Arabian Journal of Chemistry (2023) 16, 104764

King Saud University

Arabian Journal of Chemistry

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ORIGINAL ARTICLE

Green tannins /Avocado oil composites; suncare and skincare materials

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Received 22 October 2022; revised 15 February 2023; accepted 27 February 2023
Available online 4 March 2023

KEYWORDS

Tannins;
Avocado oil;
Antiaging;
Sun care;
Skin care characteristics;
Antimicrobial

Abstract Soft skin-friendly green-tea tannins/Avocado oil of antiaging creams were formulated. The active ingredients tannins and Avocado oil were extracted from green-tea and avocado skin, respectively. The active ingredients were carefully investigated for their chemical configurations using 1H NMR and ATR-FTIR spectroscopy, crystal structure using XRD pattern, and thermal stability using TGA and DTG thermograms. The antiaging effect of the cream were carefully investigated for their nourishing effect and protection against solar UVB radiation. Physicochemical properties of the antiaging effect of cream were explored through; in-vitro sun protection factor (SPF), which demonstrated medium SPF value capable of UVB absorption to high content. Optimum viscosity values in presence and absence of Carbopol® 940 moisturizer were evaluated and appropriate spreadability and microscale particle size distribution were demonstrated. The antiaging soft material has also demonstrated antibacterial and antifungal activity. As a result, the advantages and the skin-friendly characteristics; nourishing and protection against solar UVB radiation, and antibacterial and antifungal activity can consider the green-tea tannins/Avocado oil a promising antiaging cream, which not only protects but also nourishable with antibacterial and antifungal activities.

1. Introduction

Eternal seek of humans for youth appearance is always been the splendor of living, and according to this but to a lesser extent, the search of humans to minimize signs of aging is always a persistent prerequisite (Lodén et al., 2007). Wrinkles and other signs of aging are fought by healthy diet food as been described by world health organization (WHO) (xxx, n.d.), sport, and targeted anti-aging creams that fight the harmful solar effectiveness on the human skin like sun protection creams (above 50). Skin aging is a complex process featured by rough texture, irregular pigmentation, skin discoloration and thinning, loss of hydration, wrinkles, harsh and fine lines (Longo et al., 2013). Appearance of wrinkles is directly correlated with intrinsic and extrinsic factors; intrinsic is an internal and genetic factor correlated with food intake and metabolism processes taking place inside the human body, whereas extrinsic is an environmental factor correlated with outside effects that encourage wrinkles appearance such as photo-aging from sun's UV irradiation, environmental pollutants, and cigarette smoking (Ahmed et al., 2020). Furthermore, it was found that free radicals' formation was steadily increased due to chronic exposure to UV

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Peer review under responsibility of King Saud University.

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https://doi.org/10.1016/j.arabjc.2023.104764
1878-5352

irradiation, to other factors, and to life-style oxidative stress (David McDaniel et al., 2018; Warraich et al., 2020). The increase rate of free radical formation in human body such as reactive oxygen species (ROS) found responsible for wrinkles formation due to; degradation of extracellular matrix, and hence cell destruction (Eckersley et al., 2020), skin DNA damage (Dupont et al., 2013), decrease of oil-secreting glands and losing elasticity, resulting in dryness and wrinkle formation (Ali and Gupta, 2022; Zrinka Bukvić Mokos et al., 2018), Therefore, healthy diet food, sport, and mask against unnecessary UV irradiation may play vital role in fighting against free radical damage for the human skin, and hence act as daily antiaging practices. Furthermore, the use of good quality creams that are nourishable and qualified sunscreeners are another solution to prevent free radical damage, and hence fight against wrinkles formation (Eckersley et al., 2019). Natural polyphenols such as green tea tannins show high ability for radical scavenging due to their ability to trap and neutralize free radicals without causing any side effects to the skin (Chen et al., 2021; Zeb, 2020; Zhu et al., 2019). Phenolic extracts found to inhibit activity of proteinases responsible for accelerated degradation of skin proteins (Zillich et al., 2015; Mukherjee et al., 2015). On the other hand, monounsaturated fat found in avocado oil can reduce appearance of wrinkles by boosting collagen production, moisturizing the skin, and increasing skin elasticity (Badiu and Rajendram, 2021), it also demonstrated skin shield from ultraviolet irradiation, due to the presence of the fat-soluble vitamins A, B, E, and D, and polyphenols such as phytosterols that play major role in rejuvenating stressed skin (Ahmed et al., 2020; Jahan and Happy, 2022; Ghose et al., 2019). Therefore, well-known high-reputable cosmetic firms such as Nivea, Dove, and L'oreal are using it in their supplies and products (xxx, n.d; xxx, n.d.; xxx, n.d.). In this report, topical anti-wrinkle cream consists of avocado oil and green-tea tannins as active ingredients was formulated for fighting against wrinkles and preserving the look of eternal youth. Different characterization techniques such as ATR-FTIR, ^{1}H NMR for chemical structure TGA and DTG for thermal stability and XRD for crystal structure were used for active ingredients of the cream. Eventually, the *in-vitro* sun protection factor, antibacterial and antifungal activity, physicochemical properties such as viscosity, spreadability and particle size distribution of the tannins/Avocado oil cream were checked and examined.

