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Moroccan Propolis: Unraveling the Phytochemical Diversity, Chemical Composition, and Antioxidant Potential Across Two Seasons

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ABSTRACT

Propolis, a natural resinous substance collected by honeybees from plant and tree buds, has been recognized for its diverse biological activities and therapeutic potential. In this research, we delve into the potential of propolis collected from the Gharb region of Morocco during the summer and autumn seasons. This study aimed to highlight its nutritional profile and phytochemical compounds, shedding light on its potential as an antioxidant and a valuable product. Through detailed chemical analysis, we discern significant variations in the composition of two types of propolis coded propolis$_1$ and propolis$_2$, particularly evident in the elevated ash (15.23% vs. 13.83%) and lipid (23.9% vs. 15.67%) content. While protein contents (0.66% vs. 1.29%) and crude fiber (1.7% vs. 1.6%) were relatively lower. While, the phytochemical screening revealed the presence of triterpenes, steroids, flavonoids, and tannins, displaying their potential efficacy against diverse diseases. The methanolic extracts exhibited substantial total phenolic content, measuring 2130.07 mg GAE/g DP for Propolis$_1$ and 2124.7 mg GAE/g DP for Propolis$_2$, highlighting robust antioxidant potential. Eventually, propolis exhibited wide-ranging bioactive compounds, reflecting a potent antioxidant effect and positioning it as a miraculous product. These findings emphasize the significance of propolis as a natural resource with diverse health-promoting properties, contributing to potential applications in the cosmetic and dietary fields.

Keywords: propolis, chemical analysis, phytochemical screening, antioxidant, natural resource.

Introduction

From the buds and cracks in the bark of different trees, honeybees (*Apis mellifera*) collect the resin, which is chewed, mixed with salivary enzymes, and then partially digested before being mixed with beeswax to produce a precious product of natural origin called propolis or bee glue.[1,2] Used by bees to serve as an antiseptic and to defend and protect the hive from several external factors.[3] Studies on propolis have been oriented mainly toward its medicinal use and its ability to fight against various diseases.[4,5] Several investigations have proven its diverse biological activities, including anticancer, antifungal, antioxidant,[6] antiviral, antiatherogenic, antiproliferative, and proapoptotic properties. Moreover, propolis has been found to possess cardioprotective and hepatoprotective effects.[7] These therapeutic and medicinal virtues are attributed to its complex composition, with resin and wax being the major constituents, associated with bioactive compounds, vitamins, minerals, pollen, terpenoids, carboxylic acids, alkaloids, steroids, hydrocarbons, sugars, ketones, amino acids, and other components.[8,9] Moreover, the composition of propolis varies depending on its geographical origin and the season of collection, which directly affects its biological activities, including antibacterial efficacy.[10] Indeed, all the biological activities of propolis depend on its chemical composition, which also differs according to the race of the bee.[11]

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The food and medicinal sectors have taken a keen interest in the botanical origin and chemical composition of propolis due to its bioactive compounds. Notably, phenolic compounds, especially flavonoids, emerge as the predominant group of polyphenols in terms of both quality and quantity. Which are associated with esters, ketones, and phenolic aldehydes. Moreover, propolis consists of diverse additional constituents that constitute the major groups within the 300 compounds identified in its composition.[12,13]

As per earlier research, propolis consists of various components that contribute to its diverse biological effects. Throughout history, propolis has served as a therapeutic remedy, with evidence found in the historical records of its use by ancient Greek, Egyptian, Roman, and Persian civilizations to alleviate a variety of discomforts.[14] Currently, propolis is available in raw form and extracts, which are used for wound healing, and immune system boosting.[15] Extraction methods include maceration and alcoholic extraction, revealing constituents such as phenolic acids, flavonoids, and terpenes.[16] The history of ethnomedicine involves the treatment of wounds, focusing on antibacterial characteristics, immune support, and wound healing.[17] Several studies have been conducted on Brazilian propolis, and obviously, those of other countries have also been extensive. Yet, this study takes an original path by thoroughly analyzing Moroccan propolis derived from purified and unprocessed beeswax, [18,19,20,21,22,23] as a comprehensive physicochemical and phytochemical analysis, considering two distinct collection seasons. Consequently, the study aims to perform a phytochemical screening and characterization of propolis sourced from the Gharb-Kenitra-Morocco region. The methodology involves employing three organic solvents with differing polarities to identify the optimal solvent for dissolving the maximum bioactive compounds present in propolis.

