**Running title:** The Potential of the *Uncaria sclerophylla* Plant as an Antidiabetic

**Phytochemicals, Antioxidant, and Inhibitory Activity against α-Glucosidase in *Uncaria sclerophylla* Twigs and Stems**

**Nita Triadisti1,2, Berna Elya1\*, Muhammad Hanafi3,4, Najihah Mohd Hashim5,6**

*1Faculty of Pharmacy, Universitas Indonesia, 16424, Depok, Indonesia.*

*2Faculty of Pharmacy, Universitas Muhammadiyah Banjarmasin, 70115, Banjarmasin, Indonesia.*

*3Research Centre for Pharmaceutical Ingredients and Traditional Medicine, National Research and Innovation Agency (BRIN), Serpong, 15314, Indonesia*

*4Department of Phytochemistry, Faculty of Pharmacy, Pancasila University, South Jakarta,12640, Indonesia*

*5Department of Pharmaceutical Chemistry, Faculty of Pharmacy, Universiti Malaya, Kuala Lumpur, 50603, Malaysia.*

*6Centre for Natural Products Research and Drug Discovery (CENAR), Universiti Malaya, Kuala Lumpur, 50603, Malaysia.*

\*For correspondence: berna.elya@farmasi.ui.ac.id

**Novelty Statement**

The people of Kalimantan have traditionally used the stems and twigs of *Uncaria sclerophylla* as a medicinal plant to treat diabetes. However, there is no scientific data on this plant's effectiveness in inhibiting the a-glucosidase enzyme as an anti-diabetic agent, nor is there any information available on its antioxidant activity.

This research aims to investigate the scientific activity of this plant as an anti-diabetic by inhibiting a-glucosidase and its antioxidant activity. This study supports and strengthens the traditional use of this plant as an anti-diabetic medicine.

**Abstract**

The medicinal plant *Uncaria sclerophylla* has been used as a traditional antidiabetic drug by the people of Kalimantan, Indonesia. However, scientific data on this plant as an antidiabetic has never been reported. This research aims to investigate the antidiabetic activity of the twigs and stems of *U. sclerophylla* as an inhibitor of α-glucosidase, and its antioxidant activity, including phytochemical screening. Four-graded maceration was used as the extraction method, thin-layer chromatography was used as a screening method, and all bioassays were conducted by spectrophotometric principles to determine inhibition of α-glucosidase and antioxidant activity from n-hexane, dichloromethane, ethyl acetate and methanol extracts of twigs and stems. The research results show that *U. sclerophylla* twigs and stems contain alkaloids, phenols, and flavonoids. Inhibitory activity against α-glucosidase was shown from both twigs and stems of the plant, with the most active extract being n-hexane extract from twigs with an IC50 of 84.44 ppm. The best antioxidant activity was shown by methanol extract from both twigs (IC50 28.76 ppm) and stems (IC50 27.76 ppm). The assay results have underlined that the twigs and stems of this species have the potential to be developed in the treatment of diabetes mellitus through α-glucosidase inhibition and antioxidant activity.

**Keywords:** Antidiabetes; *Uncaria sclerophylla*; Antioxidant; α-glucosidase; Phytochemical content

**Introduction**

α-glucosidase inhibitors have been widely used in treating diabetes mellitus as first-line drugs and combinations. This class of antidiabetic therapy has effectiveness in reducing HbA1C (0.3% to 1%) and reducing postprandial glucose concentrations (40 to 50 mg/dL) (Dipiro et al., 2011). The ability of α-glucosidase to control blood sugar levels due to its inhibition of the enzyme α-glucosidase as a carbohydrate breakdown, so that the amount of glucose as a result of carbohydrate breakdown can be suppressed and blood glucose spikes can be reduced thus, this class of antidiabetic therapy provides benefits in the treatment of diabetes (Ibrahim et al., 2017; Prasad et al., 2019; Zaidi et al., 2019). In vivo studies show that α-glucosidase inhibitors can slow down the dysfunction of insulin secretion and positively affect the progress of diabetes (Fukaya et al., 2009). This therapy class is also positively related to an increase in GLP-1, which is an inducer of insulin secretion, which will reduce post-prandial hyperglycemia (Dabhi et al., 2013).

