2. The percentages of tyrosinase inhibition on Kojic acid and *P. dactylifera* fruit extract

performed by Meer et al. (2017) showed that incorporating *Phoenix dactylifera* extract into the formulation of a topical cream reduced skin melanin levels, exhibiting whitening effects. This discovery has demonstrated that the extract derived from date fruit exhibits promising potential as a lightening agent.

The Value of SPF

Sunscreen contains a combination of active components that can absorb, reflect, and disperse solar radiation. The efficacy of sunscreen can be evaluated by utilising the SPF. Sunscreen products need to possess a standardised SPF suitable for human skin, considering its inherent characteristics and prevailing weather conditions, to mitigate the harmful effects of UV rays that pose a significant risk and can cause harm to the skin. Consistent utilisation of products containing SPF has the potential to mitigate and safeguard against the detrimental consequences of UV radiation exposure. The UV electromagnetic spectrum can be categorised into three distinct sections, namely ultraviolet A (UVA, 320 to 400 nm), ultraviolet B (UVB, 290 to 320 nm), and ultraviolet C (UVC, 200 to 290 nm).

The sunscreen activity assessment involves measuring the transmission spectrum of the *P. dactylifera* extract within the wavelength range of 200 to 400 nm. The absorbance acquired from the spectrum is utilised to compute SPF. Figure 3 illustrates the absorption spectrum of UVA, UVB, and UVC for both date extract and other commercially available UV sunscreen active components. The provided figure depicts the potential of the samples as UV sunscreen agents, as determined by the highest intensity peak observed in the UV zone. The current study observed that the transmission spectrum of date extract displayed notable photoprotective activity. The figure in the study indicates the presence of distinct spectrometric absorption peaks in the UVC and UVB regions, which implies a potential for photo-protection.

The *P. dactylifera* fruit extract has an absorption peak wavelength (λ_{max}) of 210 nm in the UVC region and 290 nm in the UVB region. UVC radiation is efficiently absorbed by the ozone layer located in the stratosphere. However, UVA and UVB radiation can penetrate the Earth's atmosphere, directly impacting human populations and ecosystems. The penetration of UVA and UVB rays into the skin can result in many effects, including sunburn, pigmentation changes, erythema, and inflammation. In contrast, the effects of UVA radiation become apparent only

after a longer period of sun exposure, regardless of the dosage levels (Fonseca & Rafaela, 2013). The outcomes of this study suggest that the extraction of dates can mitigate the occurrence of sunburns and pigmentation, which are predominantly attributed to exposure to UVB radiation (Fonseca & Rafaela, 2013). The detrimental consequences of sun exposure caused by UVB rays are more closely associated with immediate skin damage, such as induced erythema, as opposed to the detrimental consequences of sun exposure caused by UVA rays, which only become evident following an extended duration of exposure (Herrling et al., 2006).

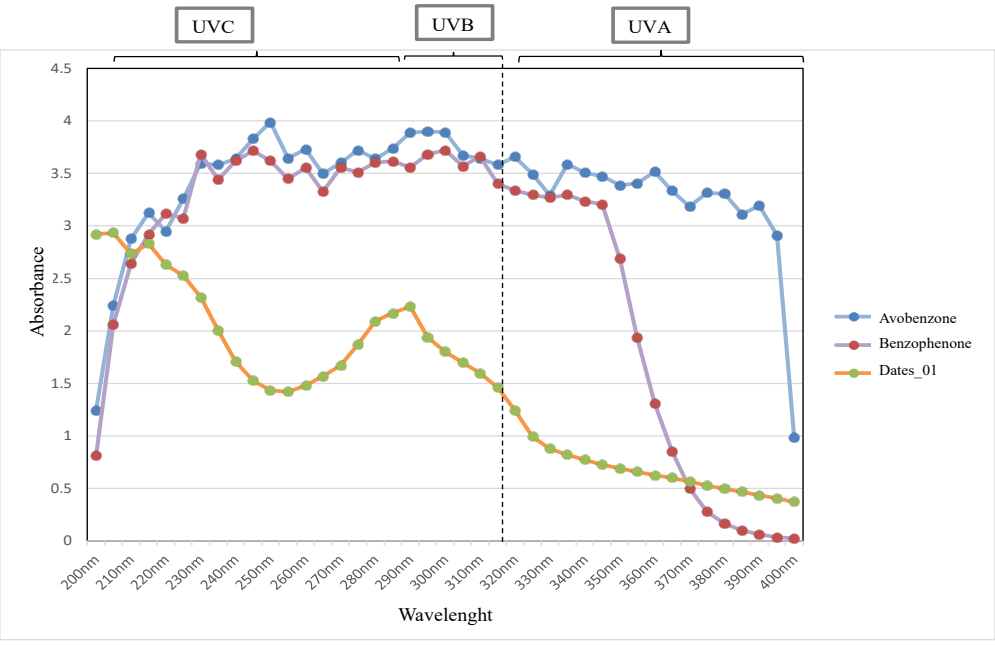

Figure 3. Spectrophotometric absorption profile of fruit extract of *Phoenix dactylifera*

Note. UVA = Ultraviolet A; UVB = Ultraviolet B; UVC = Ultraviolet C

Table 2 displays the calculations to determine the SPF value of *P. dactylifera* extract compared with other commercial UV sunscreen active ingredients. The level of UVB protection offered by a product can be quantified through its SPF, indicating that goods with higher SPF values offer greater defence against the detrimental consequences of solar radiation compared to those with lower SPF values. The table shows that date extract showed an SPF value of 17.09, compared to avobenzone and benzophenone as standard, with values of 37.45 and 36.21 at a concentration of 1 mg/ml, respectively. It is undeniable that this date extract has potential as a sunblock. According to European Union guidelines, products with SPF values of 6 and 10 are classified as low, medium (SPF 15, 20, 25), high (SPF 30, 50), and very

