Pharmacogn J. 2022; 14(4): 305-312
A Multifaceted Journal in the field of Natural Products and Pharmacognosy
www.phcogj.com

Original Article

Antioxidant Capacity and Potential as an Alpha-Glucosidase Inhibitor in *Phaleria macrocarpa* (Scheff.) Boerl Fruit Peel Ultrasonic Extract

Candra Irawan[1], Maman Sukiman[2,*], Ismail[3], Imalia Dwi Putri[1], Andita Utami[3], Andrean Nur Pratama[4], M. Ilham Kumala Zalni[2]

Candra Irawan[1], Maman Sukiman[2,*], Ismail[3], Imalia Dwi Putri[1], Andita Utami[3], Andrean Nur Pratama[4], M. Ilham Kumala Zalni[2]

[1]*Department of Food Nanotechnology, Politeknik AKA Bogor, Jalan Pangeran Sogiri, Tanah Baru, Bogor 16154, INDONESIA.*

[2]*Department of Industrial Waste Treatment, Politeknik AKA Bogor, Jalan Pangeran Sogiri, Tanah Baru, Bogor 16154, INDONESIA.*

[3]*Department of Chemical Analysis, Politeknik AKA Bogor, Jalan Pangeran Sogiri, Tanah Baru, Bogor 16154, INDONESIA.*

[4]*Research and Development Planning Agency, Tanggamus District, Lampung, INDONESIA.*

Correspondence

Maman Sukiman

Department of Industrial Waste Treatment, Politeknik AKA Bogor, Jalan Pangeran Sogiri, Tanah Baru, Bogor 16154, INDONESIA.

E-mail: maman@aka.ac.id

History

- Submission Date: 07-05-2022;
- Review completed: 02-06-2022;
- Accepted Date: 06-06-2022.

DOI : 10.5530/pj.2022.14.100

Article Available online

http://www.phcogj.com/v14/i4

ABSTRACT

Phaleria macrocarpa (Scheff.) Boerl is native to the tropical region of Papua Island, Indonesia, and has traditionally been used as a herbal drink, either alone or in combination with other medicinal plants, to treat diseases such as cancer, hypertension, and diabetes mellitus. This study aimed to obtain the fruit peel extract of *Phaleria macrocarpa* (Scheff.) Boerl. through the application of ultrasound-assisted extraction (UAE) with variations in time and amplitude to produce optimal extraction conditions. The potential of the extract as an antioxidant using the cupric ion reducing antioxidant capacity (CUPRAC) and ferric reducing antioxidant power (FRAP) methods, and its potential as an antidiabetic through alpha glucosidase inhibition. The optimum extract selected was extract C (extraction time was 45 minutes and amplitude 60%) with IC_{50} values for antioxidant activity in the CUPRAC method of 39.63 ± 0.009 mg/L and the FRAP method of 77.37 ± 0.8 mg/L, while the inhibition of alpha glucosidase was 0.45 ± 0.007 mg/L. It can be concluded that the ethanol extract of *Phaleria macrocarpa* fruit peel has the potential as a source of antioxidants and anti-diabetic.

Key words: *Phaleria macrocarpa* (Scheff.) Boerl, Antioxidant, Antidiabetic, Alpha-glucosidase.

INTRODUCTION

Since 2000, a natural and healthy lifestyle has attracted the attention of people all over the world. The use of natural bioactive compounds in food or for medical applications is increasing.[1] Because of its numerous antioxidant properties, the medicinal properties of this natural bioactive compound have been studied scientifically all over the world. Furthermore, the use of plants as traditional medicine is a topic of research because medicinal plants have good benefits such as low toxicity if used properly, low cost, and easy access.[2] *Phaleria macrocarpa* (Scheff.) Boerl is one of these plants. It is a native plant of Indonesia's Papua Island's tropical areas.[3]

P. macrocarpa has traditionally been used as a herbal drink, either alone or in combination with other medicinal plants, to treat illnesses such as cancer, hypertension, and diabetes mellitus.[4] Several studies have been conducted on the biological and pharmacological activities of the stem, leaves, fruit, and seed parts.[5] Furthermore, studies show that secondary metabolites of this plant, such as tannins, saponins, phenolic compounds, flavonoids, terpenoids, and alkaloids, play an important role as antioxidants, anti-inflammatory, antimicrobial, and cytotoxic agents.[6,7]