Various studies have explained the role of antioxidants in helping to overcome the condition of diabetes mellitus; this is related to the oxidative stress that occurs in diabetes due to an increase in free radicals. In diabetes, there is a decrease in the concentration of endogenous antioxidants, both enzymatic and non-enzymatic antioxidants, and this is accompanied by an increase in the levels of advanced oxidation products, which exacerbate oxidative stress (Kanwugu et al., 2021; Rajendiran et al., 2018). Increased reactive oxygen species (ROS) in diabetes can modulate insulin signaling pathways, thereby contributing to the progression of diabetes and the development of diabetic vascular complications (Akpoveso et al., 2023; Ghasemi-Dehnoo et al., 2020). Various studies show that antioxidant therapy helps repair beta cell damage caused by oxidative stress and that antioxidants help improve insulin sensitivity and reduce the incidence of diabetes complications (Dinić et al., 2022; Ghorbani et al., 2019; Rajendiran et al., 2018).

Various medicinal plants have been used traditionally in the treatment of diabetes; these plants have been used for generations by the local community, one of which is the *Uncaria sclerophylla* plant, which is known for its efficacy in the treatment of diabetes mellitus by people of Kalimantan, Indonesia. The genus *Uncaria* itself is known to contain various phytoconstituents such as flavonoids, alkaloids, phenols, and terpenoids (Hoyos et al., 2015; Qin et al., 2021; Sakti et al., 2019) and has shown much potential in the treatment of diabetes, both in vivo and in vitro assays as both α-glucosidase and antioxidant inhibitors (Ahmad et al., 2011; Apea-Bah et al., 2009; Aprely et al., 2021), but the species *U. sclerophylla* has never been reported for its scientific data as antidiabetes, even though this species has been consumed for generations to help treat diabetes mellitus. Exploration of scientific data on *U. sclerophylla* is urgently needed because of its widespread traditional use. This research includes investigating phytochemical content (alkaloid, phenol, and flavonoid) where various studies show the potential of these phytoconstituents as inhibitors of α-glucosidase as well as antioxidants (Famuyiwa et al., 2019; Junejo et al., 2020; Sarian et al., 2017; Wairata et al., 2022).

**Material and Methods**

**Plant material**

Stems and branches of *U. sclerophylla* were collected from Meratus Forest, South Kalimantan, Indonesia. Plant authenticity was determined, and a voucher specimen was deposited in the faculty of pharmacy, Universitas Indonesia (voucher specimen number 237/LB/XI/2021). The stems and twigs were cleaned, dried at 16˚ C, powdered, and sieved using 40 mesh. The stem and twig powder were stored at 16˚ C until it was time to be extracted.

**Chemical and Instrumentations**

Chemicals: n-hexane (SmartLab), dichloromethane (SmartLab), ethyl acetate (SmartLab), methanol (SmartLab), TLC Plate 254GF (Merck). Dragendorff reagent, 1% ethanolic AlCl3 (Merck), folin-ciocalteu reagent (Merck), quercetin (Sigma Aldrich), 96% ethanol (Merck). Enzyme α-glucosidase (Sigma Aldrich), para-nitrophenyl-α-D glucopyranoside (Sigma Aldrich), acarbose (Sigma Aldrich), bovine serum albumin (Sigma Aldrich), potassium dihydrogen phosphate, sodium carbonate (Merck), dimethylsulfoxide. 1,1-diphenyl-2-picrylhydrazyl (DPPH) (Sigma-Aldrich),. Instruments: rotary evaporator (IKA), UV lamp (Camag), micropipette (Eppendorf), microplate reader (Glomax Promega), pH meter (Eutech 510 Instrument).

