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Cyperus rotundus tubers resin from Algeria: a promising source of natural antioxidants, anti-inflammatory, and photoprotective compounds

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Abstract. This study evaluated the properties and potential applications of *Cyperus rotundus* tubers resin, a herbaceous plant native to North Africa, Asia, and Australia. The resin was evaluated for yield, phenolic composition, antioxidant activity, anti-inflammatory potential, and sun protection factor (SPF). Results showed that the resin contained five types of phenolic compounds, namely vanillic acid, gallic acid, caffeic acid, quercetin, and rutin. The resin exhibited significant antioxidant activity in all assays tested, with IC_{50} values ranging from 0.0638 to 0.454 mg/mL. The SPF value of the resin was determined to be 5.794, suggesting its potential as a sunscreen. The resin also showed significant anti-inflammatory activity in both human serum albumin (HSA) and egg albumin denaturation assays. Overall, the findings of this study suggest that *Cyperus rotundus* tubers resin is a promising source of natural antioxidants and anti-inflammatory compounds. It has the potential to be used in a variety of applications, including food and beverage products, cosmetics, and pharmaceuticals. This study is an important step in understanding the properties and applications of *Cyperus rotundus* tubers resin. The results indicate that this natural product has great potential in a variety of health applications.

***Keywords*:** *Cyperus rotundus*; tubers resin; antioxidant; anti-inflammatory; sun protection factor.

1. Introduction

Cyperus rotundus, a member of the Cyperaceae family, is a perennial weed characterized by slender and scaly creeping rhizomes. Its bulbous tubers, ranging from 1 to 3 cm in length, emerge singularly from the base. These tubers exhibit a blackish external coloration and a reddish white interior, accompanied by a distinctive aroma. The plant stems grow up to approximately 25 cm tall, while the leaves are linear, dark green, and possess grooves on their upper surfaces. Inflorescences are small and consist of 2-4 bracts, housing minute flowers enveloped by a red-brown husk. The nuts, oblong-ovate and three-angled in shape, appear yellow when unripe and black upon reaching maturity. Although indigenous to India, *Cyperus rotundus* can now be found in tropical, subtropical, and temperate regions as well [1].

Due to its diverse therapeutic properties, *Cyperus rotundus* has been employed in traditional medicine for centuries [2]. Among its various components, the tubers of *Cyperus rotundus* have attracted significant attention for their medicinal potential as an antiandrogenic, antibacterial, anticancerous, anticonvulsant, anti-diabetic, antidiarrheal, antigenotoxic, anti-inflammatory, antilipidemic, antimalarial, anti-mutagenic, anti-obesity, antioxidant, anti-uropathogenic, hepatoprotective, cardioprotective, neuroprotective, and nootropic agent [3].

In the past, various techniques have been utilized to extract compounds from *Cyperus rotundus* tubers. These methods encompassed the use of organic solvents like methanol, ethanol, and chloroform, as well as aqueous solvents. These extraction methods varied in their effectiveness, cost implications, and their influence on the chemical composition of the extracted compounds. These extracts also showed many activities, including antioxidant, anti-inflammatory and anti-bacterial properties[3].

Plant resins are complex and diverse natural products with a wide range of potential applications [4]. However, there is a lack of interest in the extraction and study of plant resins, with most research funding being directed towards studying the more well-known and established natural products, such as plant extracts and essential oils; this limits our understanding of these valuable resources and their ability to benefit society. Notably, the resin extracted from these tubers demonstrates promising bioactive characteristics, including antioxidant, anti-inflammatory, and photoprotective effects. Among the methods used, the extraction of resin from *Cyperus rotundus* tubers has been insufficiently explored in previous discussions. Investigating this resin in more depth compared to organic and aqueous extracts offers several potential benefits. Delving further into this could improve our understanding of the phenolic compounds found in resins as a whole and reveal innovative applications for

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these resinous extracts. The resin derived from *Cyperus rotundus* tubers might display unique traits that distinguish it from other extracts, potentially exhibiting higher concentrations of specific compounds, increased chemical stability, and potentially being more amenable to processing techniques[4]. In this study, we will delve into the comprehensive evaluation of the medicinal properties associated with *Cyperus rotundus* tubers resin, conducting a multifaceted exploration of its potential as a medicinal agent.