Materials and Methods

Collection of plant materials

Two samples of propolis were obtained from the APIA cooperative, situated in the Gharb region of Kenitra province-Morocco (13° 49' 59.999″ S 171° 45′ 0″ W). Gathered by *Apis mellifica intermissa* (the black strain), marked with voucher number "1814," was identified by Buttel-Reepen.[24] The collection involved propolis harvested during the autumn (Pr_1) and summer (Pr_2) seasons in July and October 2021, respectively.

Analysis of ash, crude fiber, protein, fat, total sugars, and reducing sugars content

The nutritional constituents of propolis were assessed using established methods. Ash, crude fiber, and lipids were determined using the AOAC method,[25] while protein content was analyzed using the Kjeldahl method.[26] Total soluble sugar content was measured using the phenol-sulfuric acid method described by Dubois *et al.*,[27] and reducing sugar content was assessed using DNS, dinitrosalicylic acid (98% purity, with a molecular weight of 228.12 g/mol) as per Miller's method.[28] The outcomes were expressed in milligrams of Glucose equivalent per gram of dry propolis (mg GE/g DP).

Phytochemical screening and quantification of phenolic compounds, tannins, and flavonoids

Extracts preparation

The extraction was performed by maceration. Briefly, 3 g of each propolis sample was placed in centrifuge tubes with 36 mL of extraction solvent (absolute ethanol 99%, methanol 99.85% from Sigma, and distilled water), then subjected to agitation at room temperature for 4 hours. Subsequently, the mixture underwent centrifugation employing a CENTRO 8-BL model centrifuge (J.P. Selecta s.a., Spain) and was filtered using 25-mm filter paper. The resultant solution was concentrated under vacuum and stored at -20°C until subsequent analysis.[29]

Evaluation of the presence of flavonoids

In two sets of test tubes, equal volumes of extract, hydrochloric alcohol, and Isoamylic alcohol were reacted. In the first set, magnesium chips were added to detect flavones, distinguished by an orange-pink color; flavanones, indicated by a purplish-pink shade; or the appearance of a red hue representing flavonols and flavanonols. In contrast, the second set underwent boiling for 15 minutes without magnesium shavings. This step aimed to reveal the presence of leucoanthocyanins, or catechols, as determined by the resulting color. A cherry red or purplish hue indicated leucoanthocyanins, while a brown-red color characterized catechols.[30]

Evaluation of the presence of tannins

The presence of gallic and catechic tannins was established through the reaction between iron chloride (III) $FeCl_3$ and propolis extracts. In a set of test tubes, 2 mL of each extract was introduced, and then 500 µL of aqueous $FeCl_3$ solution was added (2%). The resulting color, blue-black or green-black after the reaction, can be used to distinguish gallic tannins from catechic tannins.[31]

Evaluation of the presence of saponins, steroids, and triterpenes

Matos's methods[32] were employed to conduct screening for saponins, steroids, and triterpenes. In the saponins assessment, 0.3g of propolis extract was subjected to a 2-minute boil with 5 mL of distilled water, followed by shaking and a 3-minute rest. The presence of foam was indicative of saponins. To detect steroids, 1 mg of the extract underwent a reaction with 10 mL of 37% hydrochloric acid, and subsequently, then 10 mL of sulfuric acid (98%) was cautiously introduced along the tube's edge. A red upper layer discerned the presence of steroids. Subsequently, for triterpene detection, a mixture of 5 mL of hydrochloric acid and 0.3 g of propolis extract was heated for 30 minutes using a Precisterm model water bath from J.P. Selecta s.a., Spain. Then, a few drops of concentrated sulfuric acid at 98% were incorporated. Intense shaking of the mixture revealed a red coloration, indicating the presence of triterpenes.