**Extraction**

Extraction of the stems and twigs of *U. sclerophylla* was carried out using a four-stage maceration, adopting the method from (Triadisti et al., 2018) with modifications to the number of solvent types. Solvents with increasing polarity were used for extraction, including n-hexane, dichloromethane, ethyl acetate, and methanol in a ratio of 1:20 between simplicia and solvent to obtain n-hexane extract, dichloromethane extract, ethyl acetate extract and methanol extract. Evaporation of the extract was assisted by a rotary evaporator and finished with a dehydrator. The extract was stored at 16˚ C until it was time to be analyzed.

**Identification of Alkaloids, Phenols, and Flavonoids using Thin Layer Chromatography**

Identification of the extracts' alkaloid, phenol, and flavonoid phytoconstituent content was carried out using the adopted method with slight modification (Maya et al., 2019). Alkaloids were detected using Dragendorff’s reagent to spray the TLC plate containing the eluted extract. A yellow-orange color in visible light indicated a positive result. Phenol was detected using a 10% folin-ciocalteau spray reagent on the TLC plate, where a positive result was shown by the presence of a blue color in visible light. Flavonoids were detected using a 1% ethanolic AlCl3 spray reagent to detect them, where the presence of flavonoids was shown by yellowish fluorescence under UV light 366/365.

**α-Glucosidase Enzyme Inhibition Activity Assay**

The α-glucosidase inhibitory activity assay was carried out using the spectrophotometric method, where the absorbance was read with a microplate reader (Triadisti et al., 2017). The solution mixture consisting of 30 μL of sample solution, 36 μL of phosphate buffer pH 6.8, and 17 μL of pNP-G substrate (5 mM) was incubated for 5 minutes at 37°C then added 17 μL of α-glucosidase enzyme solution (0.12 Unit/mL) and incubated for 15 minutes at 37˚C. After 15 minutes of incubation, 100 μL of 267 mM Na2CO3 was added to stop the enzyme reaction, and the absorbance of the p-nitrophenol produced from the enzyme reaction was read using a microplate reader. In the sample control solution, the Na2CO3 solution was added before adding the α-glucosidase enzyme so that the reaction did not occur. Each assay was carried out three times (triplication), and the standard deviation was measured for each sample.

The percentage of α-glucosidase inhibition can be calculated by the formula = [(AB blank–AB sample) / AB blank] x 100 %, where AB blank is the absorption of enzyme activity without inhibitor corrected by blank control, and AB sample is the absorbance of sample corrected by sample control. IC50 can be calculated using the regression equation y = a + bx with sample concentration as the x-axis and % inhibition as the y-axis. The IC50 value is calculated by the formula: (50 – a) / b.

**Antioxidant Activity Assay**

The antioxidant activity assay method used was the DPPH free radical scavenging method adopted with slight modifications (Bobo-garcía et al., 2014). Pipette 20 μL sample solution, then 180 μL of 150 μmol/L DPPH solution was added to each solution. The control solution consisted of 20 μL methanol and 180 μL of 150 μmol/L DPPH solution, while the blank solution consisted of 200 μL methanol p.a. The solution was shaken for 60 seconds and then incubated at room temperature in a dark room for 40 minutes. Each assay solution was then measured for its absorbance at a wavelength of 517 nm. Each assay was carried out three times (triplication), and the standard deviation was measured for each sample.

The EC50 value is calculated based on the percentage of free radical scavenging from each sample solution concentration with the formula % absorption = [(Absorbance of control solution – Absorbance of Sample)/Absorbance of control solution] x 100%. After obtaining the percentage of free radical scavenging for each concentration, the equation y = a + bx is determined by a regression calculation where x is the concentration (μg/mL) and y is the percentage of free radical scavenging (%). Antioxidant activity is expressed by an Effective Concentration of 50% (EC50).