2. Experimental

2.1. Plant material

The underground tubers of the plant *Cyperus rotundus*, commonly known as nutsedge, were collected in September 2022 from the El Oued province of southeastern Algeria. The plant material was authenticated by Professor Chouikh Atef of the Department of Biology at the University of El Chahid Hamma Lakhdar El Oued, Algeria.

The tubers were washed with running cold water to remove any debris. They were then dried in the dark for 7 days, milled into a coarse powder, and stored for future use.

2.2. Resin extraction procedure

The extraction of resin from *Cyperus rotundus* tubers was performed according to the following procedure, as described in patent WO2017103769A1 [5]:

- *Preparation of the basic aqueous solution pH=10*. 100 grams of dried *Cyperus rotundus* tuber powder were immersed in a 0.4 L of basic aqueous solution at room temperature for 24 hours. The basic aqueous solution consisted of 0.2% by weight of NaOH and an antioxidant system. In this study, the antioxidant system consisted of hydroquinone derivatives, phenol derivatives substituted with sterically bulky groups, *p*-phenylenediamines with sterically hindered amino groups, or a combination thereof. We added 0.05 mg of gallic acid.
- *Filtration and secondary maceration*. The resulting infusion was filtered by using filter paper with pressure until total filtration of the solvent, and the remaining plant residue was subjected to secondary maceration in a 0.4 L of a polar organic solvent. We used 97% ethanol. The polar solvent system also pH = 10 and included an antioxidant system.
- *Drying and yield calculation*. The mixture was filtered by using filter paper, and the resulting material was dried in a oven at 35 °C, resulting in the resin obtained from the tubers of the *Cyperus rotundus* plant. The extraction yield was calculated using the following:

$$\%Yield = (m_E/m_S) \times 100$$

where m_E represents the mass of the sample after solvent evaporation in grams (g), and m_S represents the dry mass of the initial sample in grams (g).

The basic aqueous solution helps to solubilize the resin from the *Cyperus rotundus* tubers. The antioxidant system helps to prevent the resin from degrading during the extraction process. The polar organic solvent helps to extract any remaining resin from the plant residue.

2.3. Qualitative phytochemical screening

A comprehensive phytochemical analysis was performed on resin sample to identify specific phytochemical groups, following the methods described in previous studies [6-8]. The study employed various chemical reagents to detect and identify different classes of compounds in the samples. For alkaloids, they used Dragendorff's reagent, Bouchardat's reagent (composed of iodine and magnesium iodide), and Meyer's reagent (containing potassium iodide and magnesium chloride). To identify coumarins, a diluted sodium hydroxide solution in combination with ultraviolet (UV) light was applied. Flavonoids were detected using metallic magnesium and hydrochloric acid. The presence of anthraquinones was determined using Borntrager's reagent. Cardiac glycosides were tested with Kedde's reagent and Baljet's reagent. Iridoids were identified through diluted hydrochloric acid, while saponins were detected through a foam test. Steroids were analyzed using the Liebermann reaction, which involves acetic anhydride and concentrated sulfuric acid. Tannins were identified with a mixture of ferric chloride and concentrated hydrochloric acid, known as the Bath-Smith reaction, and gallic tannins were tested using the Stiasny reagent.

2.4. Analysis with HPLC

To determine the content of phenolic acids and flavonoids in plant resins, a high-performance liquid chromatography (HPLC) system, specifically the Shimadzu LC 20 AL model, was employed. This system utilized an universal injector (Hamilton, 25 µL) and an analytical column (Shim-pack VP-ODS C18, 4.6 mm×250 mm, 5 µm). A UV-VIS detector SPD 20A (Shimadzu) was used. The analysis involved the use of a mobile phase, which combined a polar solvent (distilled water) with an organic solvent (methanol or acetonitrile), and it was delivered at a flow rate of 1 mL/min.

The sample solution was prepared by dissolving 5 mg of the plant resin in 1 mL of the mobile phase. Subsequently, 20 µL of the sample solution was introduced into the HPLC system. Separation of the compounds was achieved within a timeframe of 40-50 minutes, and detection was performed at a wavelength of 268 nm. Quantification of the specific chromatographic peaks was accomplished through standard calibration, using standards of phenolic acids (chlorogenic acid, gallic acid, caffeic acid, vanillic acid, and *p*-coumaric acid) and flavonoids (rutin and vanillin).