Determination of total phenolic compounds

The quantification of total phenolic compounds was conducted using the Folin-Ciocalteu colorimetric technique, as outlined by Amri *et al.*[33] This procedure involved adding 2.5 mL of the Folin-Ciocalteu reagent (diluted 1:10 in distilled water) to 500 µL of the extract. After a 5-minute rest, 2 mL of the aqueous sodium carbonate solution (7.5% w/v Na_2CO_3) was added. The reaction mixture underwent agitation using an Assistent Reamix 2789 Vortex Mixer model from siehe oben, Bayern, and was then incubated for 1 hour at room temperature. Subsequently, the absorbance was measured at 765nm employing a spectrophotometer (UV-2005 model, J.P. Selecta s.a., Spain), against a blank. Besides, Gallic acid served as a reference standard to plot the calibration curve. Eventually, the results of total phenolic compounds were presented in milligrams of Gallic acid equivalent per gram of dry propolis (mg GAE/g DP).

Flavonoids assay

The total flavonoid content was expressed in milligrams of Quercetin equivalent per gram of dry propolis (mg QE/g DP). Adopting the aluminum chloride spectrophotometric method described by El Kabous *et al.*[34] Briefly, 2 mL of aluminum chloride solution ($AlCl_3$) at 2% in methanol (98.85%) was added to 2 mL of the diluted extract. After agitation, the mixture underwent a 15-minute incubation at room temperature. The results were measured at 430nm against a blank.

Condensed tannins assay

The condensed tannin content was determined using the vanillin/HCl method described in the study by El Kabous *et al.*[35] The results were calculated using the Catechin calibration curve and expressed in milligrams of Catechin equivalent per gram of dry propolis (mg CE/g DP).

Antioxidant activity estimation

DPPH radical scavenging activity*

The assessment of DPPH (2,2'-diphenyl-1-picrylhydrazyl) radical scavenging activity was performed following the study by Bouaziz *et al.*[36] Typically, 50 µL of different concentrations of the extract were introduced to 5 mL of DPPH solution (0,004% in methanol). After a 30-minute dark incubation at room temperature, optical densities were measured at 517nm against a blank containing all reagents except the sample extract.

The inhibition percentage (I%) of DPPH free radicals is calculated using equation number (1):

$$I\% = \left(\frac{\text{OD (B)} - \text{OD(S)}}{\text{OD (B)}}\right) \text{x } 100 \qquad (1)$$

Where:

OD (B) is the optical density of positive control

OD (S) is the optical density of the extract

The antioxidant activity of the studied propolis was assessed both in terms of percentage and the concentration required to inhibit 50% of the DPPH* radicals (IC50). Trolox and ascorbic acid (Vitamin C) were used as positive controls.

Ferric reducing antioxidant power (FRAP) assay

The reducing power assessment was conducted according to Oyaizu's method.[37] In separate tubes, 1 mL of propolis extracts at varying concentrations was mixed with 2.5 mL of 0.2 mol/L pH 6.6 phosphate buffer and 2.5 mL of 1% aqueous potassium ferricyanide solution [$K_3Fe(CN)_6$]. After a 20-minute incubation in a water bath at 50°C, the reaction was halted by adding 2.5 mL of 10% trichloroacetic acid (TCA). Centrifugation (3000 rpm, 10 min) yielded the supernatant, which was then mixed with 2.5 mL of distilled water and 0.5 mL of 1% ferric chloride in a separate set of tubes. Subsequently, the absorbance of the samples was measured against a blank at 700 nm. Besides, Ascorbic acid was used as a positive control under the same conditions.

Statistical analysis

The statistical analysis of the present study results was performed using software packages including SPSS version 25.0, GraphPad

Prism version 8.0.2, and NCSS 2021 (64-bit) Software version 21.0.3. The outcomes are presented as the mean ± standard deviation.