**Result**

**Identification of alkaloids, phenols, and flavonoids from stems and twigs of *Uncaria sclerophylla***

The stems and twigs of *U. sclerophylla* were macerated at four levels, and n-hexane extract, dichloromethane extract, ethyl acetate extract, and methanol extract were obtained, and the yield of the obtained extract is shown in Table 1 Extracts with different polarities were detected for their alkaloid, phenol, and flavonoid content using TLC. The results of detecting these phytoconstituents can be seen in Table 2-3. Phytochemical screening revealed the presence of alkaloids, phenols, and flavonoids in the n-hexane, dichloromethane, and methanol extracts obtained from the stem. The twigs were found to contain alkaloids in the n-hexane and dichloromethane extracts and phenols and flavonoids in the ethyl acetate and methanol extracts.

**α-Glucosidase Enzyme Inhibitory Activity of *Uncaria sclerophylla* extract**

Assay results on *U. sclerophylla* extracts at various polarities showed inhibition of the α-glucosidase enzyme at a assay concentration of 75 ppm, where good inhibition was shown by n-hexane and methanol extracts from twigs, also ethyl acetate and methanol extracts from stems with inhibition percentages of 45.53 % ± 2.2388, 33.21 % ± 2.3724, 30.09 % ±5.2537, and 25.34 % ± 3.1383 respectively (Table 4). Acarbose, as a positive standard, still showed better activity with an IC50 of 65.12 ppm compared to n-hexane extracts from twigs as the most active extract with an IC50 of 84.44 ppm (Table 5).

**Antioxidant activity of *Uncaria sclerophylla* extract**

Assays for antioxidant activity using the DPPH methods showed that the highest antioxidant activity was possessed by methanol extract, both from twigs and stems, with IC50 28.76 ppm and 27.76 ppm, respectively (Table 6-7). This is in line with the results of the flavonoid content screening, which showed that flavonoids was present in methanol extracts from both twigs and stems. Flavonoids have a role in antioxidant activity, as has been reported in various studies (Cui et al., 2022; Tao et al., 2023; Uysal, 2023; Wang et al., 2023).

**Discussion**

**Identification of alkaloids, phenols, and flavonoids from stems and twigs of *Uncaria sclerophylla***

Several studies show the potential of alkaloids, phenols, and flavonoids in antidiabetic and antioxidant activity (Famuyiwa et al., 2019; Junejo et al., 2020; Sarian et al., 2017; Wairata et al., 2022). Screening of alkaloid, phenol, and flavonoid phytoconstituents using thin-layer chromatography has been widely used in various studies (Maya et al., 2019). Screening on *U. sclerophylla* extracts showed the presence of alkaloids in dichloromethane, ethyl acetate, and methanol extracts from stems, as well as in n-hexane and dichloromethane extracts from twigs. Phenol content was seen in all extracts except the n-hexane extract (both from stems and twigs) and dichloromethane extracts from twigs, and flavonoids were seen in ethyl acetate and methanol extracts, both from twigs and stems. Complete screening results can be seen in Table 2-3. Various alkaloid, phenolic, and flavonoid compounds have been reported as inhibitors of α-glucosidase, and as antioxidants (Kim et al., 2017; Kumar et al., 2021; Sakulkeo et al., 2022; Sharma et al., 2019; Yin et al., 2014).

**α-Glucosidase Enzyme Inhibitory Activity of *Uncaria sclerophylla* extract**

The TLC screening results showed the presence of alkaloids, phenols, and flavonoids of these extracts. Several compounds, including alkaloids, phenols, and flavonoids, have been shown to inhibit α-glucosidase (Kumar et al., 2021; Sakulkeo et al., 2022; Yin et al., 2014).

Alkaloid compounds have been reported to have antidiabetic and antioxidant activity, including: the compound vindolysin from Catharanthus roseus with the activity of inducing glucose uptake in TC6 cells and C2C12 cells and showing antioxidant activity (Tiong et al., 2013); the compound vindoline from Catharanthus roseus shows antioxidant activity and significantly increases insulin secretion in vitro (Goboza et al., 2020); magnoflorin compounds from Mahonia aquifolium, Tinospora cardifolia, and Rhizoma coptidis show antioxidant activity and inhibitory activity of the α-glucosidase enzyme and the PTP-1B (Protein tyrosine phosphatase 1B) enzyme (Okon et al., 2020). In silico studies show the role of alkaloid structural features in inhibition, including the presence of benzene rings forming π-π stacking, hydrogen atoms from hydroxyl groups and nitrogen atoms forming hydroxy bonds, carbonyl groups of piperidine rings, halogen atoms in alkaloids also forming halogen bonds (Zafar et al., 2016).

