Antioxidant Properties of Red Betel (Piper crocatum) Leaf Extract and its Compounds

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Abstract

Background: Piper crocatum, also known as red betel, is a potential herbal medicine. Aims: Current study was planned to determine the antioxidant activities of red betel (Piper crocatum Ruiz and Pav.) leaves extract (RBLE) as compared to eugenol and hydroxychavicol compounds. Methods: DPPH radical scavenging, H2O2 scavenging, ABTS reduction, and FRAP reduction assay were carried out. Results: In DPPH scavenging, RBLE showed an IC50 value of 3.98 μg/mL, eugenol of 2.98 μg/mL, and hydroxychavicol of 18.00 μg/mL. Meanwhile, H2O2 scavenging activity showed an IC50 value of RBLE, eugenol, and hydroxychavicol as 186.33 μg/mL, 97.36 μg/mL, and 41.06 μg/mL respectively. ABTS reduction assay showed an IC50 value of 38.43 μg/mL, 181 μg/mL, and 3.10 μg/mL for RBLE, eugenol, and hydroxychavicol respectively. The highest FRAP reduction activity was shown by Eugenol with a concentration of 50 μg/mL which was equal to 424.67 µM Fe (II)/µg. Conclusion: The RBLE and its compounds (eugenol and hydroxychavicol) have antioxidant activity as indicated by the results of the DPPH scavenging, H2O2 scavenging, ABTS reduction, and FRAP reduction assays. However, RBLE had the lowest antioxidant activity compared to other compounds.

Keywords: Eugenol, Free Radicals, Hydroxychavicol, Piper crocatum

1. Introduction

Molecules or fragment of molecules when they lose an electron in an atomic orbit make them as unstable free radicals. To attain stability, free radicals damage or react with neighboring molecules. External origin of free radicals are X-rays, ozone, cigarette smoke, industrial chemicals, ultraviolet light, and environmental pollutants1,2. Imparity between Reactive Oxygen Species (ROS) and the anti-oxidative defense systems cause oxidative stress that could lead to many diseases such as cancer, cardiovascular diseases, rheumatoid arthritis, and atherosclerosis3.

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Article Received on: 29.04.2019 Revised on: 04.09.2019 Accepted on: 18.11.2019
against cervical cancer. Red betel has been reported to contain several active compounds such as flavonoids, steroids, tannins, saponins, alkaloids, polyphenolics, quinones, and essential oil. Red betel also contains chavicol, chavibetol, carvacrol, caryophyllene, estragole, eugenol, and hydroxychavicol.

Hydroxychavicol and eugenol were antifungal compounds. In addition, eugenol at lower concentration has been reported to have antioxidant and anti-inflammatory properties, but at higher concentration exhibits pro-oxidant properties. Hydroxychavicol isolated from the aqueous extract of P. betle was the major phenolic component and has been suggested as antimutagenic, anticarcinogenic, antioxidant, anti-inflammatory, and chemopreventive agent. The extract of red betel has been reported to be active against Colletotrichum gloeosporioides, Candida albicans, and Botryodiplodia theobromae. Betel oil nowadays has been used as an antiseptic component in gels, balms, it is anti-inflammatory and also is a treatment for several diseases.

The aim of the study was to observe the antioxidant activity of the red betel (P. crocatum Ruiz and Pav.) leaf ethanol extract as compared to hydroxychavicol and eugenol.

2. Materials and Methods

2.1 Preparation of Extract
Red betel (P. crocatum Ruiz and Pav.) leaves were obtained from Pabuaran Cilendek Timur, Bogor. The plants were identified by Herbarium Bogoriense, Botanical Field Research Center for Biology-Indonesian Institute of Sciences, Bogor, Indonesia. Red betel leaves were dried using food dehydrator (Zhengzhou Well-known) then mashed (160 g) and extracted by 500 mL of distilled ethanol 70% by maceration method. Ethanol filtrate was filtered in every 24 h and wastes were remacerated until there was colourless filtrate. The filtrate was concentrated in evaporator at 50 °C (Zhengzhou Well-known, RE-201D) to obtain the red betel leaves extract (RBLE).