Results and Discussion

Nutritional composition

The data summarizing the contents of ash, crude fibers, proteins, and lipids is presented in Figure 1, highlighting two distinct types of propolis collected by bees during different seasons. Propolis from the autumn season (Pr_1) exhibited the highest percentages of ash, proteins, and lipids, standing at 15.23%, 1.29%, and 23.9%, respectively. In contrast, propolis from the summer season (Pr_2) displayed comparatively lower values, averaging 13.83%, 0.66%, and 15.66%, respectively. However, no significant difference was observed between the crude fiber results (Pr_1 = 1.6% versus Pr_2 = 1.7%).

The substantial lipid content found in the studied propolis aligns closely with existing literature, where lipids have been identified as a predominant component in propolis across various bee species due to its resin and wax-rich composition.[38] Notably, propolis collected by stingless bees contains elevated lipid percentages compared to honeybees, attributed to their floral preferences, contributing to greater water resistance within the stingless bee hive.[39]

Comparing the results of ash content in both Pr_1 and Pr_2 propolis, they significantly exceed the range reported by El Menyiy *et al.*,[40] which varied from 0.72% to 5.01%. This divergence could potentially indicate adulteration within propolis samples, underscoring the importance of ash content as a diagnostic criterion.[41]

Furthermore, the protein and crude fiber results are also noteworthy, with average values of (Pr_1 = 1.7 versus Pr_2 = 0.66%) and (Pr_1 = 1.6 versus Pr_2 = 1.29%), respectively. This underscores propolis' potential as a natural functional food, a trait also detailed in a study by Viuda-Martos *et al.*[42]

Figure 2 illustrates the season-dependent influence of bee collection on total soluble sugar and reducing sugar content, favoring Pr_2 with higher values (3.13 mg GE/g DP; 1.01 mg GE/g DP), respectively, compared to Pr_1 (1.85 mg GE/g DP; 0.86 mg GE/g DP). According to a study conducted by Syed Salleh *et al.*,[43] sugars such as α-D-Mannopyranoside, α-D-Galactopyranoside, Hexopyranose, α-D-Glucopyranoside, D-Fructose, D-Glucose, D-Galactose, d-Ribose, Glycoside, and α -D-Glucofuranoside constitute a significant portion of compounds found in propolis aqueous extract. Additionally, carbohydrate concentration varies between 4.67 mg/mL and 9.56 mg/mL, contingent on the bee species. However, in line with the study of Abdullah *et al.*,[44] propolis extracts contain minimal carbohydrate concentrations, ranging from 0.17% to 0.48% relative to the overall propolis components, varying with bee species and collection season.

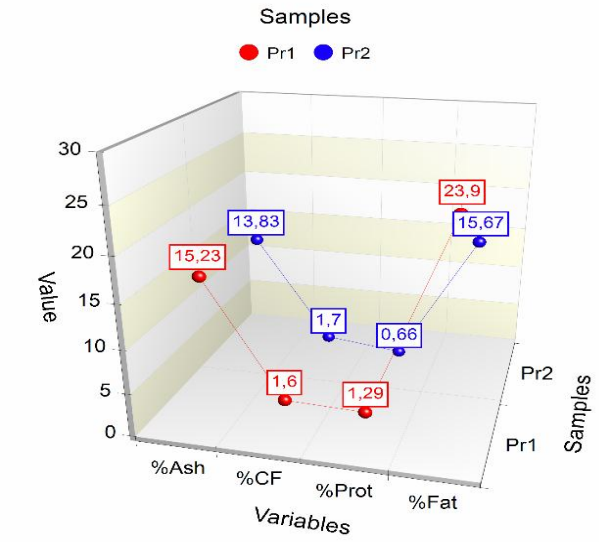

Figure 1: Graphic representation of ash, crude fiber, protein, and lipid content expressed as a percentage.

% CF: percentage of crude fibers; % Prot: percentage of proteins; Pr_1: propolis collected during the autumn season; Pr_2: propolis collected during the summer season.