2.5. Fourier-transform infrared (FTIR) characterization

The resin sample was subjected to FTIR spectroscopy, which was conducted using a Shimadzu-00463 spectrophotometer. The FTIR ana[l]ysis employed a resolution of 4 cm^{-1} and involved 64 scans that were co-added. The spectral range examined spanned from 4000 to 400 cm^{-1}.

2.6. Antioxidant activity

2.6.1. Free radical DPPH• scavenging activity. Free radical scavenging activity of resin was assessed using the method described by Brand-Williams et al. [9]. 1 mL of analyzed sample resins at different concentrations was mixed with 1 mL of a methanolic solution of 1,1-diphenyl-2-picryl-hydrazyl (DPPH•) at a concentration of 0.1 mM. The resulting mixtures were then incubated in the absence of light for 15 minutes at room temperature. Subsequently, the absorbance of these solutions was measured at 517 nm using a UV-Vis spectrophotometer (type Shimadzu). Ascorbic acid standards (0.005-0.5 mg/mL) were also prepared for the purpose of the positive comparison. The percentage of inhibition was calculated using the following:

$$\%I = A_c/A_s \times 100$$

where A_c represents the absorbance of the control, while A_s represents the absorbance of a sample resin.

IC_{50} values, which denote the concentration of antioxidants required to decrease the DPPH• content by 50%, were determined by fitting a linear equation to the scavenging activity data (% I) obtained at different sample concentrations in the analyzed resin [10].

2.6.2. The Total Antioxidant Capacity (TAC) assay. Determination of total antioxidant activity was conducted using the phosphomolybdenum method, as outlined by Zengin et al. [11]. Each sample resin (0.2 mL) was combined with 2 mL of a reagent solution consisting of phosphoric acid (6 mol/L), NaH_2PO_4 (28 mmol/L), and ammonium molybdate (4 mmol/L). The resulting mixture was then incubated in a water bath at a temperature of 95 °C for 90 minutes. Following the incubation period, the sample was removed from the water bath and allowed to cool down to a room temperature. The absorbance of such solution was subsequently measured at 695 nm. To quantify total antioxidant activity, ascorbic acid was employed as a reference standard; the result was expressed in mg of ascorbic acid equivalent per gram of the sample resin.

2.6.3. Reducing power test (FRAP). Evaluation of iron's restorative capacity in the analyzed sample resin was determined according to the method described by Huda-Faujan et al. [12]. Accordingly, 250 µL of the analyzed sample resins of varying concentrations were mixed with 625 µL of a 0.2 mol/L phosphate buffer solution (pH 6.6) and 625 µL of a 1% solution of $K_3[Fe(CN)_6]$. The resulting mixtures were thoroughly shaken and then incubated in a water bath at 50 °C for 20 minutes. Following this, 625 µL of a 10% trichloroacetic acid solution was added to these solutions. Subsequently, they were centrifuged at a speed of 3000 rounds/min for 10 minutes to separate the precipitates formed. Afterwards, 625 µL of the resulting supernatants were combined with 625 µL of distilled water and 125 µL of a 0.1% $FeCl_3$ solution. The absorbance of the latter solutions was measured at 700 nm. For comparison purposes, ascorbic acid was utilized as a positive control. An increase in the measured absorbance indicated an increase in the reductive power of iron. This evaluation was done according to the method described by Karagözler et al. [13].

2.6.4. ABTS·⁺ assay. The ABTS·⁺ scavenging assay was conducted following the methodology outlined by Re et al. [14] with slight modifications. Firstly, a phosphate buffer saline (PBS) solution was prepared by dissolving 8.18 g NaCl, 0.27 g Na_2HPO_4, and 0.15 g KCl in 1 L of distilled water, resulting in a concentration of 75 mmol/L and a pH of 7.4. The ABTS·⁺ solution was prepared by combining 50 mL of ABTS·⁺ (2 mmol/L in PBS) with 200 µL of $K_2S_2O_8$ (70 mmol/L), and the mixture was incubated in the absence of light at room temperature for 1 hour prior to analysis. The working solution was prepared by diluting the ABTS·⁺ solution with PBS until an absorbance of 0.700 at 734 nm was achieved. Subsequently, 50 µL of resin was mixed with 3000 µL of the ABTS·⁺ working solution, and the absorbance was measured at 734 nm [15]. The inhibition percentage (I%) of the resin is determined using the following:

$$I\% = [(A_0 - A)/A_0] \times 100$$

where A_0 = the absorbance in the absence of the inhibitor (control), A = the absorbance in the presence of the inhibitor (sample).