Phenolic and flavonoid compounds have been reported to have antidiabetic and antioxidant activity, such as protocatechic acid, a diphenol that is active as an antioxidant and antidiabetic (Famuyiwa et al., 2019), 8-hydroxyapigenin 7-O-β-D-glucopyranoside isolated from the extract Tetrastigma angustifolia leaf methanol which has hypoglycemic effects on mice induced by streptozotocin and antioxidants (Junejo et al., 2020); the antioxidant compounds resveratrol, epicatechin, quercetin, gallic acid which have inhibitory activity against both the α-glucosidase enzyme and the DPP-4 enzyme (Praparatana et al., 2022); isoscutellarein, hypolaethin and kaempferol compounds which have antioxidant activity and inhibit the α-glucosidase enzyme and the DPP-4 enzyme (Sarian et al., 2017).

**Antioxidant activity of *Uncaria sclerophylla* extract**

Apart from having antioxidant activity, flavonoids have also been reported to have antidiabetic activity, so the flavonoid compounds contained in the extract have a role in helping to overcome diabetes (Kim et al., 2018; Kumar et al., 2021; Sharma et al., 2019). Diabetes complications can be reduced with the help of antioxidants, which can be used as therapy or in combination with the treatment of diabetes. β-cell function can be maintained by antioxidants by addressing oxidative stress, thereby reducing diabetes-related complications and helping to restore insulin sensitivity (Suresh et al., 2021). Various studies have shown that antioxidants such as lycopene, retinol, tocopherol, ascorbic acid, carotene, lutein, and zeaxanthin, contained in various plants, offer an essential role in helping overcome diabetes complications. The antioxidant activity of phytoconstituents in reducing complications of chronic diseases such as diabetes, heart disease, and obesity has been confirmed in various studies (Ghasemi-Dehnoo et al., 2020).

*U. sclerophylla* has been widely used in traditional medicine as an antidiabetic, especially by the people of Kalimantan, Indonesia. The assay results showed that there was inhibitory activity against diabetes-related enzyme such as α-glucosidase from *U. sclerophylla* extracts. To further explore the mechanism of the antidiabetic activity of this species, it is necessary also to assay other diabetes-related targets such as dipeptidyl peptidase-4, sodium-glucose cotransporter type-2 (SGLT-2) and peroxisome proliferator-activated receptor γ (PPARγ). The twigs and stems of this plant also show excellent antioxidant activity, supported by data on the phytochemical content of phenols and flavonoids; this further strengthens the potential of this plant to help treat diabetes mellitus because the role of antioxidants has been widely reported to help treat diabetes (Darenskaya et al., 2021; A. N. Khan et al., 2020; Suresh et al., 2021).

**Conclusion**

The twigs and stems of *Uncaria sclerophylla* showed inhibitory activity against the α-glucosidase enzyme and had antioxidant activity, which underlies that the twigs and stems of this species have the potential to continue to be explored and developed in the treatment of diabetes mellitus, as is its traditional use as an antidiabetic.

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**Author Contributions**

All authors have contributed equally to this work and have permitted it to be published.

**Conflict of interest**

The authors declare that no conflict of interest or personal relationship can affect the research results written in this paper.

**Data Availability**

The author can provide access to the data upon reasonable request.