Antioxidants are important in life because they can neutralize or destroy free radicals such as reactive oxygen species (ROS). ROS can damage cell membranes, damage proteins, and cause DNA mutations. If this condition persists, it can cause oxidative stress,[8] which can cause cancer, inflammation, arthritis, atherosclerosis, Alzheimer's disease, Parkinson's disease, neurodegenerative diseases, and diabetes mellitus.[8-11]

According to the International Diabetes Federation (IDF), diabetes will affect 643 million people in 2030 and 783 million people in 2045.[12] Type 2 Diabetes Mellitus (T2DM) accounts for approximately 90% of all diabetes cases, and it is primarily caused by obesity and a lack of physical activity.[13] Agents with alpha-glucosidase inhibitory activity have been found to be effective as oral hypoglycemic agents in the treatment of hyperglycemia in T2DM patients.[14] Acarbose, miglitol, voglibose, and emiglitate are currently the most commonly used drugs for the treatment of diabetes.Side effects of these medications include flatulence, stomach cramps, vomiting, and diarrhea. Because of these effects, several studies have been conducted to identify natural sources of alpha-glucosidase inhibitors.[15]

The use of ultrasound-assisted extraction (UAE) to obtain an ethanolic extract of *Phaleria macrocarpa* fruit peel and assay of antioxidant activity using the FRAP and CUPRAC methods as well as alpha glucosidase inhibitory activity against ultrasonic extracts have not been previously reported. This extract will be prepared using an UAE method. In order to obtain optimum conditions, the extraction is carried out by varying the time and percent amplitude.

METHODS

Simplicia setup

The plants used were previously determined by the correctness of identity in the Herbarium Bogoriense, Botany field of the National Research and Innovation

Cite this article: Irawan C, Sukiman M, Ismail, Putri ID, Utami A, Pratama AN, et al. Antioxidant Capacity and Potential as an Alpha-Glucosidase Inhibitor in *Phaleria macrocarpa* (Scheff.) Boerl Fruit Peel Ultrasonic Extract. Pharmacogn J. 2022;14(4): 305-312.

Agency, Cibinong, Bogor Regency, West Java. *Phaleria macrocarpa* fruit peel samples were obtained farmers in Bogor. Simplicia was mashed using a blender then the simplicia powder was stored in a dry container, closed, identified and protected from direct sunlight.

Extraction of simplicia

The procedure refers to Irawan's research using the UAE method.[16] The dried fruit peel powder was weighed as much as 7 grams and placed in a 250 mL beaker four times. Then 70% technical ethanol solvent was added, until the dried fruit peel powder was submerged and everything was well mixed. Fruit peel simplicia was extracted with UAE using time variation parameters/minutes and amplitude/% at 30 minutes-60% (A); 35 minutes-65% (B); 45 minutes-60% (C); and 45 minutes-65% (D). The extraction results were filtered to separate the liquid extract from the dregs and placed in a weighed beaker. Each beaker has a capacity of 250 mL. To obtain a fruit peel yield, the filtrate in the 250 mL beaker was removed by removing the ethanol solvent by evaporation using an oven at a temperature setting of 40 °C and leaving it until all of the ethanol had evaporated. The extract was weighed without the solvent, and the percent yield value was calculated.

Total phenolic content

The total phenolic content of fruit peel *Phaleria macrocarpa* was determined using the Folin–Ciocalteu method.[17] The crude extract solution with a concentration of 1000 ppm was pipetted as much as 400 µL and put into a measuring flask with a capacity of 10 mL. The solution was added with distilled water up to 5 mL, then shaken until homogeneous, then 1 mL of Folin-Ciocalteu reagent was added and shaken again until homogeneous, then allowed to stand for 3 minutes. Then 2.5 mL of sodium carbonate (10% w/v) was added and homogenized again. The solution was left in the dark for 60 minutes, and the absorbance was measured at a wavelength of 650 nm. Gallic acid calibration curves (concentrations of 0, 2, 4, 6, and 8 mg/L) were used to calculate the total phenol content. The result is given in milligrams of gallic acid equivalent per gram of dry mass.