2. Experimental

2.1. Materials

Avocado fruits were collected from local vegetable market; the green-tea was purchased from local hypermarket. Lanolin, stearic acid and Triethanolamine (TEA) were procured from Riedel-de Haen AG (Germany), glycerin was supplied by Fluka AG, Calcium Chloride anhydrous (98%) purchased from Fizmerk chemicals (India), Ethanol (99%) purchased from Carlo Erba (France), Carbopol® 940 polymer (ULTREZ 20) was purchased from Lubrizol (USA), Deionized water was used in all experiments.

2.2. Spectroscopic means

X-ray diffractometer (XRD) (Ultima IV (185 mm)) used to investigate crystal structure of samples. ***Thermogravimetric analyzer (TGA)*** (NETZSCH TG 209 F1Iris) used to analyze thermal stability of samples in 25–800 °C range under N_2 atmosphere using a heating rate of 10 °C/min. ***Fourier transform infrared (FTIR)*** in the range of 4000–400 cm^{-1} (Shimadzu IRAffinity^{-1}) supplied with ***attenuated total reflectance (ATR)*** unit for best deconvoluted functional peaks and chemical structure. 400 MHz ***Nuclear Magnetic Resonance*** (^{1}H NMR Bruker biospin) used to investigate chemical structure using deuterated methanol (CD_3CN). ***Vibro Viscometer:*** (SV-A Series Sine-wave Vibro Viscometer) wide range measurement (0.3–10,000 mPa.s). ***Laser-Diffraction Particle-size Analysis*** (Microtrac S3500) used for particle size distribution.

2.3. Green-tea tannins

Green tea was grounded to 1.0 mm powder size using commercial grinder. 5.0 g of grounded green tea were dissolved in 50 mL of 1:1 ratio of ethanol/water mixture. The solution was heated under 500 rpm stirring at 60 °C for 1 h. After heating, the solution was ultrasonicated for 10 min until tannins orange color appeared. The tannins extract was filtered, and filtrate was dried in the oven at 50 °C for 24 h. The brownish orange green-tea tannins powder was collected and restored in dried place until used (Das et al., 2020).

2.4. Avocado oil

Green Avocado was peeled off from avocado fruit, and the avocado skin was washed with deionized water, cut into small pieces, and left to dry overnight in an oven at 40 °C The dried pieces were grounded to 1.0 mm powder size and stored in dry place at ambient temperature. 10 g of avocado skin powder were dissolved in 60 mL ethanol and sonicated with ultrasonication device for 15 min at ambient temperature. The solution was decanted and placed in the oven at 40 °C overnight to evaporate leftover solvent and the green avocado oil was collected. The avocado oil was saved at room temperature until used. The avocado oil is known for its stability over a wide range of temperature (Espinosa-Solis et al., 2022; Chin Xuan Tan, 2019).

2.5. Four in one antiaging materials

Oil phase: In a 100 mL beaker, 4.0 g lanolin were mixed with 5.0 g stearic acid and 5.0 mL of avocado oil under vigorous stirring. The temperature was raised to 70 °C to enhance intermixing and homogeneity. The mixture was continuously stirred until homogenous oily phase was obtained. *Aqueous phase:* In another 100 mL beaker, 0.15% tannins (w/w) were added to 25 mL deionized water in presence of 1.0 mL triethanolamine and heated at 70 °C until homogenous aqueous phase obtained. Later on, the oil phase was slowly added to the aqueous phase, and the mixture was vigorously stirred at 1000 rpm for 10 min until the desired creamy texture was obtained. Afterwards, 5% $CaCl_2$ with respect to the total weight of avocado oil and tannins powder (w/w) was added to crosslink avocado oil with green-tea tannins. Finally, 10% glycerin or Carbopol® 940 moisturizer was added to give silky texture to the cream.

2.6. In-vitro antimicrobial activity

The silky material was exposed to *in-vitro* antimicrobial activity test against common infection bacteria, and consequently determine the optimum effective concentration of antiaging cream required for well antimicrobial activity as follows; Four different concentrations (12.5%, 25%, 50%, 100% (w/w)) of original concentration of the cream were prepared. For measurement of antibacterial activity, Agar well diffusion method was used to assess the cream antibacterial effectiveness against standard strains of bacteria; S. aureus, (ATCC 25923), Escherichia coli (E. coli) (ATCC 23452) as follows; the surface of agar plate is inoculated by distributing a the microbial inoculum over the entire agar surface. consequently, a hole with a diameter of 6–8 mm is made in sterile manner with a sterile cork borer, and a volume of 20 to 100 µL of certain concertation of antiaging cream is introduced into the well. Then, agar plates were incubated at 37 °C for 24 h. The antiaging cream diffuses in the agar medium and inhibits the growth of the microbial strain tested. The antimicrobial activity was expressed as the diameter of the inhibition zone (in mm) produced by the cream's active ingredients. For Fungal culture test, few amount of cream was cultured and incubated in humidified Sabouraud Dextrose Agar (SDA) medium at 22 °C for 21 days to enhance the fungi growth. SDA medium is a non-selective medium used for isolation, cultivation, and maintenance of pathogenic and non-pathogenic species of fungi and yeasts at adjusted pH of 5.6 suitable enough to enhance the growth of fungi especially dermatophytes (Monwar et al., 2017).