**Ethics Approval**

Outside the scope of this paper

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**Table 1**. Extracts yield with various solvents

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Plant Sample | Solvent | Simplisia Weight (g) | Extract Weight (g) | % Yield |
| Stems | n-Hexane | 100  |  0.1590 |  0.1590 |
| Dichloromethane |  0.3720 |  0.3720 |
| Ethyl acetate |  1.0820 |  1.0820 |
| Methanol | 21.3640 | 21.3640 |
|  |  |  |  |  |
| Twigs | n-Hexane | 100 |  0.1000 |  0.1000 |
| Dichloromethane |  0.4310 |  0.4310 |
| Ethyl acetate |  0.7499 |  0.7499 |
| Methanol | 10.7981 | 10.7981 |

**Table 2.** Alkaloid, phenol, and flavonoid content of *Uncaria sclerophylla* stem extract

|  |  |  |  |
| --- | --- | --- | --- |
| Solvent | Presence of alkaloids | Presence of phenols | Presence of flavonoids |
|  | TLC | Result | TLC | Result | TLC | Result |
|  |
| n-Hexane | - | Not detected | - | Not detected | - | Not detected |
| Dichloromethane |  | Detected |  | Detected | - | Not detected |
| Ethyl acetate |  | Detected |  | Detected |  | Detected |
| Methanol |  | Detected |  | Detected |  | Detected |

**Table 3.** Alkaloid, phenol, and flavonoid content of *Uncaria sclerophylla* twigs extract

|  |  |  |  |
| --- | --- | --- | --- |
| Solvent | Presence of alkaloids | Presence of phenols | Presence of flavonoids |
|  | TLC | Result | TLC | Result | TLC | Result |
| n-Hexane |  | Detected | - | Not detected | - | Not detected |
| Dichloromethane |  | Detected | - | Not Detected | - | Not detected |
| Ethyl acetate | - | Not detected |  | Detected |  | Detected |
| Methanol | - | Not detected |  | Detected |  | Detected |

**Table 4.** α-Glucosidase Enzyme Inhibitory Activity of *Uncaria sclerophylla* extract (75 ppm)

|  |  |  |  |
| --- | --- | --- | --- |
| Plant Sample  | Solvent Maceration | % α-Glucosidase Inhibition | Mean ± SD |
|  |  | Data 1 | Data 2 | Data 3 |  |
| Twigs | n-Hexane | 47.83  | 45.39 | 43.36 | 45.53 ± 2.2388 |
| Dichloromethane | 12.47 | 11.11 | 13.96 | 12.51 ± 1.4233 |
| Ethyl Acetate | 20.17 | 19.68 | 21.77 | 20.54 ± 1.0933 |
| Methanol | 35.92 | 32.23 | 31.49 | 33.21 ± 2.3724 |
|  |  |  |  |  |  |
| Stem | n-Hexane |  4.88 |  8.67 |  6.78 |  6.78 ± 1.8970 |
| Dichloromethane | 10.70 |  8.81 |  8.54 |  9.35 ± 1.1813 |
| Ethyl Acetate | 26.08 | 28.17 | 36.04 | 30.09 ± 5.2537 |
| Methanol | 28.54 | 25.22 | 22.26 | 25.34 ± 3.1383 |

Data are mean ± SD or % ± SD for triplicate measurements.

**Table 5.** IC50 α-Glucosidase inhibition of Acarbose and *Uncaria sclerophylla* twigs n-hexane extract

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Sample | Concentration (ppm) | Mean % α-Glucosidase Inhibition ± SD | R2 | IC50 (ppm) |
| Acarbose | 45 | 45.48 ± 1.7415 | 0.9986 | 65.12 |
| 60 | 48.53 ± 3.5557 |
| 90 | 55.96 ± 1.2512 |
| 105 | 59.39 ± 1.2848 |
| 120 | 62.33 ± 0.1959 |
|  |  |  |  |  |
| n-Hexane extract of Twigs | 75 | 43.08 ± 2.2007 | 0.9901 | 84.44 |
| 105 | 62.63 ± 4.3385 |
| 120 | 73.78 ± 6.2537 |
| 135 | 81.20 ± 2.8391 |
| 150 | 87.40 ± 2.4306 |

Data are mean ± SD or % ± SD for triplicate measurements.

