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Spectroscopic Characterization and UV-Protective Potential of *Arcangelisia flava* Extract

Tety Wahyuningsih Manurung[a*], Rokiy Alfanaar[a], Mokhamat Ariefin[a], Marvin Horale Pasaribu[a], Eva Susanty Simaremare[b]

[a]*Department of Chemistry, Faculty of Mathematic and Sciences, Universitas Palangka Raya, Palangka Raya and 73112, Indonesia*

[b]*Department of Pharmacy, Faculty of Mathematic and Sciences, Universitas Cenderawasih, Jayapura and 99358, Indonesia*

[*]*tety.manurung@mipa.upr.ac.id*

Abstract. The increasing demand for natural UV-protective agents has led to the exploration of plant-based bioactive compounds. Yellow root (*Arcangelisia flava*) extract is traditionally used in medicine and contains flavonoids, alkaloids, and terpenoids with potential photoprotective properties. This study aimed to characterize the chemical composition of A. flava extract and evaluate its UV-absorbing properties using UV-Vis and FTIR spectroscopy. The extract was obtained through maceration with ethanol, followed by spectroscopic analysis. The UV-Vis spectrum (200–400 nm) revealed multiple absorption peaks, particularly at 270 nm, 292 nm, 306 nm, 340 nm, 354 nm, 360 nm, and 396 nm, indicating the presence of UV-absorbing compounds. FTIR analysis confirmed the presence of hydroxyl (-OH), carbonyl (C=O), and aromatic (C=C) functional groups, which are characteristic of flavonoids and other bioactive compounds. These findings suggest that A. flava extract has potential as a natural UV-protective agent. Further studies on compound isolation, fractionation, and photostability assessments are required to optimize its purity and effectiveness in sunscreen formulations.

Keywords: Arcangelisia flava, UV-Vis spectroscopy, FTIR spectroscopy, flavonoids, UV protection

Introduction

Yellow root (*Arcangelisia flava*) is a plant widely found in Indonesia and has long been utilized in traditional medicine [1]. The local community uses yellow root to treat various skin diseases such as itching, wounds, and ulcers. In the Kalimantan region, this plant is commonly used to treat fever, diarrhea, hepatitis, helminthiasis, digestive disorders, and mouth ulcers, as well as to maintain overall health [2], [3]. Previous studies on the stems and roots of A. flava have demonstrated its potential activities as an antimalarial [4], antidepressant [5], antioxidant [6], antidiabetic [7], antibacterial [8], and anticancer agent [9]. Secondary metabolite analysis has revealed that yellow root contains compounds such as flavonoids, terpenoids, and protoberberine alkaloids, including berberine, jatrorrhizine, and palmatine [10].

Flavonoids are a diverse group of polyphenolic compounds widely distributed in plants, known for their strong antioxidant properties. These compounds play a crucial role in protecting biological systems from oxidative stress by scavenging free radicals and reactive oxygen species (ROS) generated by environmental factors, including ultraviolet (UV) radiation exposure [11]. Excessive exposure to UV radiation, particularly UVA (320–400 nm) and UVB (280–320 nm), can induce skin damage by triggering oxidative stress, inflammation, and degradation of structural proteins such as collagen and elastin. Over time, this damage can lead to premature skin aging, hyperpigmentation, and an increased risk of skin cancer, making UV protection an essential aspect of dermatological research. Consequently, natural compounds with potent antioxidant activity, such as flavonoids, have garnered significant attention for their potential role in mitigating UV-induced skin damage and serving as protective agents in skincare formulations [12]. Given the growing interest in plant-based bioactive compounds, the evaluation of flavonoid-rich plant extracts, such as those derived from yellow root (Arcangelisia flava), is essential to explore their effectiveness in UV protection [13].