2.6.5. Hemolysis test. The aim of this experiment is to evaluate the protective effects of our resin on erythrocytes (red blood cells) against explosion-induced damage following exposure to oxidative stress. This is achieved by assessing the proportion of degenerated erythrocytes [16]. Hemolysis, which refers to the release of hemoglobin into the serum, was measured to quantify the extent of cell rupture [17].

To conduct the experiment, a blood sample was obtained from a healthy human donor (the approval was obtained from the Bioethics Committee of the University of El Oued) with blood type O^+ using a modified version of the method described by Malagoli [18]. The experimental procedure was based on the methodology outlined by Abirami et al. [19], with certain modifications.

In summary, 40 µL of erythrocytes from the blood sample were mixed with 2 mL of resin at different concentrations. This mixture was then incubated at a temperature of 37 °C for 5 minutes. Additionally, 40 µL of H_2O_2 (30 mmol) and $FeCl_3$ (80 mmol) were added to the mixture. After incubating for 1 hour at 37 °C, the mixture was centrifuged at 700 rpm for 10 minutes. The absorbance of the supernatant was measured at a wavelength of 540 nm using a UV-Vis spectrophotometer [19]. Ascorbic acid served as a reference standard (positive control). The percentage of hemolysis was calculated using the following:

$$\%Hemolysis = (A_c/A_S) \times 100$$

Here, A_c represents the absorbance in the absence of the resin, while A_s represents the absorbance in the presence of the resin or the standard.

2.7. Anti-inflammatory activity

2.7.1. Denaturation of human serum albumin (HSA). This experiment was conducted following the procedure outlined in [20, 21], with certain modifications. A 1 mL volume of the resin at varying concentrations was mixed

with 1 mL of human albumin (5%) (Biotest pharma GmBH). After a 15 minute incubation period at 27 °C, the tubes were placed in a water bath at a temperature of 70 °C for 10 minutes. Following cooling to room temperature, the absorbance of the samples was measured at 660 nm. Diclofenac sodium was utilized as the reference standard [22]. The results are expressed as mg diclofenac sodium equivalent per mg of resin.

2.7.2. Denaturation of egg albumin. The *in vitro* assessment of anti-inflammatory potential was conducted using the egg albumin denaturation assay with some adjustments following the method outlined by Alam et al. [23]. The purpose of this assay was to investigate whether resin of our plants could inhibit protein denaturation, a process associated with inflammation.

To carry out the assay, egg albumin was gently drawn out from fresh hen's eggs, specifically from those laid on the same day. A 5 mL reaction mixture was prepared by combining 0.2 mL of the fresh albumin, 2.8 mL of phosphate-buffered saline, and 2 mL of resin with varying concentrations. The mixture was then incubated at 37 °C for 15 minutes, followed by heating at 70 °C for 5 minutes. After cooling the mixture under running water and vortexing, absorbance was measured at 660 nm. Diclofenac sodium was used as the reference medicine. The percentage inhibition of denaturation, which serves as an indicator of anti-inflammatory activity, was calculated using the provided by de Vera et al. [24]:

$$Percent\ Inhibition\ of\ Protein\ Denaturation = \left[1 - \frac{(Abs\ Sample - Abs\ Blank)}{(Abs\ Untreated\ Control - Abs\ Blank)}\right] \times 100$$

2.8. The sun protection factor by UV-Vis spectrophotometry

The assessment of protection effectiveness against UV rays was conducted in vitro to determine the SPF value using UV-Vis spectrophotometry. To summarize the method described in [25], the SPF value is calculated by measuring the difference in spectroscopy readings of an alcohol solution (0.5 mg/mL) over the spectral range from 290 nm to 320 nm, with a spectral transition interval of 5 nm.