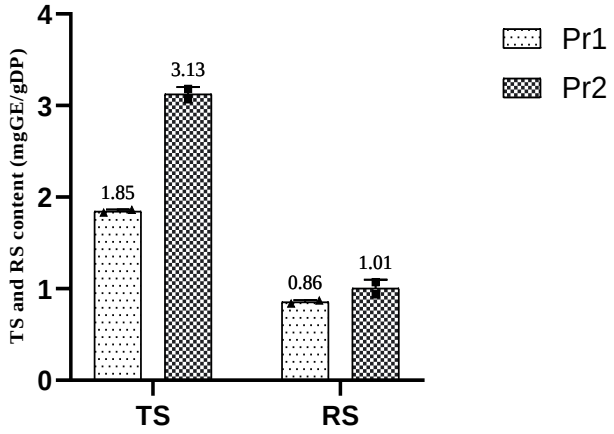

Figure 2: Variation of total and reducing sugar contents according to the propolis collection season

TS : total sugars ; RS : reducing sugars; mgGE/gDP: milligram of glucose equivalent per gram of dry propolis; Pr_1: propolis collected during the autumn season; Pr_2: propolis collected during the summer season

Table 1: Secondary metabolites characterization

Compounds name	Pr_1 [a]	Pr_2 [b]
Saponins	-[d]	-[d]
Triterpenes	+[c]	+[c]
Steroids	+[c]	+[c]
Flavonoids	+[c]	+[c]
Tannins	+[c]	+[c]

[a]: propolis collected during the autumn season; [b]: propolis collected during the summer season; [c]: present; [d]:absent

Conversely, the study by Moskowa *et al.*[45] also notes the presence of sugars in propolis composition, attributing these findings to bee-resin interactions and other accidental factors.

Phytochemical screening

Through phytochemical screening, we aimed to identify secondary metabolites in the two propolis types under study, providing insights into their presence or absence. The evaluation encompassed saponins, triterpenes, steroids, flavonoids, and tannins, delving into specific categories like flavones, flavanones, flavonols, flavanonols, leucoanthocyanins, and catechols, as well as a focused analysis of tannins, specifically catechic tannins and gallic tannins. The results of these analyses are presented in Tables 1, 2, and 3.

The screening process revealed the absence of saponins, diverging from the findings of Afata *et al.*,[46] who reported the presence of saponins in Ethiopian propolis. In contrast, triterpenes were identified in the extracts of both propolis types, aligning with consistent findings in existing literature.[47] This subgroup of terpenes, numbering 133 identified compounds within propolis, serves as volatile compounds responsible for the aroma, odor, and some of the biological activities attributed to propolis. Additionally, the presence of steroids, flavonoids (specifically flavones, flavanones, flavonols, flavanonols, leucoanthocyanins, and catechols), and tannins (catechic tannins and gallic tannins) have been found in the two types of propolis. Thus, in previous studies on propolis from various regions, underscoring their significance as major components of this natural product.[48, 49, 50]

Bioactive compounds

Table 4 illustrates notable variations in the total phenolic compound (TPC), flavonoid, and tannin contents within the aqueous, ethanolic, and methanolic extracts of the two propolis types investigated in this study. The methanolic extract exhibited the highest levels of total phenolic compounds, flavonoids, and tannins, yielding (Pr_1 = 2130.07 versus Pr2 = 2124.7 mg GAE/g DP); (Pr_1 = 71 versus Pr_2 = 68.9 mg QE/g DP); and (Pr_1 = 35.10 versus Pr_2 = 47.47 mg CE/g DP), respectively. Similarly, the ethanolic extract displayed slightly elevated total phenolic compound values, with content of Pr_1 = 897.88 versus Pr_2 = 597.82 mg GAE/g DP, respectively. In contrast, the aqueous extract contained relatively lower total phenolic compound levels (Pr_1 = 69.34 and Pr_2 = 228.20 mg GAE/g DP) compared to the ethanolic and methanolic extracts. This aligns with the study of Silva *et al.*,[51] that found phenolic compounds and flavonoids to be notably lower in aqueous extracts than in methanol and ethanol extracts. However, the current study reports substantially higher total phenolic compound and flavonoid contents compared to the aforementioned research. Following Corbellini Rufatto *et al.*[52] findings, the ethanolic extract of Moroccan propolis exhibits higher TPC values than the range observed for Korean propolis, while the flavonoid levels align with the same study. Notably, the plant sources chosen by bees for propolis resin greatly influence the content of these bioactive compounds. The province of Kenitra (Morocco) boasts a rich diversity of resin-source plants containing total phenolic compounds, flavonoids, and tannins, contributing to their diverse biological activities, including antioxidant properties. This botanical variability contributes to the differences observed in bioactive compound contents not only between the two-propolis types (Pr_1 and Pr_2) but also in comparison to propolis from various countries, as documented in the literature.[53]