2.7. In-vitro sun care

Sun Protection Factor (SPF) is the worldwide factor that expresses the level of protection of sunscreens against harmful solar ultraviolet rays (UVA and UVB). SPF can be measured using *in-vivo* or *in-vitro* methods. In *in-vivo* method, the minimal erythemal dose (MED) of UV radiation to make skin redness is measured, in presence and absence of sunscreen (Kiriiri Geoffrey et al., 2019), In *in-vitro* method, reliable UV spectrophotometric method is used to measure SPF value using the following relation (Santos et al., 1999);

$$\mathbf{SunProtectionFactor}(\mathbf{SPF}) = \mathbf{CV} \times \sum_{290}^{320} \mathbf{EE}(\lambda) \times \mathbf{I}(\lambda) \times \mathbf{A}(\lambda) \quad (1)$$

Where, CV is the correction factor which equals 10, EE (λ) was the spectrum of the erythema effect, I (λ) was the spectrum of the sun's intensity, and the absorbance at each λ value (A (λ)) of the samples was measured by a UV–Vis spectrophotometer in 290–320 nm wavelength range. The relationship between erythemogenic effect and radiation intensity (EE × I) was determined for each λ value where EE (λ) is spectrum of the erythema effect and **I (λ)** is the spectrum of the sun's intensity **(I (λ))** as described in Table 1 (Mansur et al., 1986; Milleno Dantas Mota et al., 2020).

The cream sample was synthesized as follows; in 100 mL volumetric flask 1.0 g of the antiaging cream was incubated and 100 mL ethanol were added. The flask was ultrasonicated in water bath for 15 min. In addition, different concentrations of the cream active ingredient (green tea tannins) were prepared (0.15%, 0.25%, 0.30% (w/w%)).

2.8. Viscosity

Tuning-fork vibration method that can determine wide range of viscosity measurements (0.3–10,000 mPa.s) with high accuracy technique. The sine-wave Vibro viscometer (SV-10) is able to detect the growing electromagnetic force between two thin sensor plates at fixed 30 Hz frequency and amplitude less than 1 mm. The viscosity of the antiaging cream in absence and presence of Carbopol® 940 moisturizer (5%, 10%, 15%, 20% (w/w)), which showed values in the range of 0.3–10,000 mPa.s at 22 °C.

Table 1 The multiplication of EE (λ) × I (λ) values for each wavelength reading.

λ (nm)	EE (λ) × I (λ)
290	0.0150
295	0.0817
300	0.2874
305	0.3278
310	0.1864
315	0.0839
320	0.0180

2.9. Spreadability

For spreadability test, the successful cream is assumed to spread smoothly like silk on human skin without dragging, and should not make ascending friction during the rubbing process (Sabale et al., 2011).

2.10. Particle size distribution

Microtrac laser-diffraction (LD) particle size analyzer was used with specifications of tri–laser, multi-detector, multi-angle optical system. The particle's measurement ranges from 0.02 to 2800 µm with accurate, reliable and reproducible particle size analysis. In order to obtain the statistical distribution of the particle size of cream, different cream portions were added in a dropwise manner to deionized water in the dispersion cell of the laser diffraction unit. The selected optical parameters were as follows: continuous phase refractive index of 1.33, and a relative refractive index of 1.59. Each sample was analyzed in triplicate at 25 °C and the data were presented as mean ± SD values.

3. Results and discussion

3.1. Characterization of active ingredients

3.1.1. Chemical configuration of active ingredients

Polyphenolic tannins extracted from green-tea were exposed to ^{1}H NMR investigation using 400 MHz ^{1}H NMR spectrometer (Fig. 1A). Obviously, several chemical shifts exhibited the chemical structure of polyphenolic tannins as follows; C$\boldsymbol{H}_2$ peak next to heterocyclic ring at δ = 4.09 ppm (peak ***1***), C***H*** peaks inside the heterocyclic ring at δ = 5.01 and δ = 5.35 ppm, respectively (peaks **2** and **3**), aliphatic O***H*** peak at δ = 5.61 ppm (peak ***4***), C***H*** peak inside the heterocyclic ring at δ = 5.96 ppm (peak ***5***), C***H*** peak in aromatic benzene ring at δ = 6.64 ppm (peak ***6***), C***H*** peaks in aromatic benzene ring meta position at δ = 7.01 and 7.15 ppm (peaks ***7 and 8***), C***H*** peak inside the heterocyclic ring surrounded by two