Antioxidant activity test using Cupric Ion Reducing Antioxidant Capacity (CUPRAC) method

Antioxidant testing of the CUPRAC method using the procedure that has been used by Irawan *et al.*[16] The work was done on the crude ethanol extracts of treatments A, B, C, and D that were obtained during the extraction process with the UAE. A solution of fruit peel ethanol extract with a concentration range of 20 to 80 mg/L was prepared from a mother liquor of 1000 mg/L fruit peel ethanol extract. Each solution was placed in five 5 mL volumetric flasks, followed by 1 mL of CUPRAC solution. After that, each solution was homogenized with ethanol p.a. The solution was incubated for 30 minutes at 37°C, then the absorbance of the solution was measured using a visible spectrophotometer at a wavelength of 459 nm. The same steps were conducted on a standard solution of butylated hydroxytoluene (BHT) with a concentration of 1, 2, and 3 mg / L. Reducing activity can be calculated with the following equation:

$$\%.\,Reduction\,Power = \frac{(A_{sample} - A_{blank})}{A_{sample}} x\,100\%$$

Details:

A_{blank} = Absorbance without sample

A_{sampel} = Absorbance of sample

The calculated values were tranformed into a linear equation (Y = bX + a) with the ppm concentration (mg / L) as the abscissa (X-axis) and the % value of the reduction as the ordinate (Y-axis). The IC_{50} value was obtained from the calculation when the % reduction was 50%.

$$IC50 = \frac{50 - a}{b}$$

Antioxidant activity test using Ferric Reducing Antioxidant Power (FRAP) method

Antioxidant testing of the FRAP method using the procedure that has been used by Irawan *et al.*[17] The work was done on the crude ethanol extracts of treatments A, B, C, and D that were obtained during the extraction process with the UAE. A solution of fruit peel ethanol extract with a concentration range of 40 to 160 mg/L was prepared from a mother liquor of 1000 mg/L fruit peel ethanol extract. Each solution was placed in five 5 mL volumetric flasks, then 0.4 mL of 0.001 M citric acid was added; 0.2 mL of 0.002 M Fe^{3+} solution; and 0.4 mL of 0.2% o-phenanthroline, then filtered with distilled water and homogenized. The solution was incubated for 35 minutes at 37°C, then the absorbance of the solution was measured using a visible spectrophotometer at a wavelength of 510 nm. The same steps were conducted on a standard solution of gallic acid with a concentration of 0.25, 0.5, and 0.75 mg/L. The IC_{50} value can be calculated based on the equation as in the determination of the CUPRAC method.

Alpha-Glucosidase inhibitor activity test

Testing of alpha-glucosidase inhibitory activity refers to the procedure used by Budiarso.[18] The work was done on the crude ethanol extracts of treatments A, B, C, and D that were obtained during the extraction process with the UAE. Acarbose as a standard and fruit peel ethanol extract samples were weighed and dissolved in phosphate buffer pH 6.8. Then, standard and sample solution were diluted into some concentrations. Thirty microliter standard and sample solution were added to 17 µL of para-Nitrophenyl-α-D-glucopyranoside substrate 4mM. The solutions were incubated at 37°C for 5 minutes, then 17 µL alpha-glucosidase solution was added. The solution was incubated again at 37°C for 15 minutes. After that, 100 µL sodium carbonate 200 mM was added, then the absorption of the solution was measured using a microplate reader at λ 405 nm. The same operation was carried out for sample control and blank control, but the addition of sodium carbonate was carried out before the addition of alpha glucosidase.