The SPF value is determined using the following:

$$SPF = CF \times \sum EE(\lambda) \times I(\lambda) \times Abs(\lambda)$$

where: *EE* represents the erythemal effect spectrum, I represents the solar intensity spectrum, *Abs* represents the absorbance of the sunscreen product, and *CF* represents the correction factor (equal to 10).

The constants for EE x I values (Table 1) were previously established by Mbanga et al. [26].

Table 1. Normalized product function used in the calculation of SPF.

Wavelength (nm)	EE x I (normalized)
290	0.0150
295	0.0817
300	0.2874
305	0.3278
310	0.1864
315	0.0837
320	0.0180
Total	**1**

The results were compared to categories of sunscreens in Table 2 according to Schalka and Reis [27].

Table 2. Categories of sunscreens based on the value of the SPF.

Protection level	SPF Value
Maximum	> 50
High	30-15
Medium	15-30
Low	2-15

3. Results and discussion

3.1. Yield and properties of resin

The resin had a dark brown color (Figure 1) and had the nature of a viscous and sticky elastic paste which, when exposed to air, hardens. The resin yield was determined to be 10.57% relative to the dry weight of the material. This yield is comparable to the ethanol extract yield for all plant parts of about 10.5% reported by Kabbashi et al. [28].

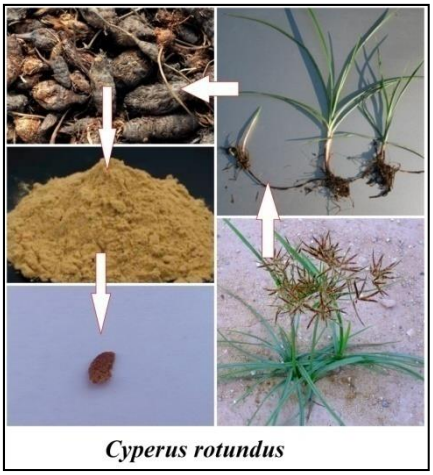

Figure 1. The plant and plants resin.

3.2. Qualitative phytochemical screening

The phytochemical screening of *Cyperus rotundus* tuber resin revealed that it contains a wide variety of secondary metabolites (Table 3). The phytochemical screening of both the aqueous and alcoholic extracts of *Cyperus rotundus* tuber revealed that they contain the same secondary metabolites as the respective resins [29]. This suggests that the type and composition of secondary metabolites in the extracts and resins are similar. This is consistent with the findings of previous studies [29]. The strong correlation in the phytochemical profiles between the different forms of the plant material suggests that the analytical results are reliable and reproducible across various extraction methods. This is important because it means that the phytochemical profile of *Cyperus rotundus* tuber resin can be accurately determined using a variety of extraction methods. The phytochemical screening of *Cyperus*

rotundus tuber resin is an important step in identifying its potential medicinal and pharmacological properties. The fact that the aqueous and alcoholic extracts contain the same secondary metabolites as the resin suggests that these extracts may also have similar medicinal and pharmacological properties.

Table 3. Extraction yields and phytochemical screening of secondary metabolites from *Cyperus rotundus* tuber resin.

Resin	Phytochemical screening							
	Alkaloids	**Coumarins**	**Flavonoids**	**Anthraquinones**	**Cardiac glycosides**	**Saponids**	**Steroids**	**Gallic tanins**
C. rotundus	+	-	+	-	+	+	+	+

+ = presence; − = absence

3.3. Analysis with HPLC

The HPLC chromatogram of the resin obtained from *Cyperus rotundus* tubers is depicted in Figure 2. Upon comparing the retention time with standards, it was observed that there were variations in the number and concentration of compounds present in the extract.

The resin extract showed 5 types of phenolic compounds as shown in Table 4. We managed identification five compounds in resin extract (vanillic acid, gallic acid, caffeic acid, quercetin, and rutin).

The resin extract exhibits a lower abundance of compounds compared to certain other extracts. This difference in compound content may be attributed to the high polarity of these solvents, which have a tendency to attract a diverse range of phenolic compounds, unlike the conventional resin extraction method. That alternative extracts, such as aqueous, ethanol, and methanol extracts of *Cyperus rotundus* tubers and *Cyperus rotundus* plants, contain various phenolic compounds in varying proportions. These compounds include vanillic acid, gallic acid, caffeic acid, quercetin, rutin, chlorogenic acid, *p*-coumaric acid, ferulic acid, catechin, kaempferol, and myricetin [30-32].