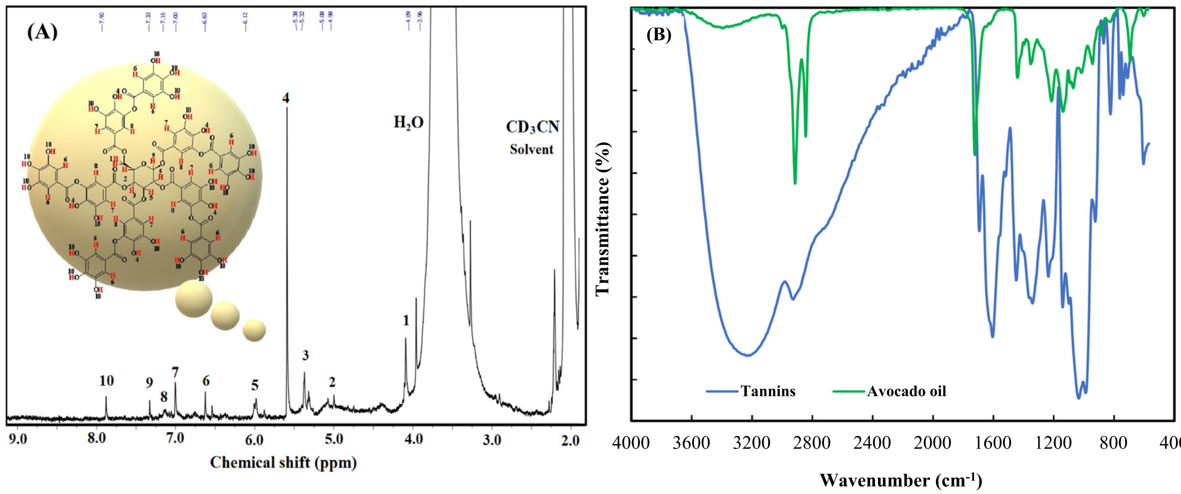

Fig. 1 (A) ^{1}H NMR spectrum of green-tea tannins, (B) ATR-FTIR spectra of green-tea tannins and avocado oil.

oxygen atoms at $\delta = 7.34$ ppm (peak ***9***), and aromatic hydroxyl groups (OH groups) at $\delta = 7.89$ ppm (peak ***10***). The peak at 2.0 ppm corresponds to deuterated acetonitrile (CD_3CN) solvent used. All ^{1}H NMR peaks provided evidence of successful extraction of polyphenolic tannins from green-tea. On the other hand, Fig. 1B shows the ATR-FTIR spectra of polyphenolic tannins and Avocado oil, the two active ingredients of antiaging cream. Table 2 illustrate the vibrational modes and wavenumber (in cm^{-1}) of polyphenolic tannins and Avocado oil. Clearly, the functional groups of tannins show distinct peaks as follows; hydroxyl group at 3232 cm^{-1}, aromatic C–H stretching at 3036, aliphatic C–H stretching at 2925 and 2888 cm^{-1}, sharp carbonyl group at 1692 cm^{-1}, conjugated aromatic C = C stretching at 1603 cm^{-1}, and C–O–C stretching at 1140 cm^{-1}, which came in accordance with NMR peak values, and confirm the chemical structure of polyphenolic tannins.

On the other hand, Avocado oil show characteristic peaks of hydroxyl groups of fatty acids through hydroxyl groups (O–H) at 3382 cm^{-1} and carbonyl groups (C = O) at 1723 cm^{-1}, aromatic C–H stretching of Linoleic acid at 3001 cm^{-1}, Long aliphatic CH_3 and CH_2 groups through C–H stretchings at 2914 and 2845 cm^{-1}, respectively. Moreover, characteristic C = C stretching at 1646 cm^{-1} that corresponds to double bond of Oleic and Palmitoleic acids moieties, and conjugated C = C stretching at 1622 cm^{-1} that corresponds to conjugated double bond of Linoleic acid moiety are other evidences of accurate chemical structure of Avocado oil.

3.1.2. Thermal stability

Thermal stability of active ingredients is an extremely significant step toward the applicability, transportation, short and long-run storage, and erosion factors of the so-called antiaging cream. Each sample is exposed to increasing temperature from 25 to 1000 °C at constant heating rate of 10 °C/min. The decomposition temperature is a direct evidence of how feasible the cream can resist storage and erosion factors. Fig. 2 displays the thermogravimetric analysis (TGA) and differential thermogravimetry (DTG) of the active ingredients of avocado oil, green-tea tannins and the mixture of both in the cream. The decomposition of Avocado oil (Fig. 2A) with broad band begins at 200 °C (onset) and ends at 500 °C (endset) and show multiple decomposition temperature (mid-set) at 300, 370, 410, 430, and 480 °C. The decomposition stage is referred to the onset of degradation of polyunsaturated fatty acids (Linoleic acid), followed by monounsaturated fatty acids (Oleic and

Table 2 Vibrational modes of polyphenolic tannins and Avocado oil, the active ingredient.ts of antiaging cream.

Active Ingredient	Wavenumber (cm^{-1})	Vibrational Stretching modes
Tannins Polyphenol	3232	O–H stretching
	3036	Aromatic C–H stretching
	2925 and 2888	Aliphatic C–H stretchings
	1692	C = O Stretching
	1603	Conjugated C = C stretching
	1140	C-O-C stretching
Avocado Oil	3382	O–H stretching of fatty acids
	3001	Aromatic C–H stretching of polyunsaturated Linoleic acid
	2914 and 2845	Aliphatic C–H stretchings of fatty acids
	1723	C = O Stretching of fatty acids
	1646	C = C stretching of monounsaturated Oleic and Palmitoleic acids
	1622	Conjugated C = C stretching of polyunsaturated Linoleic acid