RESULT AND DISCUSSION

Ultrasonic-assisted extraction

Ultrasound assisted extraction of *Phaleria macrocarpa* fruit peel using 70% ethanol solvent with variations in time and amplitude resulted in a crude extract and yield of 1.5848 g and 21.83% for treatment A, 1.5449 g and 21.29% for treatment B, 1.5485 g and 21.33% for treatment C, and 1.3212 g and 18.47% for treatment D. Extracts A-C produced relatively

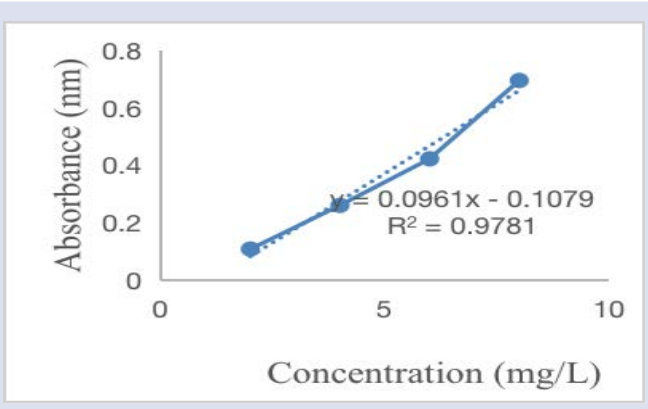


Figure 1: Curve for gallic acid used as a standard.

the same yield, which was about 21%, but in extract D (extraction time of 45 minutes and amplitude of 65%), the yield decreased to 18.47%. When compared with other extraction methods such as maceration, subcritical water, and microwave-assisted extraction (MAE), UAE was found to be more effective because it reduces the degradation of phenolic compounds.[19-21]

Total phenolic content of ethanol extract

The total phenolic content of *Phaleria macrocarpa* fruit peel was determined using the Folin-Ciocalteu method, with gallic acid as a control compound.[22,23] The absorbance of the measured standard series of gallic acid can be seen in the standard curve as in Figure 1. The standard curve of gallic acid had a linear regression equation y = 0.0961x - 0.1079 with an R^2 value of 0.9781. The total phenol content in the ethanol extract of fruit peels with various times and amplitudes obtained from this equation can be seen in Table 1.

Table 1 shows that the highest total phenol content in the *Phaleria macrocarpa* fruit peel extract with treatment B was 2072.63 ± 0.6 mg GAE/g extract. For treatments A and C, the total phenolic content was relatively the same, while for treatment D it was lower. However, the total phenolic content identified from the 4 treatments was relatively high.

In general, phenolic compounds act as antioxidants. The greater the total phenolic content of natural ingredients, the greater their antioxidant activity.[24] Phenolic compounds donate a proton to free radicals, causing them to become stable radicals.[25,26]

Antioxidant activity using CUPRAC method

The antioxidant activity test results with CUPRAC method are expressed as % reduction power (Table 2), which is then linked to a series of sample or standard concentrations to produce a curve, as shown in Figure 2. The regression equation of BHT and ethanol extract of *Phaleria macrocarpa* fruit peel with treatments A, B, C, and D obtained were y = 19.905x + 9.8499; y = 0.2612x + 38.913; y = 0.5285x + 28.866; y = 0.4445 + 32.384; and y = 0.4723x + 29.693, respectively. From this equation, the IC_{50} values for BHT, treatment extracts A, B, C, and D were 2.02 ± 0.01, 42.45 ± 0.6, 39.99 ± 0.2, 39.63 ± 0.009, and 39.99 ± 0.2 mg/L, respectively. In general, BHT has a stronger reducing power against CUPRAC reagent than the ethanol extract of *Phaleria macrocarpa* fruit peel. The antioxidant activity of *Phaleria macrocarpa* fruit peel extract with treatments A, B, C, and D was included in the very strong category because the IC_{50} value was less than 50 mg/L.[27]

These findings suggest that an ethanol extract of *Phaleria macrocarpa* fruit peel could be used as an alternative source of natural antioxidants. The oxidation and reduction properties of phenolic compounds in natural materials can cause an antioxidative effect. This redox property is important in peroxide digestion, quenching singlet and triplet oxygen and trapping and neutralizing free radicals.[28,29]

Antioxidant activity using FRAP method

The antioxidant activity test results with FRAP method are expressed as % reduction power (Table 3), which is then linked to a series of sample or standard concentrations to produce a curve, as shown in Figure 3.

Table 1: Total phenolic content of ethanolic extract of *Phaleria macrocarpa* fruit peel.