2.2 DPPH Scavenging
A total of 200 µL DPPH (Sigma Aldrich D9132) 0.077 mmol in methanol was added with 50 µL of samples including RBLE, hydroxychavicol (Chengdu Biopurify Phytochemical Ltd, BP3020), eugenol (Chengdu Biopurify Phytochemical Ltd, BP0569) with various concentration added on the 96-well microplate. The mixture was incubated for 30 min at room temperature, then the absorbance value was read at 517 nm wavelength using a micro plate reader (Multiskan™ GO Microplate Spectrophotometer, Thermo Scientific). For the sample, 200 µL of DPPH and 50 µL of sample was used, while for negative control 250 µL of DPPH was used, while for blanks, 250 µL of an absolute DMSO was used. Calculation of DPPH scavenging activity was done by using the following formula:

DPPH scavenging activity (%) = (A-B)/A × 100
A: control absorbance
B: sample absorbance

2.3 H₂O₂ Scavenging
The scavenging of H₂O₂ was measured based on the method described by Mukhopadhyay et al. with slight modification. Each sample contained 60 µL of sample, 12 µL of ferrous ammonium sulphate (1mM, Sigma Aldrich 7783859), and 3 µL of H₂O₂ (5mM, Merck 1.08597.1000). For the negative control, 12 µL of ferrous ammonium sulphate and 63 µL of DMSO were used, while for blanks, 60 µL of RBLE and 90 µL of DMSO was used.

After adding H₂O₂, control, sample, and blank solutions was added into the 96-well plate and incubated for 5 min in a dark room at room temperature. Sample and control solutions were added with 75 µL of 1,10-phenanthrolines and incubated again for 10 min in a dark room at room temperature. Absorbance value was measured at 510 nm wavelength. The percentage of scavenging activities was calculated using the formula:

H₂O₂ scavenging activity (%) = (A-B)/A X 100
A: control absorbance
B: sample absorbance

2.4 ABTS Reduction
Briefly 2 µL of sample in various concentrations was added into the well followed by 198 µL of 2,2’-Azinobis-(3-ethylbenzo thiazoline-6-sulfonic acid) (ABTS⁺) (Sigma Aldrich, A1888) and also in control well with 200 µL ABTS. Blank well was added by 200 µL of
DMSO. Microplate was then incubated at 37°C for 6 min. Absorbance was measured at a wavelength of 745 nm\textsuperscript{11–13}. Calculation of ABTS reduction percentage was carried out by the following formula:

\[
\text{ABTS reduction activity (\%) = } \frac{(A-B)}{A} \times 100
\]

A: control absorbance
B: sample absorbance

2.5 FRAP Reduction

The Ferric Reducing Antioxidant Power Assay (FRAP) reagent was prepared by mixing 10 mL of acetate buffer 300 mM, 1 mL ferric chloride hexahydrate (Merck 1.03943.0250), 20 mM dissolved in distilled water, and 1 mL of 2,4,6-Tris-(2-pyridyl-5-Triazine) (TPTZ) (Sigma Aldrich 368235-7) 10 mM and dissolved with HCl 40 mM. Briefly 7.5 μL of samples were added with 142.5 μL FRAP reagent in 96-well microplate reader then mixed and incubated for 30 min at 37°C. The absorbance was measured at 593 nm with a microplate reader (Multiskan™ GO Microplate Spectrophotometer, Thermo Scientific). The standard curve was made using FeSO\textsubscript{4}, between 0.49 and 62.50 μM FeSO\textsubscript{4}. The results were expressed in μM Fe (II)/μg extract\textsuperscript{11–13}.

2.6 Statistical Analysis

Statistical analysis was performed using SPSS software (version 20.0). Values are presented as Mean ± Standard Deviation. Significant differences between the groups were determined using the Analysis of variance (One Way ANOVA) followed by Tukey’s HSD Post-hoc Test. The results of DPPH scavenging, H\textsubscript{2}O\textsubscript{2} scavenging, ABTS reduction activity were continued by linear regression analysis. Then the value of Median Inhibitory Concentration 50 (IC\textsubscript{50}) was determined for DPPH scavenging, H\textsubscript{2}O\textsubscript{2} scavenging, ABTS reduction.

3. Results and Discussions

Red betel was extracted using 70% ethanol to extract active compounds that have antioxidant activity, such as flavonoids, polyphenols, alkaloids, and tannins. Ethanol is a polar solvent but less polar than water so it is more efficient in degrading cell walls in red betel leaf\textsuperscript{17}.