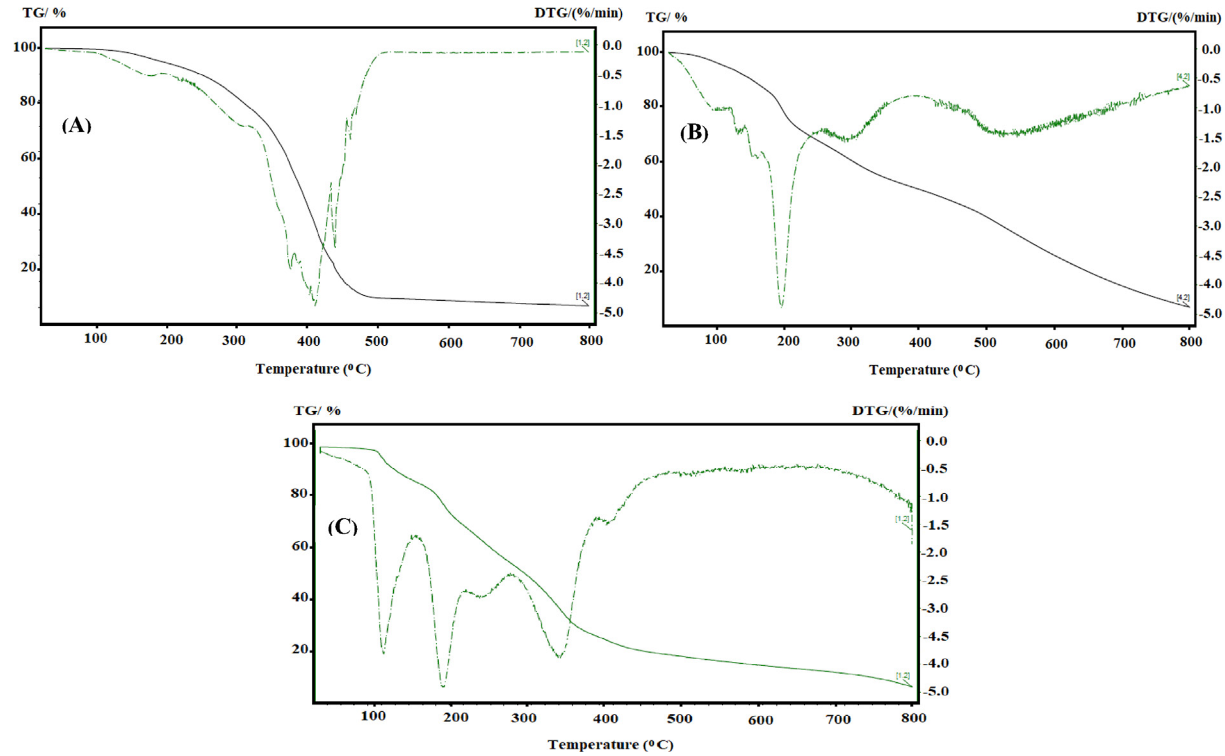

Fig. 2 Thermogravimetric analysis (TGA) and Differential thermogravimetry (DTG) thermograms of (A) Avocado oil, (B) Greem-tea tannins, (C) Green-tea tannins/Avocado oil formulation in presence of Ca^{+2} crosslinker.

Palmitoleic acids) and eventually saturated fatty acids (Palmitic and Stearic acids) (Santos et al., 2002). Whereas, the decomposition of green-tea tannins (Fig. 2B) begins at 120 °C (onset) and ends at 700 °C (endset) and show multiple decomposition temperatures (mid-set) at 200, 300, and 550 °C. The 200 °C decomposition peak corresponds to low molecular weight volatile compounds (H, CO, and CO_2), the 300 °C peak corresponds to the degradation of the laterals chains of the green-tea tannins (Zhang et al., 2011), and the 700 °C corresponds to the decomposition of flavonoid rings to form carbon skeleton (Konai et al., 2016). Fig. 2C show that tannins can bind avocado oil and form stable ingredients in presence of Ca^{2+} crosslinker, all decomposition peaks of avocado oil and green-tea tannins were present.

3.1.3. Crystal structure

Crystal structure of green-tea tannins was identified by X-ray diffraction pattern (XRD) using Bragg's equation as follows;

$$n\lambda = 2d\sin\theta \tag{2}$$

where n is the diffraction order (n = 1), λ is the radiation wavelength (λ = 1.5406 Å), θ is the glancing angle, and copper source of radiation (CuKα) used. The interlayer spacing (d) between tannins layers can be calculated from equation (1). Clearly, green-tea tannins displayed one broad band at 2θ = 20.6° (Fig. 3) as depicted in the literature (Zhang et al., 2015). This indicate characteristic amorphous nature of tannins. Moreover, two small intensity crystalline peaks at 2θ = 28.5° and 40.6° correspond to 3.1 and 2.2 Å interlayer spacings (d), respectively. The appearance of such small intensity crystalline peaks can be attributed to the processing technique of the gentle solvent evaporation process during the extraction of green-tea tannins.