Spectrophotometric methods have been widely employed to analyze the chemical constituents of medicinal plant extracts, offering a reliable approach for assessing their bioactive properties (Mabry

et al., 1970). UV-Visible (UV-Vis) spectrophotometry, in particular, is a commonly used technique to determine the presence of flavonoids and other phenolic compounds by measuring their characteristic absorption spectra at specific wavelengths [14]. Previous studies by Marpaung et al. and Wahyuni et al. demonstrated the application of UV-Vis spectrophotometry in identifying key bioactive compounds in yellow root extracts, highlighting its potential for qualitative and quantitative analysis [15], [16] The absorption patterns observed in UV-Vis spectroscopy provide insight into the conjugated systems present in flavonoids, which contribute to their ability to absorb UV radiation. This analytical approach, therefore, serves as an initial screening tool for assessing the photoprotective properties of plant extracts, providing valuable data for further investigation into their efficacy as UV-protective agents.

Additionally, infrared (IR) spectrophotometry is widely used due to its rapid chemical analysis capability with large sample throughput. It is commonly employed for qualitative determinations, especially in identifying chemical compounds [17]. FTIR spectroscopy enables the identification of functional groups based on their unique vibrational frequencies, offering critical insights into the molecular composition of bioactive substances. The presence of characteristic functional groups, such as hydroxyl (-OH), carbonyl (-C=O), and aromatic rings, can be detected through specific absorption bands in the IR spectrum, providing a deeper understanding of the chemical interactions responsible for antioxidant and UV-protective activities [18]. Given its efficiency in qualitative analysis, FTIR spectroscopy complements UV-Vis spectrophotometry by confirming the structural identity of flavonoids and other phenolic compounds in yellow root extracts. Therefore, integrating UV-Vis and FTIR spectrophotometric analyses is a comprehensive approach to evaluating the chemical composition and potential photoprotective properties of plant-derived extracts.

Considering the increasing demand for natural and effective UV-protective agents, the exploration of plant-based antioxidants remains a promising research avenue. Yellow root (*Arcangelisia flava*), a medicinal plant traditionally used for its therapeutic properties, is rich in flavonoids and other bioactive constituents that may contribute to its photoprotective potential. However, scientific validation of its efficacy as an anti-UV agent requires a thorough investigation using advanced spectrophotometric techniques. By employing UV-Vis and FTIR spectroscopy, this study aims to characterize the chemical composition of yellow root extract and evaluate its potential as a natural UV-protective agent. These findings will provide valuable insights into the development of plant-based sunscreens and other dermatological applications, emphasizing the importance of natural compounds in skincare and photoprotection research.

Experimental

Materials and Tools

Yellow Root (*Arcangelisia flava*), etanol (Merck), filter paper Whatman No.40, test sieve 40 mesh, centrifugator, rotary evaporator, oven (Memmert), UV-Vis spectrophotometer (Thermo Scientific), Spektrofotomter FT-IR (Bruker).

Preparation Yellow Root (*Arcangelisia flava*)

The yellow root (*Arcangelisia flava*) samples were washed with clean water to remove impurities and then dried in an oven at 65°C for 24 hours. Once dried, the samples were ground into a fine powder and sieved using a 40-mesh sieve for uniformity

Extraction of Yellow Root (*Arcangelisia flava*)

A total of 500 grams of the powdered sample was macerated in ethanol for three consecutive days (3 × 24 hours) to extract bioactive compounds. The macerated extract was then filtered using filter paper, followed by centrifugation to further separate solid residues. Finally, the solvent was evaporated using a rotary evaporator under reduced pressure, yielding a concentrated crude extract for further analysis.

Characterization of Functional Groups and Absorbance of Yellow Root (*Arcangelisia flava*) Ethanol Extract

The crude extract of yellow root (*Arcangelisia flava*) was characterized using FTIR spectroscopy within the wavenumber range of 500–4000 cm^{-1} to identify functional groups present in the extract. Additionally, the chromophore groups were analyzed using UV-Vis spectrophotometry at wavelengths between 200–400 nm to determine the presence of compounds with potential UV-protective properties.