**Table 6.** Antioxidant activity of *Uncaria sclerophylla* twigs extract

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Sample | Concentration (ppm) | Mean % Scavenging of Free Radicals ± SD | R2 | EC50 (ppm) |
| Quercetin | 1 | 17.63 ± 1.7310 | 0.9938 | 2.9786 |
| 2 | 35.96 ± 2.8494 |
| 3 | 50.06 ± 7.0280 |
| 4 | 68.59 ± 6.8984 |
| 5 | 79.44 ± 2.4677 |
|  |  |  |  |  |
| Twig Methanol Extract | 20 | 36.51 ± 0.3590 | 0.9843 | 28.76 |
| 25 | 41.89 ± 1.0220 |
| 30 | 54.25 ± 1.4166 |
| 35 | 59.82 ± 0.7950 |
| 40 | 67.41 ± 2.1097 |
|  |  |  |  |  |
| Twig Ethyl acetate Extract | 20 | 17.66 ± 0.5587 | 0.9961 | 68.13 |
| 30 | 23.43 ± 1.7557 |
| 40 | 30.53 ± 0.7541 |
| 50 | 36.49 ± 0.7072 |
| 60 | 43.33 ± 1.2423 |
| 80 | 59.42 ± 1.0583 |
|  |  |  |  |  |
| Twig Dichloromethane Extract | 40 | 19.15 ± 4.2478 | 0.9893 | 114.52 |
| 80 | 38.00 ± 0.5297 |
| 120 | 55.20 ± 0.5657 |
| 160 | 68.16 ± 0.8136 |
| 200 | 79.89 ± 1.0019 |
|  |  |  |  |  |
| Twig n-Hexane Extract | 50 | 44.30 ± 1.4611 | 0.9877 | 65.14 |
| 60 | 46.79 ± 2.8944 |
| 70 | 52.75 ± 0.8270 |
| 80 | 55.93 ± 1.5271 |
| 90 | 60.17 ± 1.2046 |

Data are mean ± SD or % ± SD for triplicate measurements

**Table 7.** Antioxidant activity of *Uncaria sclerophylla* stems extract

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Sample | Concentration (ppm) | Mean % Scavenging of Free Radicals ± SD | R2 | EC50 (ppm) |
| Quercetin | 1 | 17.63 ± 1.7310 | 0.9938 | 2.9786 |
| 2 | 35.96 ± 2.8494 |
| 3 | 50.06 ± 7.0280 |
| 4 | 68.59 ± 6.8984 |
| 5 | 79.44 ± 2.4677 |
|  |  |  |  |  |
| Stem Methanol Extract | 10 | 18.67 ± 3.8869 | 0.9817 | 27.76 |
| 20 | 38.54 ± 1.1798 |
| 30 | 57.89 ± 1.4329 |
| 40 | 71.12 ± 0.7843 |
| 50 | 81.51 ± 0.8494 |
|  |  |  |  |  |
| Stem Ethyl acetate Extract | 20 | 21.12 ± 0.5311 | 0.9922 | 62.98 |
| 30 | 28.90 ± 0.2452 |
| 40 | 35.92 ± 0.5398 |
| 50 | 42.25 ± 0.3786 |
| 60 | 47.00 ± 0.5889 |
|  |  |  |  |  |
| Stem Dichloromethane Extract | 50 | 17.59 ± 2.9922 | 0.9975 | 220.20 |
| 100 | 27.74 ± 2.8347 |
| 150 | 38.06 ± 0.6976 |
| 200 | 45.63 ± 0.9014 |
| 250 | 55.40 ± 0.6873 |
|  |  |  |  |  |
| Stem n-Hexane Extract | 50 | 48.14 ± 0.7625 | 0.9890 | 84.98 |
| 100 | 51.16 ± 0.6474 |
| 150 | 52.75 ± 1.0025 |
| 200 | 54.65 ± 0.9518 |
| 250 | 56.78 ± 0.2421 |

Data are mean ± SD or % ± SD for triplicate measurements