3.2. Sun care materials; mechanism of action

Solar ultraviolet radiation covers wide range of wavelength (400–100 nm). It is divided into three wavelength regions; UVA (400–315 nm), UVB (315–280 nm) and UVC (280–100 nm) (Baker et al., 2016). UVC rays are dispersed by the ozone layer in the stratosphere layer and its penetration to earth may lead to catastrophic global warming, while the remaining rays (UVA and UVB) rays can reach the earth's surface (Pillai et al., 2005). The chronic exposure of skin to UV rays (especially UVB rays) can induce the formation of reactive oxygen species (ROS), which cause cellular, tissue, and skin damage. They also may lead to DNA, RNA, lipid, protein damage, which eventually result with photoaging and wrinkle formation of human skin (Rittié and Fisher, 2015). When skin absorbs photon energy, excited botanic species can form by translocation of electrons from occupied orbitals (ground state) to the unoccupied orbitals (the excited state) (Ichihashi et al., 2003; Onoue et al., 2017). Jablonski suggested this mechanism of energy transfer from an excited triplet photosensitizer to an oxygen atom, and obtain an excited singlet oxygen that might play major role in the oxidization of membrane lipids and proteins, or in the oxidative damage of DNA (Hall et al., 1996; Davies, 2003). Reactive oxygen species (ROS) including hydroxyl and/or peroxyl radicals can be formed from electron or hydrogen transfer (Krumova and Cosa, 2016). At the same time, the overproduction of ROS leads to consumption of ROS-scavenging enzyme levels (such as superoxide dis-

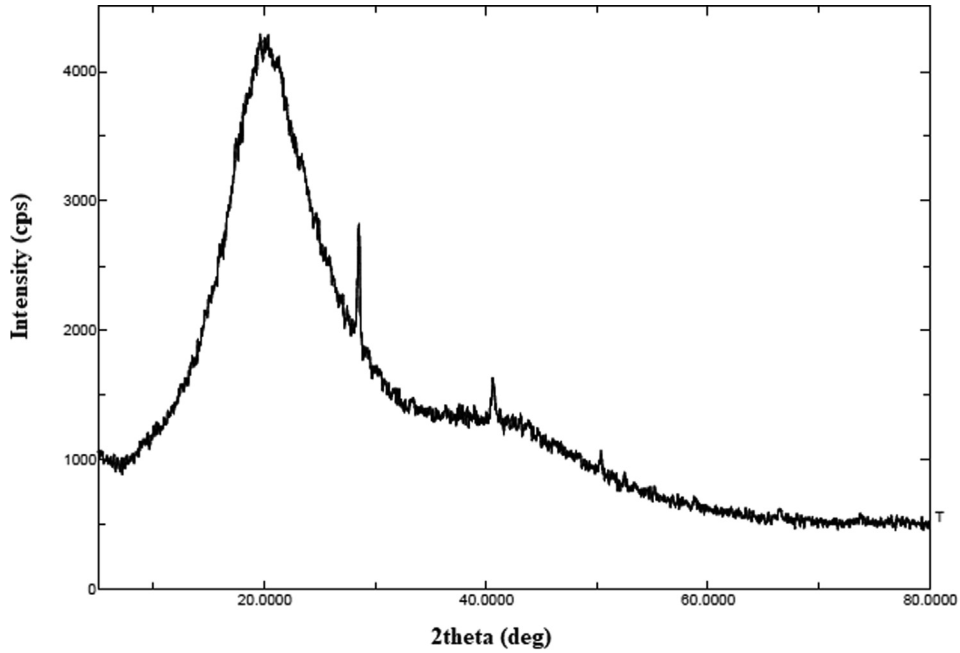

Fig. 3 X-ray diffraction pattern (XRD) of tannins polyphenol.

mutase (SOD) and catalase), which result in DNA, proteins and lipids damage, and prepare for photoaging and wrinkles formation (Kong et al., 2018). Green-tea tannins have a unique set of polyphenolic groups namely, chatechin (C), epicatechin (EC), epigallocatechin (EGC), and their gallate esters: epicatechin gallate (ECG), and epigallocatechin gallate (EGCG), are natural antioxidants and radical scavengers (Guo et al., 1999). Such structural features of green-tea tannins enable stabilization of radicals via electron delocalization and/or termination, which in turn can enhance radical scavenging and antioxidant activity of flavonoids (Quideau et al., 2011). Additionally, it has also been reported that epigallocatechin gallate (EGCG) can enhance the ROS-scavenging enzyme activity (Ji Hoon Jeong et al., 2004). As a result, green-tea tannins with their biologically active flavan-3-ols groups can be involved as radical scavenging antioxidant in fighting against photoaging and thus as natural sunscreens against sunburns and wrinkles formation (Fig. 4A) (Zillich et al., 2015). Sun protection factor (SPF) is a factor that measures how efficient sunscreens can protect human skin against UVB sunburns. Higher SPF value indicates higher capability of efficient protection against sunburns (González et al., 2008). SPF values of the green-tea tannins/Avocado oil antiaging cream were calculated using equation (1) and described in Fig. 4B. Clearly, 0.15% tannin solution showed SPF value of 6.2, when concentration of tannin increased to 0.25%, the SPF value reached 8.1. Continuous increase of tannin solution to 0.3%, led to maximum value of SPF = 15.7. This clearly confirm the role of green-tea tannins in increasing protection against sunburns and wrinkle formation. On the other hand, the SPF value of our green-tea