Sample	Total Phenolic Content (mg GAE/g extract)
A (30 minutes - 60%)	1676.43 ± 0.2
B (35 minutes - 65%)	2072.63 ± 0.6
C (45 minutes - 60%)	1670.81 ± 0.3
D (45 minutes - 65%)	1633.71 ± 0.3

Table 2: The results of the CUPRAC method antioxidant activity test.

Sample	Concentration (mg/L)	% Reduction Power	IC_{50} (mg/L)
	1	27.42 ± 0.3	
BHT	2	54.34 ± 0.2	2.02 ± 0.01
	3	67.23 ± 0.1	
	20	44.05 ± 0.2	
A	40	49.54 ± 0.1	42.45 ± 0.6
	60	54.50 ± 0.1	
	20	38.14 ± 0.2	
B	40	51.95 ± 0.1	39.99 ± 0.2
	80	70.50 ± 0.08	
C	20	41.17 ± 0.2	
	40	50.32 ± 0.1	39.63 ± 0.009
	80	67.89 ± 0.06	
D	20	38.14 ± 0.2	
	40	51.95 ± 0.1	39.99 ± 0.2
	80	70.50 ± 0.08	

Table 3: The results of the FRAP method antioxidant activity test.

Sample	Concentration (mg/L)	% Reduction Power	IC_{50} (mg/L)
	0.25	29.21 ± 0.3	
Gallic Acid	0.50	46.98 ± 0.1	0.60 ± 0.006
	0.75	56.90 ± 0.7	
	40	19.71 ± 0.6	
A	80	42.01 ± 0.5	116.67 ± 1.4
	160	63.62 ± 0.5	
	40	40.14 ± 0.5	
B	60	47.98 ± 0.6	64.61 ± 0.9
	80	56.28 ± 0.4	
C	40	26.43 ± 0.5	
	60	37.92 ± 0.9	77.37 ± 0.8
	80	52.15 ± 0.4	
D	40	33.20 ± 0.7	
	60	44.70 ± 0.4	73.46 ± 0.7
	80	52.56 ± 0.4	

Table 4: The results of the alpha-glucosidase activity inhibition test.

Sample	Concentration (mg/L)	% Reduction Power	IC_{50} (mg/L)
	10	27.01 ± 0.2	
Acarbose	50	47.68 ± 0.07	55.84 ± 0.2
	100	71.59 ± 0.4	
	0.25	27.96 ± 0.05	
A	0.75	40.47 ± 0.03	1.60 ± 0.04
	2	55.12 ± 0.1	
	0.25	27.01 ± 0.2	
B	0.75	35.13 ± 0.03	1.78 ± 0.001
	2	53.19 ± 0.01	
C	0.25	37.69 ± 1	
	0.50	53.87 ± 0.04	0.45 ± 0.007
	0.75	66.50 ± 0.03	
D	0.5	36.81 ± 0.05	
	0.75	41.28 ± 0.1	1.33 ± 0.03
	1.5	52.53 ± 0.06	