Evaluation of antioxidant activity and IC_{50} values

The antioxidant activity results of Moroccan propolis, categorized as Pr_1 and Pr_2, were assessed using the FRAP (Ferric Reducing Antioxidant Power) method. The results unveiled a substantial ability to convert ferric ions to ferrous ions, demonstrating a concentration-dependent capacity to counteract reactive oxygen species, confirmed by an ascending absorbance at 700 nm and corresponding inhibition percentages. As shown in Table 5, the inhibition percentage ranged from 1.65 to 35.32 for Pr_1 and from 5.24 to 50.74 for Pr_2, as propolis concentrations escalated from 0.05 to 1 mg/mL. Expressing the total antioxidant capacity as a percentage, the results revealed a potent antioxidant power in propolis, closely aligned with values seen in other natural antioxidant sources.[54,55] Although the IC_{50} value of ascorbic acid (IC_{50} = 0.09) exceeded that of the two-propolis types (Pr_1 = 1.31 and Pr_2 = 0.92), the results remained highly promising. These findings also harmonize with prior studies highlighting the presence of antioxidant compounds like flavonoids and phenolic acids within propolis, renowned for their capacity to neutralize reactive oxygen species.[56,57]

Table 2: Flavonoids characterization

Compounds name	Pr_1[a]	Pr_2[b]
Flavones	-[d]	-[d]
Flavanones	-[d]	-[d]
Flavonols	+[c]	+[c]
Flavanonols	+[c]	+[c]
Leucoanthocyanins	-[d]	-[d]
Catechols	+[c]	+[c]

[a]: propolis collected during the autumn season; [b]: propolis collected during the summer season; [c]: present; [d]: absent

Table 3: Tannin characterization

Compounds name	Pr_1[a]	Pr_2[b]
Catechic tannin	+[c]	+[c]
Gallic tannin	+[c]	+[c]

[a]: propolis collected during the autumn season
[b]: propolis collected during the summer season; [c]: present

Table 4: Variation in total phenolic compounds, flavonoids, and tannin content across three solvents with different polarities

Variables	Type of extract	Pr_1[a]	Pr_2[b]
TPC[c] (mgEGA/gDP)[f]	Methanolic	2130.07 ± 4.34	2124.7 ± 7.04
Flav[d] (mgQE/gDP)[g]		71 ± 5.26	68.9 ± 11.86
Tan[e] (mgCE/gDP)[h]		35.10 ± 1.5	47.47 ± 4.55
TPC[c] (mgGAE/gDP)[f]	Ethanolic	897.88 ± 1.15	597.82 ± 55.78
Flav[d] (mg QE/gDP)[g]		45.03 ± 0.92	49.84 ± 3.23
Tan[e] (mgCE/gDP)[h]		14.82 ± 3.52	38.86 ± 5.24
TPC[c] (mgGAE/gDP)[f]	Aqueous	69.34 ± 4.79	228.20 ± 2.4
Flav[d] (mg QE/gDP)[g]		35.25 ± 5.81	49.35 ± 1.76
Tan[e] (mgCE/gDP)[h]		10.81 ± 0.45	34.57 ± 0.277

[a]: propolis collected during the autumn season; [b]: propolis collected during the summer season; [c]: total phenolic compounds; [d]: flavonoids; [e]: tannin; [f]: milligram of gallic acid equivalent per gram of dry propolis; [g]: milligram of Quercetin equivalent per gram of dry propolis; [h]: milligram of Catechin equivalent per gram of dry propolis.