DPPH is a free radical that belongs to the hydrogen radical group. DPPH is sensitive to light, oxygen, and pH. However, it is stable in a radical form so it may be quite an accurate measurement of antioxidant activity. DPPH free radical can capture hydrogen atoms from the component of antioxidant sample which are mixed and then react to their reduced form and are characterized by reducing intensity of purple DPPH solution with maximum uptake at 517 nm\textsuperscript{11–13}. When antioxidants interact with DPPH, they shift an electron or hydrogen atom (H\textsuperscript{+}) to DPPH to counteract its free radical character\textsuperscript{18}. This process changes the color of the solution from purple to yellow. DPPH assay in this study shows that the radical-scavenging activities of the samples were in the order of hydroxychavicol < RBLE < eugenol. The differences between each concentration were significant (Figure 1) and the IC\textsubscript{50} value of samples against DPPH free radical scavenging activity was shown in Table 1. IC\textsubscript{50} value of RBLE, hydroxychavicol and eugenol was 3.98 μg/mL, 18.00 μg/mL and 2.98 μg/mL respectively. IC\textsubscript{50} of hydroxychavicol and eugenol was equivalent to 119.86 μM and 18.15 μM. Based on the result of DPPH scavenging test, each sample had the highest DPPH scavenging activity at 250 μg/mL concentration.

Widowati et al\textsuperscript{5} has reported that DPPH scavenging activity of piper extracts based on IC\textsubscript{50} value. P. pellucidum and P. umbellatum had the highest scavenging activity of DPPH of 9 and 15.36 μg/mL respectively. Those piper extracts were also compared to eugenol which had an IC\textsubscript{50} value of 3.8 μg/mL. Risdian et al\textsuperscript{1} suggested that DPPH scavenging activity of P. betle L. ethanol extract was strong with an IC\textsubscript{50} value of 3.48 μg/mL. Alfarabi et al\textsuperscript{17} reported that P. crocatum leaves at 200 ppm concentration could hamper DPPH by 73.41% with an IC\textsubscript{50} of 85.82 ppm. As a natural antioxidant, P. crocatum leaves extract could hinder the oxidation of linoleic acids because of the presence of flavonoids, tannins, and alkaloids as bioactive compounds. Based on another study, if the compound has IC\textsubscript{50} value < 200 ppm or < 200 μg/mL, it is considered to possess strong antioxidant activity. Considering these previous studies, RBLE exhibited potential antioxidant property.

Hydrogen peroxide is one of the ROS having supportive roles in energy production in vivo systems, phagocytosis, intercellular signal transfer, adjustment
of cell growth and the synthesis of prominent biological compounds\textsuperscript{16}. At a concentration of 250 µg/mL, all the samples showed the highest activity of H\textsubscript{2}O\textsubscript{2} scavenging (Figure 2). Almost all of the samples had H\textsubscript{2}O\textsubscript{2} scavenging activity which was significantly different at each of the concentrations. Based on IC\textsubscript{50} value, the radical-scavenging activities of the sample were in the order RBLE < eugenol < hydroxychavicol hydroxychavicol had the strongest activity (41.06 µg/mL) compared to eugenol (97.36 µg/mL) and RBLE (186.33 µg/mL). The result can be seen in Table 2.

H\textsubscript{2}O\textsubscript{2} scavenging assay showed that the scavenging activity of hydroxychavicol at concentration of 250 µg/mL was about 1.15 times stronger than RBLE. Tamuly et al\textsuperscript{19} has reported that H\textsubscript{2}O\textsubscript{2} scavenging activity of P. wallichii Miq. Hand. -Mazz. methanol extract which was 49.30 µg/mL. In current study IC\textsubscript{50} of RBLE, eugenol, and hydroxychavicol was 186.33, 97.36, and 41.06 µg/mL respectively in which, IC\textsubscript{50} of eugenol and hydroxychavicol was equivalent to 592.92 µM and 250.06 µM respectively. It shows that the samples were not too strong for being potent antioxidant in scavenging H\textsubscript{2}O\textsubscript{2}.

ABTS-reducing activity assay is for measuring the comparative potential of antioxidant to capture ABTS induced by reacting a strong oxidizing agent (potassium permanganate/potassium persulfate) with the ABTS salt. The long wave absorption spectrum was

Table 1. IC\textsubscript{50} of DPPH Scavenging Activity of Eugenol, Hydroxychavicol, and RBLE

<table>
<thead>
<tr>
<th>Sample</th>
<th>Equation</th>
<th>R\textsuperscript{2}</th>
<th>IC\textsubscript{50} (µg/mL)</th>
<th>IC\textsubscript{50} (µM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eugenol</td>
<td>( y = 0.1788x + 49.468 )</td>
<td>0.97</td>
<td>2.98</td>
<td>18.15</td>
</tr>
<tr>
<td>Hydroxychavicol</td>
<td>( y = 0.2195x + 46.05 )</td>
<td>0.97</td>
<td>18.00</td>
<td>119.86</td>
</tr>
<tr>
<td>RBLE</td>
<td>( y = 0.1375x + 49.453 )</td>
<td>0.96</td>
<td>3.98</td>
<td>-</td>
</tr>
</tbody>
</table>