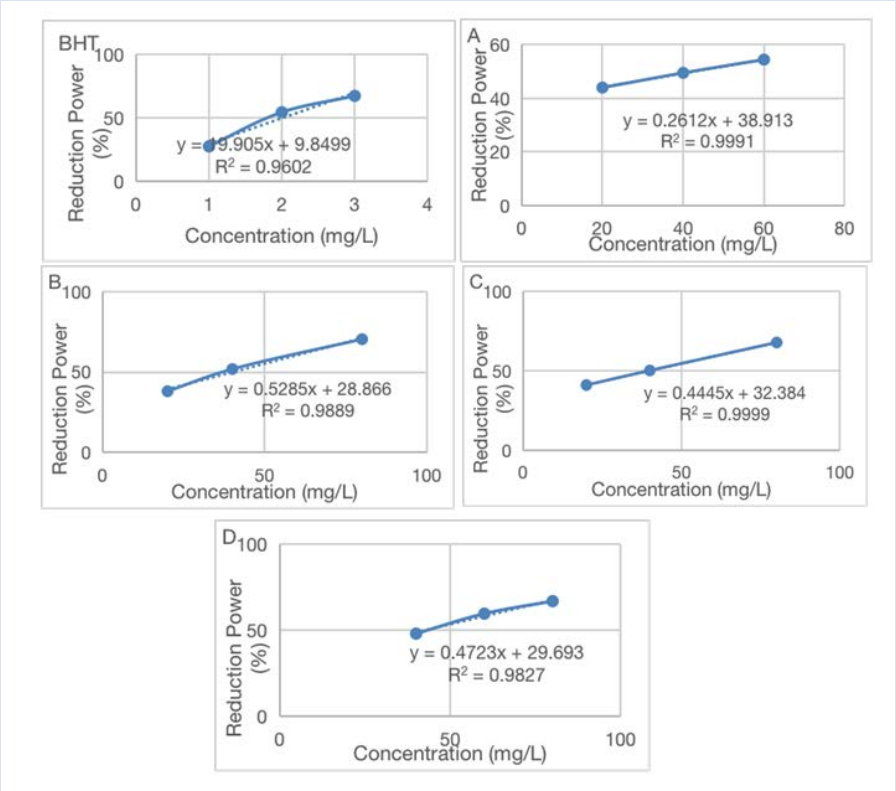


Figure 2: Graph of the relationship between concentration and % reduction power for IC_{50} determination of BHT, (A) (A) ethanolic extracts of *Phaleria macrocarpa* fruit peel in 30 minutes extraction time-60% of amplitude, (B) with 35 minutes extraction time-65% of amplitude, (C) with 45 minutes extraction time-60% of amplitude, and (D) with 45 minutes extraction time-65% of amplitude

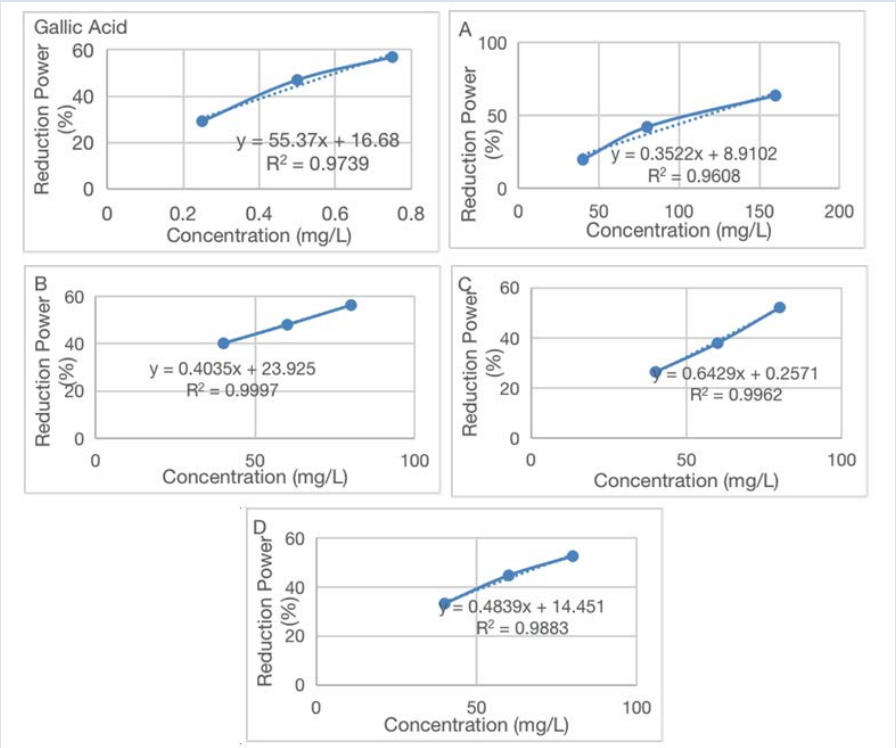


Figure 3: Graph of the relationship between concentration and % reduction power for IC_{50} determination of gallic acid, (A) ethanolic extracts of *Phaleria macrocarpa* fruit peel in 30 minutes extraction time-60% of amplitude, (B) with 35 minutes extraction time-65% of amplitude, (C) with 45 minutes extraction time-60% of amplitude, and (D) with 45 minutes extraction time-65% of amplitude