Table 2
SPF value of the extract and standards

No.	Wavelength (nm)	Erythema affect value	Dates extract	Avobenzone	Benzophenone
1	290	0.0150	0.3349	0.5838	0.5339
2	295	0.0817	1.5853	3.1843	3.0062
3	300	0.2874	5.1714	11.1919	10.6959
4	305	0.3278	5.5673	12.0411	11.7008
5	310	0.1864	2.9777	6.7874	6.8220
6	315	0.8390	1.2260	3.0058	2.8540
7	320	0.0180	0.2236	0.6583	0.6006
	Sun protection factor		17.0865	37.4526	36.2134

Note. The sun protection factor (SPF) value for the Ajwa date extract is 17.0865 compared to the other standards of avobenzone and benzonphenone, which are 37.4526 and 36.2134, respectively

high (SPF 50+). Based on Suva (2014), any substance with an SPF value greater than two is considered to have good sunscreen activity. The value of marketed sunscreen lotion with concentration (200 µg/ml) is approximately 10.66 ± 0.006 (Suva, 2014). The level of SPF directly correlates with the degree of protection a sunscreen offers against UV radiation. Therefore, the extract of *P. dactylifera* was discovered to fit the range of the best sunscreen agents.

The presence of antioxidants significantly supports the potential of the aqueous extraction of *P. dactylifera* in the absorbing UV region. In addition, the effectiveness of including antioxidant chemicals in sunscreens is believed to be higher when compared to using a conventional UV filter alone. Indeed, the combination received recognition within the realms of pharmacological and cosmetic scientific literature, as well as in commercially available products. Due to the obvious presence of phenolic chromophores, these antioxidants can provide photoprotective action (Morocho-Jácome et al., 2021). Among these phenolics, the literature indicates that antioxidant constituents such as flavonoids are the primary factor protecting plants from ultraviolet radiation. Flavonoids are polyphenols with two aromatic rings (two chromophores) that absorb at 240 to 285 nm and 300 to 550 nm.

Natural ingredients from various natural sources are frequently employed in formulating natural or vegan cosmetics. Furthermore, the cosmetic industry is witnessing a notable surge in introducing innovative, environmentally friendly products. Plants have met many human needs because their presence of various primary or secondary metabolites makes them active ingredients in cosmetics and medicines. Furthermore, diosmin compound high-performance liquid chromatography-mass spectrometry (HPLC-MS) analysis supports the function. According to Morocho-Jácome

et al. (2021), the maximum absorbance peaks of diosmin (in an alkaline medium) are at 268 and 285 nm. Consequently, the aqueous extract derived from *P. dactylifera* exhibits potential as an active ingredient for human protection through its ability to absorb, scatter, and reflect radiation, namely UVB rays.

Alharbi et al. (2021) have identified many phenolic acids, namely vanillic acid, ferulic acid, protocatechuic acid, caffeic acid, cinnamic acid, and catechin acid, produced from date fruit that exhibit cosmetic qualities. Vanillic acid and ferulic acid are present in fruit and seed of date. The bioactivity of vanillic acid has been shown to have potential benefits in the context of skin lightening and the reduction of skin pigmentation (Hong et al., 2006; Willcox et al., 2004). Moreover, the utilisation of ferulic acid has been extensively observed within the cosmetic sector. Ferulic acid plays a protective role in the primary structures of the skin, including keratinocytes, fibroblasts, collagen, and elastin. The substance hinders the process of melanogenesis, promotes the formation of new blood vessels (angiogenesis), and speeds up wound healing. The compound is commonly utilised in skincare formulations for its photoprotective properties, ability to postpone skin photoaging processes, and contribution to skin brightening (Zduńska et al., 2018).

Furthermore, protocatechuic acid has been found to contribute to attenuating the skin ageing process. A study examining the functional properties of protocatechuic acid (PCA) through experimentation on an *ex vivo* model of human skin has demonstrated that this particular phenolic molecule has the ability to enhance collagen formation (S. Shin et al., 2020). The results of this study indicate that PCA may have the ability to produce an anti-wrinkle effect in human clinical trials. At the same time, catechins enhance collagen organisation and function as a binding agent. The stabilisation of collagen by the plant polyphenol catechin has been shown through experimental and computational research. These studies suggest that hydrogen bonding and hydrophobic interactions play a significant role in this stabilisation process (Hong et al., 2006).

CONCLUSION

The results of the present study demonstrate that the fruit of *P. dactylifera* displays significant potential in the fields of cosmeceuticals, focusing on skin pigmentation and collagen enhancement. Using botanical constituents in cosmetic formulations presents a superior alternative to chemical alternatives. The natural origin of antioxidants derived from Ajwa dates is that they are rich, safe, and well-tolerated by the skin compared to synthetic chemicals that may raise concerns about potential long-term effects and interactions with the skin. Moreover, the proposed method presents a potentially superior option to using artificial skin anti-ageing chemicals in various industries, as it offers enhanced safety, cost-effectiveness, and efficiency. The aqueous extract of *P. dactylifera* has

promising potential as a cosmeceutical ingredient owing to its anti-tyrosinase and anti-collagenase activities, as well as its ability to provide substantial protection against UV radiation, thereby sheltering the skin against the harmful effects of sunshine.

In summary, antioxidant-rich date extract offers a natural and holistic approach to skin ageing, potentially providing various benefits through its diverse bioactive compounds.

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