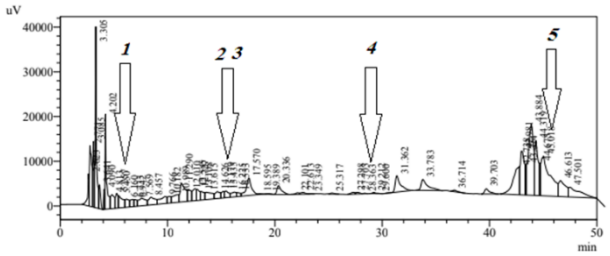

Figure 2. HPLC chromatogram of *Cyperus rotundus* tubers resin.

Table 4. Concentrations and retention times of phenolic compounds identified in *Cyperus rotundus* tubers resin.

Peak	Class	Phenolic compounds	Retention time R_T (min)	Area	Concentration (mg/g extract)
1	Hydroxy-benzoic acid	Gallic acid	5.257	53535	0.19580
2	Hydroxy-benzoic acid	Vanilic acid	15.435	39546	0.12153
3	Hydroxy-benzoic acid	Caffeic acid	16.225	34219	0.08140
4	Flavonols	Rutin	28.363	2137	0.01518
5	Flavonols	Quercetin	45.018	517196	2.27950

3.4. FTIR spectroscopy

FTIR spectroscopy was used to identify the functional groups present in the resin extracted from *Cyperus rotundus* tubers. The FTIR spectrum showed peaks at 3281, 2933, 1620, 1064, and 1297 cm^{-1}, which correspond to the presence of alkyl (C-H), carboxylate (C=O), hydroxyl (O-H), and carbonyl (C=O) groups (Figure 3).

The FTIR analysis of the resin extracted from *Cyperus rotundus* tubers revealed the presence of a variety of functional groups, including carbonyl, alkyl, carboxylate, hydroxyl, and carbonyl groups. These functional groups suggest that the resin may have a variety of potential biological activities, such as antioxidant, anti-inflammatory, and antimicrobial activity [33].

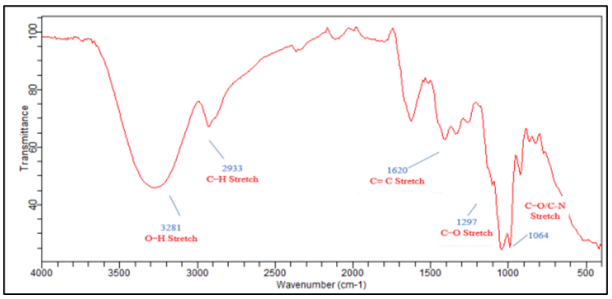

Figure 3. The FTIR spectrum of *Cyperus rotundus* tubers resin.

3.5. Antioxidant activity

Antioxidant efficacy was estimated by several methods and the results are shown in Table 5.

Table 5. Antioxidant activity test values.

Test type	The value	Ascorbic acid
DPPH	IC_{50} (mg/mL)= 0.121 ± 0.001	0.01±0.005
TAC	Moy (mg EAas/mg Ex) = 0.0911 ±0.009	/
FRAP	IC_{50}(mg/mL)= 0.0638 ±0.05l	0.016±0.002
ABTS	IC_{50} (mg/mL)= 0.045 ±0.001	0.01±0.001
Hemolysis	IC_{50} (mg/mL)= 0.158 ±0.021	0.01±0.007

In the DPPH test, the IC_{50} value of *Cyperus rotundus* tubers resin was determined to be 0.121 ± 0.001 mg/mL. This indicates a lower effectiveness compared to ascorbic acid, with its IC_{50} value estimated at 0.014 mg/mL. Among the different extracts of *Cyperus rotundus* roots (containing tubers) evaluated in the study (70% ethanol extract, methanol extract, water extract), the resin extract showed higher effectiveness only than the aqueous extract, with an IC_{50} value of 0.3 mg/mL [34]. However, it exhibited less effectiveness than the 70% ethanol extract and methanol extract, with their

IC_{50} values estimated at 0.064 mg/mL and 0.084 mg/mL, respectively [34].