Figure 1. DPPH Scavenging Activity of Eugenol, Hydroxychavicol, and RBLE in Various Concentrations (A). DPPH Scavenging Activity (B). Eugenol, Hydroxychavicol, and RBLE were diluted in DMSO to reach final concentration of 250, 125, 62.50, 31, 25, 15, 63, 7.81 (µg/mL). Different letter in the same sample of eugenol (a, b, c, d, e), hydroxychavicol (A, B, C, D, E), RBLE (α, β, γ, δ, ε) indicate significant differences among sample concentrations based on Tukey’s HSD Post hoc comparisons (P < 0.05).
used to measure decrease of blue-green colored ABTS radical solution by hydrogen-donating antioxidant.\textsuperscript{13}  
The result of ABTS-reducing activity has been shown at Figure 3. All samples showed high activity at a concentration of 50 µg/mL. RBLE has the lowest ABTS-reducing activity, indicated by the highest IC\textsubscript{50} value (38.43 µg/mL) compared to hydroxychavicol (3.10 µg/mL) and eugenol compounds (1.81 µg/mL). Based on the result, it can be indicated that RBLE had lower antioxidant activity compared to hydroxychavicol and eugenol (Table 3).

ABTS-reducing assay is based on the ability of the antioxidants to quench the ABTS\textsuperscript+ radical cation. ABTS-reducing activities of samples are RBLE < hydroxychavicol < eugenol. IC\textsubscript{50} of each sample was 38.43 µg/mL (RBLE), 3.10 µg/mL (hydroxychavicol), and 1.18 µg/mL (eugenol). IC\textsubscript{50} of hydroxychavicol and eugenol was equivalent with 20.64 µM and 7.19 µM. According to Widowati\textit{et al}\textsuperscript{11}, eugenol had IC\textsubscript{50} value of 1.56 µg/mL, equivalent with 9.54 µM.

The Ferric Reducing Antioxidant Power (FRAP) method is based on the decrease of a ferroin analog, the Fe\textsuperscript{3+} complex of tripyridyltriazine (Fe(TPTZ))\textsuperscript{3+} changes to the extremely blue colored Fe\textsuperscript{2+} complex (Fe(TPTZ))\textsuperscript{2+} by antioxidants in acidic medium. Antioxidant reduction of appropriate tripyridyltriazine Fe(III) complex produces absorbance of Fe(II) complex at 593nm.\textsuperscript{13}  Based on Figure 4, at the highest concentration, each sample had high activity
of FRAP reduction (eugenol= 424.67 µM Fe(II)/µg, hydroxychavicol= 371.17 µM Fe(II)/µg, and RBLE= 227.75 µM Fe(II)/µg) which were significant. On the other hand, at the lowest concentration, each sample had almost the same activity values (eugenol= 64.17 µM Fe(II)/µg, hydroxychavicol= 44.33 µM Fe(II)/µg, and RBLE= 50.58 µM Fe(II)/µg).

On the other hand, RBLE had the highest FRAP-reducing activity compared to eugenol and hydroxychavicol. The order can be as hydroxychavicol < eugenol < RBLE. The highest percentage of activity was RBLE (227.75 µM Fe(II)/µg) at the concentration of 50 µg/mL while the lowest was hydroxychavicol (44.33 µM Fe(II)/µg). Srivastava et al.20 reported that P. betle had FRAP-reducing activity around 3.44 GAE/g. In addition, Widowati et al.11 suggested that FRAP-reducing activity of eugenol at concentration of 250 µM and 50 µM was 402.42 µM Fe(II)/µg and 155.13 µM Fe(II)/µg respectively.

4. Conclusion

The red betel leaf extract (P. crocatum Ruiz and Pav.) and its compounds (eugenol and hydroxychavicol)
have antioxidant activity as indicated by the results of the DPPH scavenging test, H$_2$O$_2$ scavenging, ABTS reduction, and FRAP reduction. However, RBLE had the lowest antioxidant activity compared to eugenol, hydroxychavicol.

5. Conflict of Interest

All authors state there is no conflict of interest.

6. Acknowledgement

We gratefully acknowledge the financial and facilities support provided by the Research Institutions and Community Service of Universitas Prima Indonesia, Medan, Indonesia for research grant 2018 and also Aretha Medika Utama Biomolecular and Biomedical Research Center, Bandung, Indonesia for providing research methodology and laboratory facilities. We would also extend our gratitude to Annisa Amalia, Ubaydillah Zedd Munshy, Satrio Haryo Benowo Wibowo, Hanna Sari Widya Kusuma, Wahyu Setia Widodo from Aretha Medika Utama-Biomolecular and Biomedical Research Center, Bandung, Indonesia for their technical support.

7. References