Table 5: Ferric Reducing Antioxidant Power at different concentrations and IC_{50} value

Concentration (mg/mL)	1	0.8	0.6	0.4	0.2	0.1	0.05	FRAP (IC_{50})
Pr_1[a] (I%)[c]	35.32	35.11	25.93	19.65	14.22	7.59	1.65	1.31
Pr_2[b] (I%)[c]	50.74	45.48	37.75	28.50	22.97	14.59	5.24	0.92

[a]: propolis collected during the autumn season; [b]: propolis collected during the summer season; [c]: inhibition percentage

Table 6: DPPH Radical Inhibition Percentage and IC_{50} Value for Antioxidant Activity across Different Concentrations

Concentration (mg/mL)	1	0.8	0.4	0.2	0.1	0.05	DPPH (IC_{50})
Pr_1[a] (I%)[c]	80.36	76.19	60.71	44.70	28.94	21.45	0.39
Pr_2[b] (I%)[c]	78.55	75.71	61.90	48.51	35.66	24.55	0.35

[a]: propolis collected during the autumn season; [b]: propolis collected during the summer season; [c]: inhibition percentage.

This suggests that Moroccan propolis could serve as a natural antioxidant source to mitigate oxidative stress. Furthermore, the assessment of antioxidant activity in Moroccan propolis, across varying concentrations and the 50% inhibition percentage of DPPH radicals, is displayed in Table 6. Alongside positive controls, such as ascorbic acid and trolox. Methanolic propolis extracts were evaluated for their ability to inhibit DPPH free radicals. In fact, the obtained results indicate that Moroccan propolis exhibits robust DPPH radical scavenging activity, closely paralleling that of reference antioxidants, registering notable inhibition percentages at a maximum concentration of 1 mg/mL: Pr_1: I% = 80.36; Pr_2: I% = 78.55, compared to trolox: I% = 88.3, and ascorbic acid: I% = 89.2. Furthermore, the 50% inhibition percentages of DPPH radicals for both propolis samples (Pr_1: IC_{50} = 0.39; Pr_2: IC_{50} = 0.35) are notably close to trolox (IC_{50} = 0.04) and ascorbic acid (IC_{50} = 0.05). This highlights the potent DPPH radical inhibition of Pr_1, consistent with its higher chemical and phytochemical composition values. Indeed, the correlation between total phenolic compounds, including flavonoids, and biological activities like antioxidant potency is evident.[58] Overall, the antioxidant activity evaluation of the propolis methanolic extract aligns relatively with those of the ethanolic and aqueous extracts, and remains consistent with other relevant studies.[59,60]

Conclusion

The study provides an illuminating insight into Moroccan propolis. Including a description of its chemical composition and phytochemical screening of saponins, steroids, triterpenes, gallic and catechic tannins, flavanones, flavonols, and flavanonols. Subsequently, a comprehensive phytochemical evaluation unfolded, revealing the total phenolic compounds, flavonoids, and tannins. Indeed, the findings underscore the significant influence of bees' propolis collection season on its chemical composition, particularly in ash, lipids, proteins, total sugars, and reducing sugars. Similarly, the phytochemical composition, including total phenolic compounds, flavonoids, and tannins, also displayed variations. Consequently, these factors influence the biological activities of propolis, including its antioxidant potential. Remarkably, whatever the collection period, the studied Moroccan propolis exhibits a substantial profile of nutritional and phytochemical components, expressed by its high antioxidant power. Eventually, these findings encourage its potential application in the cosmetics industry, meriting further investigation in subsequent research.

Conflict of Interest

The authors declare no conflict of interest.

Authors' Declaration

The authors hereby declare that the work presented in this article is original and that any liability for claims relating to the content of this article will be borne by them.

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