Results and Discussion

1. Preparation and extraction of Yellow Root

The preparation of yellow root (*Arcangelisia flava*) involved a meticulous process to ensure the removal of impurities and the preservation of bioactive compounds. Washing the samples with clean water was a critical first step to eliminate dirt and other contaminants, which could interfere with the extraction process. Drying the samples at 65°C for 24 hours was essential to reduce moisture content, thereby preventing microbial growth and ensuring the stability of the bioactive compounds during storage. Grinding the dried samples into a fine powder and sieving them through a 40-mesh sieve ensured uniformity, which is crucial for achieving consistent extraction results. This standardized preparation process is in line with established protocols for plant material preparation, as highlighted in previous studies [19]. The fine powder form also increased the surface area, facilitating more efficient extraction of bioactive compounds during the subsequent maceration process.

The extraction of bioactive compounds from yellow root was carried out using ethanol as the solvent, a method widely recognized for its effectiveness in extracting a broad range of phytochemicals, including alkaloids and flavonoids. Maceration for three consecutive days allowed for thorough penetration of the solvent into the plant matrix, ensuring maximum extraction of target compounds. Filtration and centrifugation were employed to separate the liquid extract from solid residues, a step critical for obtaining a clear and concentrated extract. The use of a rotary evaporator under reduced pressure for solvent evaporation not only concentrated the extract but also minimized the risk of thermal degradation of heat-sensitive compounds. This method aligns with best practices in phytochemical extraction, as noted in studies emphasizing the importance of gentle solvent removal to preserve the integrity of bioactive compounds [20]. The resulting crude extract, rich in potential bioactive compounds, was thus prepared for further analytical characterization, setting the stage for subsequent investigations into its UV-protective properties.

2. FT-IR Characterization of Yellow Root Extract

The FTIR spectrum of the Yellow Root ethanol extract showed distinct absorption bands corresponding to various functional groups as shown in figure 1. presents the peak assignments and the functional groups identified from the A. flava ethanol extract. A broad absorption peak was observed around 3400 cm^{-1}.

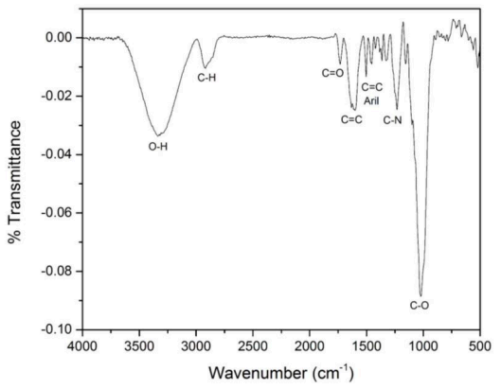

Figure 1. FTIR spectrum of Yellow Root extract

The FT-IR spectroscopy analysis of the yellow root extract revealed absorption peaks indicative of bioactive compounds such as alkaloids and flavonoids. Based table 1, a prominent absorption peak at 3400 cm^{-1} corresponds to the O–H stretching vibration, characteristic of phenolic compounds and flavonoids, which are known for their antioxidant and UV-protective properties [21]. The absorption peak at 2920 cm^{-1} indicates the presence of C–H stretching, commonly found in alkaloids and other organic compounds [22]. Additionally, the peak at 1650 cm^{-1} is attributed to C=O stretching, a functional group often present in flavonoids and alkaloids, which contributes to their UV-absorbing capabilities [23]. Further peaks at 1350 cm^{-1} and 1100 cm^{-1} suggest the presence of C–N and C–O bonds, respectively, which are also integral to the structure of these bioactive compounds [24].

Tabel 1. Comparative analysis of FTIR absorption bands of Yellow Root

FTIR Absorption Bonds	Yellow Root (cm^{-1})	References (cm^{-1})	
O–H stretching	3400	3200-3700	[25]
C–H stretching	2920	2500-3300	[26]
C=O stretching	1650	1703	[27]
C=C stretching	1600–1500	1700–1500	[28]
C–N stretching	1350	1240–1461	[29]
C–O stretching	1100	1300-1000	[30]

These findings align with previous studies demonstrating that flavonoids and alkaloids possess significant UV-absorbing properties, making them effective agents for skin protection [31]. The presence of these functional groups supports the hypothesis that yellow root extract has potential as a natural UV-protective agent. Moreover, the observed absorption patterns are consistent with reference spectra reported in the literature, further validating the results [32].