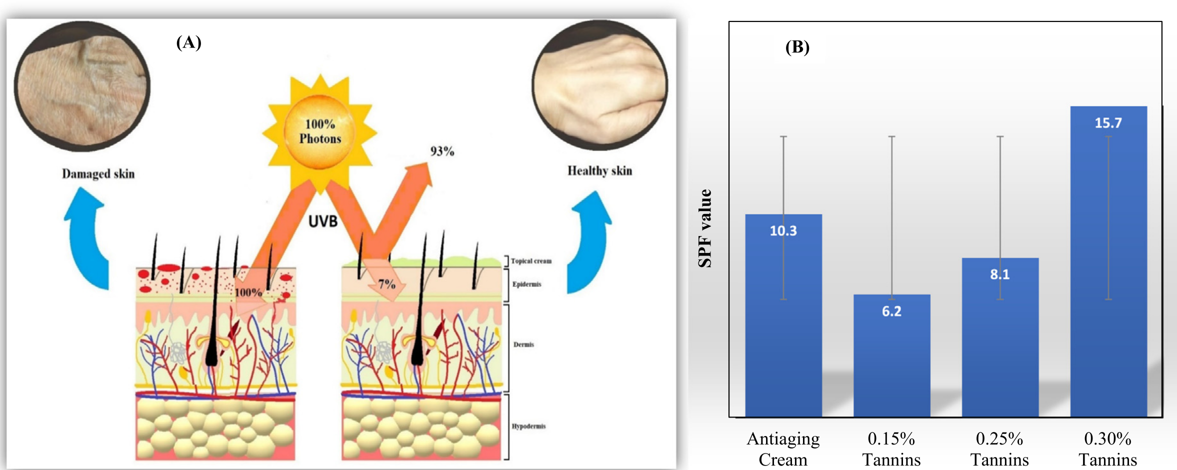

Fig. 4 (A) Schematic illustration for the effect of solar UVB irradiation in presence or absence of topical antiaging cream. (B) Change of SPF value using various green-tea tannins and green-tea tannins/Avocado oil antiaging crea.

tannin/Avocado oil antiaging cream was demonstrated to be 10.3. Although the antiaging cream contain 0.15% tannins, it showed higher SPF value than 0.15% tannin solution (SPF = 6.2), which clearly indicate that avocado oil has a significant contribution in sun protection besides its nourishing effect and antimicrobial activity. Fig. 4A illustrate the significance of sunscreen in obtaining healthy skin and the effect of UVB in obtaining damaged skin.

3.3. Antimicrobial activity

Contaminated cosmetics by microorganisms is an emerging catastrophic issue to be fully discussed. In Europe from 2005 to 2018, more than 100 reports on microbiologically contaminated cosmetics were recognized. Twenty of them were children-oriented products (Michalek et al., 2019). The growth of pathogenic microorganisms is directly affected by richness of nutrients in cosmetic environment. In cross-sectional study (Dadashi and Dehghanzadeh, 2016), 52 of daily-used skin and eye cosmetics were investigated for cosmetic contamination, all cosmetics used were polluted with bacteria (95% CI = 93.1%-100.0%) and 19.2% by fungi and yeast (95% CI = 10.8%-31.9%). Contamination of cosmetics can infect the skin and cause skin acne or irritation (Maria João Carvalho et al., 2021). The above terrifying statistics rings the bell on the emerging and upcoming cosmetic contamination lesion. Two different antibacterial and antifungal activity tests were performed for our green-tea tannins/Avocado oil antiaging cream.

3.3.1. Antibacterial activity

Different concentrations of the green-tea tannins/Avocado oil antiaging creams (25%, 50% and 100% (w/w)) were tested. The results of the well diffusion antibacterial test (Fig. 5A) showed that the diameter of the inhibition zone was 19 mm against standard strain of *E. coli* using the original concentration of the sample (100% (w/w)). On the other hand, no inhibition zones for the lower concentrations (25% or 50%) were found.

3.3.2. Antifungal activity

The fungal culture test was done to study the possible growth of fungi in the presence of green-tea tannins/Avocado oil antiaging cream, it also can help in diagnosing fungal infections caused by exposure to fungi incubated at 22 °C in humidified environment for 21 days (Hussain et al., 2020). After the passage of 21 days, samples were checked for their fungal characteristics such as color change, colony, fungal zones, and morphology changes. Our results indicate that no fungal growth was detected after 21 days of incubation (Fig. 5B), and hence our antiaging cream is said to be antifungal cream.