The mean total antioxidant capacity (TAC) value of *Cyperus rotundus* tubers resin was calculated to be 0.0911 ± 0.009 (mg EAas/mg Ex). This value indicates lower efficacy compared to the ethanol/water extract (7:3, vol/vol) derived from the aerial parts of *Cyperus rotundus*, which was estimated to be 0.166 (mg EAas/mg Ex) as reported by Yazdanparast and Ardestani [35].

In the FRAP test, the IC_{50} value for *Cyperus rotundus* roots was determined to be 0.0638 ± 0.05 mg/mL. This result indicates that it exhibits higher effectiveness compared to both the water extract (IC_{50} = 0.112 mg/mL) and the methanol extract (IC_{50} = 0.877 mg/mL) of *Cyperus rotundus* roots, as reported by Kumar et al. [36]. However, the 70% ethanol extract of the roots (IC_{50} = 0.527 mg/mL) [36] showed greater effectiveness.

The IC_{50} value, which indicates the concentration needed to scavenge 50% of the $ABTS^{\cdot+}$ radicals, was found to be 0.045 mg/mL for the resin extracted from *Cyperus rotundus* tubers. Remarkably, considering the absence of previous investigations on *Cyperus rotundus*, it demonstrated higher effectiveness compared to certain other plants, such as *Neurada procumbens* L with an IC_{50} value of 0.092 mg/mL [37], *Launaea glomerata* at 0.098 mg/ml [38], and *Lobulari alibyca* at 0.175 mg/mL [39].

In hemolysis test, *Cyperus rotundus* tubers resin exhibited an IC_{50} value of 0.158 ± 0.021 mg/mL, whereas the reference compound ascorbic acid showed a lower IC_{50} value of 0.036 mg/mL. Since there is no research on this test for this type of plant, the comparison was made with another type of plant. The comparison revealed that *Cyperus rotundus* tubers resin demonstrated significantly higher efficacy compared to *Genista saharae* at various concentrations, evident by its remarkable ability to inhibit red blood cell lysis. For instance, at a concentration of 1.2 mg/mL, *Genista saharae* exhibited a higher erythrocyte lysis percentage of 33.21% [40]. On the contrary, the resin extract achieved a much lower rate of only 14.36% at the same concentration.

3.6. Anti-inflammatory activity

The *Cyperus rotundus* tubers resin extract demonstrated anti-protein denaturation activity in human serum albumin, with an estimated value of 0.458 ± 0.012 (mg E Dc/mg Ex). Since there were no prior studies on this particular plant, a comparative analysis was conducted with the *Calligonum comosum* plant. It was found that all extracts from *Calligonum comosum* showed better efficacy than the studied resin extract, except for the aqueous extract of *Calligonum comosum*, which had a value of 0.24 (mg E Dc/mg Ex) as reported by Chouikh et al. [40].

Regarding the denaturation of egg albumin (Table 6), the IC_{50} value was determined to be 0.483 ± 0.026 mg/mL, which is in proximity to the IC_{50} value of the roots ethanol extract of *Cyperus iria*, estimated at 0.434 mg/mL as reported by de Vera et al. [24].

Table 6. IC_{50} values of the anti-inflammatory assay of *Cyperus rotundus* tubers resin and diclofenac sodium standard.

Sample	Inhibition of protein egg denaturation Assay IC_{50} (mg/mL)
Resin	0.483 ± 0.026
Diclofenac sodium	0.149 ± 0.088

3.7. The sun protection factor by UV-Vis spectrophotometry

The SPF value of *Cyperus rotundus* resin was calculated to be 5.794, which is within the lower range as shown in (Table 2) according to Schalka and Reis [27]. However, this SPF value is more effective compared to several water-based extracts such as aloe vera, cucumber, and papaya with values ranging from 1.28 to 1.75, as reported by Malsawmtluangi et al. [41]. These plants are commonly used as skin care ingredients.

4. Conclusions

The resin extracted from *Cyperus rotundus* tubers has significant antioxidant, anti-inflammatory, and photoprotective. These beneficial effects are due to the presence of phenolic compounds in the resin. The findings suggest that *Cyperus rotundus* tuber resin has promising applications in a variety of industries, including pharmaceuticals, food, and cosmetics. Further research is needed to fully explore and harness the potential of this resin in these fields.

Conflict of interest

There are no conflicts of interest declared by the authors.

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