Further research indicates that flavonoids, such as quercetin and kaempferol, can stabilize free radicals generated by UV radiation, thereby protecting skin cells from oxidative damage. This is reinforced by the detection of O–H and C=O groups in the FT-IR analysis, which are critical components of flavonoid structures responsible for their UV-protective activity [33]. Thus, the FT-IR characterization not only identifies the presence of bioactive compounds but also provides a scientific basis for their potential application in cosmetic and sunscreen formulations.

3. UV-Vis Spectral Peak Characterization

The UV-Vis absorption spectrum of the yellow root extract, measured within the 200–400 nm range, exhibits multiple distinct peaks, indicating the presence of bioactive compounds with potential UV-absorbing properties.

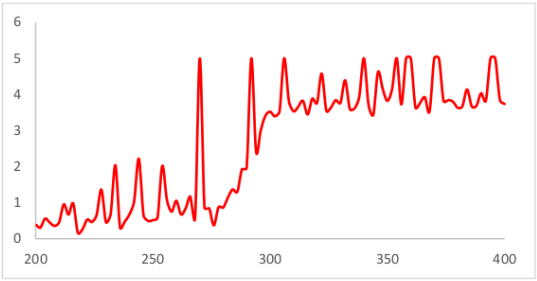

Figure 2. UV spectrum of Yellow Root extract

Based on figure and table 2. The UV-Vis spectral analysis of the yellow root extract revealed absorption peaks in both the UV-A (320-400 nm) and UV-B (290-320 nm) ranges. Peaks at 270 nm and 292 nm indicate the presence of compounds capable of absorbing UV-B radiation, which is primarily responsible for skin damage such as sunburn. Absorption peaks at 306 nm and 340 nm suggest the extract's ability to absorb UV-A radiation, which contributes to skin aging and DNA damage [34]. Additionally, peaks at 354 nm and 360 nm further confirm the presence of compounds effective in absorbing UV-A radiation, consistent with previous findings on the UV-protective properties of flavonoids [35].

Tabel 2. Maximum absorption of Yellow Root extract in the UV-B and UV-A regions

No.	Yellow Root (nm)	References Another Study (nm)	
1.	270	267,4	[36]
2.	292	290	[37]
3.	306	310	[38]
4.	340	345,2	[36]
5.	354	359	[39]
6.	360	367	[39]
7.	372	370	[39]
8.	396	390	[40]

These results are supported by studies showing that flavonoids and alkaloids can effectively absorb UV radiation, making them suitable as active ingredients in sunscreen formulations. The observed absorption patterns in the UV-Vis spectrum are consistent with reference data, indicating that yellow root extract has significant potential as a UV-protective agent. Furthermore, the presence of absorption peaks in both UV-A and UV-B ranges suggests that the extract can provide comprehensive protection against UV radiation.

Previous studies have also demonstrated that flavonoids such as luteolin and apigenin can simultaneously absorb UV-A and UV-B radiation, making them ideal for use in sunscreen formulations. The UV-Vis analysis suggests that yellow root extract contains these compounds, offering dual

protection against UV radiation. Therefore, the extract not only prevents sunburn but also protects the skin from premature aging caused by UV-A radiation [41].

Conclusion

The spectroscopic characterization of Arcangelisia flava extract confirms the presence of flavonoids, terpenoids, and alkaloids with significant UV-absorbing properties. UV-Vis analysis demonstrates absorption in both UV-A and UV-B ranges, suggesting the extract's potential as a natural UV-protective agent. FTIR findings further support the presence of bioactive functional groups associated with antioxidant and photoprotective activity. The integration of these results highlights the extract's potential application in cosmetic and dermatological formulations. Future studies should focus on compound isolation, quantitative analysis, and photostability assessments to enhance its efficacy for sunscreen development. Additionally, further research on the purified extract or its fractionation is necessary to optimize sample purity and maximize its function as an anti-UV agent.

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