3.4. Physicochemical properties

Carbopol® moisturizer is a synthetic high molecular weight polyacrylic acid (PAA) used in skincare and personalcare products as texture enhancers and thickening agents (Berardi et al., 2022); and also to boost collagen production and help enhance skincare characteristics of human body. In our green-tea tannins/Avocado oil antiaging cream, we added different Carbopol moisturizer to enhance viscosity and texture of the cream, the viscosity of the cream in the absence of Carbopol moisturizer was 8.8 Pa.s., whereas in the presence of ascending moisturizer concentration, the viscosity reached 10.8 Pa.s. (Fig. 5C). The perfect viscosity of cream depends on final applicability of the cream, for example the use of higher viscosity cream is favored for burned

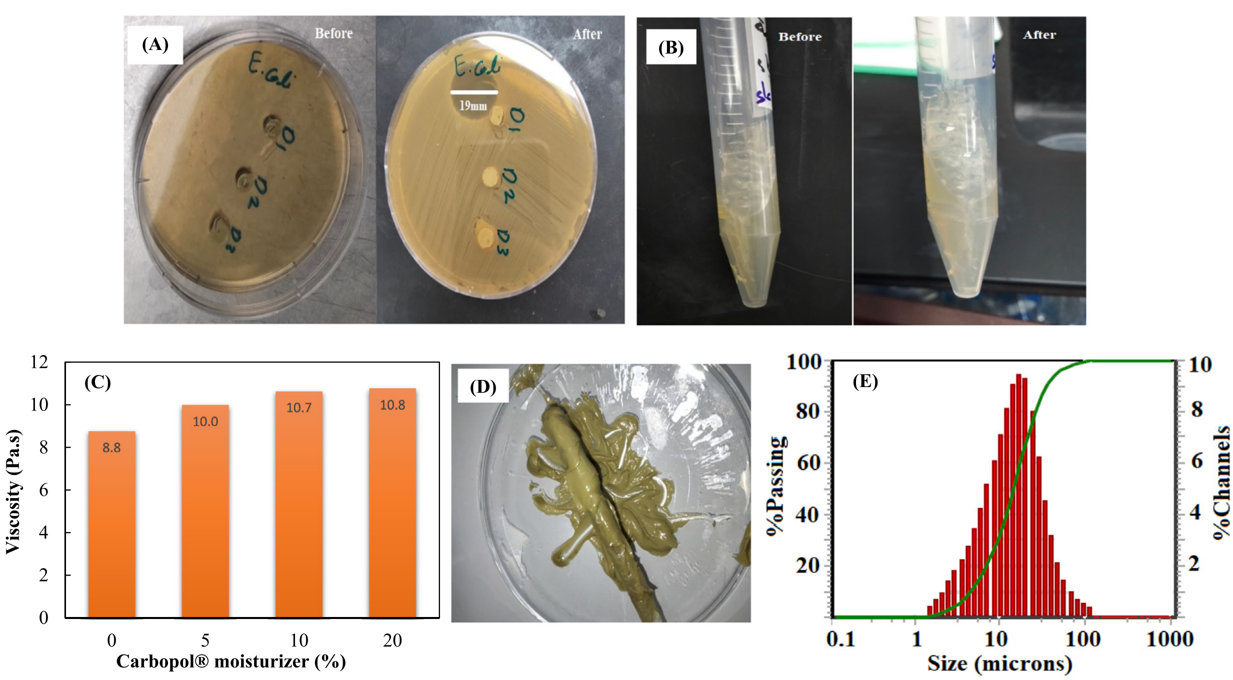

Fig. 5 (A) Antibacterial activity test, (B) Antifungal activity test, (C) Change of viscosity with Carbopol® 940 (%), (D) spreadability of green-tea tannins/Avocado oil antiaging cream., (E) Particle size distribution of the antiaging cream.

skin because it shields against infections, whereas lower viscosity cream is favored to easily spread and penetrate inside the skin for better nourishing and smoothness (Fig. 5D). Our antiaging cream show better spreadability and silky touch depending on the different viscosity values obtained. However, better penetration and skin uptake is directly correlated with smaller particle size, the use of smaller particle size can lead to easy penetration, higher skin uptake and lower retention time (Yokota and Kyotani, 2018). Fig. 5E show the particle size distribution of our antiaging creams, the average particle size of the cream was in the microscale with 1–100 µm particle size range, and average particle size of 18.5 µm. Such particle size is quite suitable for antiaging creams that properly fit to the human skin.

4. Conclusions

Tannins polyphenol/Avocado oil formulation was examined as antiaging materials with suncare and skincare characteristics. The active ingredients tannins and Avocado oil were extracted from green-tea and avocado peels, respectively. the chemical structure of active ingredients demonstrated polyphenolic tannins and four main constituents of avocado oil; oleic, palmitic, palmitoleic and linoleic acids respectively using ^{1}H NMR and ATR-FTIR. Amorphous nature of tannins using XRD pattern, and high thermal stability (above 150 °C) using TGA and DTG thermograms were investigated. The main role of antiaging effect of the active ingredients was for their nourishing effect and protection against solar UVB radiation. Physicochemical properties were investigated as follow; *in-vitro* sun protection factor (SPF) demonstrated medium SPF value from 6 to 16 using different tannins concentration capable for absorption of UVB to high content. Optimum viscosity values of 8–11 Pa.s. in presence and absence of Carbopol® 940 moisturizer, and 18.5 µm average particle distribution led to appropriate spreadability of the cream. The creamy material demonstrated antibacterial and antifungal activity, which confirm its commercial antiaging skincare specifications. Conclusively, the active ingredients green-tea tannins and Avocado oil play central role in nourishing the skin, silky touch, protecting it against solar UVB radiation benefits.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgment

Authors wish to acknowledge Jordan University for Science & Technology, Deanship of Research, project numbers = 20200117 and 20220109 for financial support and facilities.

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