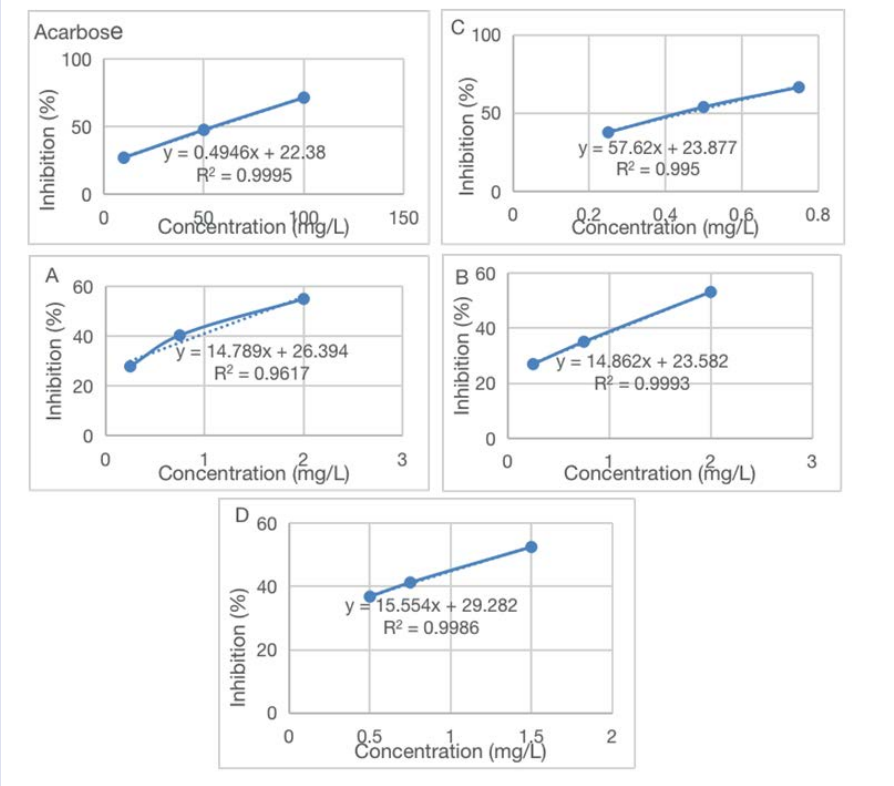


Figure 4: Graph of the relationship between concentration and % inhibition for IC_{50} determination acarbose, (A) ethanolic extracts of Phaleria macrocarpa fruit peel in 30 minutes extraction time-60% of amplitude, (B) with 35 minutes extraction time-65% of amplitude, (C) with 45 minutes extraction time-60% of amplitude, and (D) with 45 minutes extraction time-65% of amplitude.

The regression equation of gallic acid and ethanol extract of *Phaleria macrocarpa* fruit peel with treatments A, B, C, and D obtained were y = 55.37x + 16.68; y = 0.3522x + 8.9102; y = 0.4035x + 23.925; y = 0.6429x + 0.2571 and y = 0.4839x + 14.451, respectively. From this equation, the IC_{50} values for gallic acid, treatment extracts A, B, C, and D were 0.60 ± 0.006, 116.67 ± 1.4, 64.61 ± 0.9, 77.37 ± 0.8, and 73.46 ± 0.7 mg/L, respectively. In general, BHT has a stronger reducing power against CUPRAC reagent than the ethanol extract of *Phaleria macrocarpa* fruit peel. The antioxidant activity of *Phaleria macrocarpa* fruit peel extract with treatments B, C, and D was included in the because the IC_{50} value was in the range of 50-100 mg/L.[27]

The IC_{50} value produced by the FRAP method is lower than the CUPRAC method because the FRAP method is limited to water-soluble antioxidants and cannot be used for compounds containing thiol or carotenoid groups. This is because carotenoids do not have the ability to reduce iron.[30]

Potential inhibition of alpha-glucosidase activity of fruit peel ethanol extract

The alpha glucosidase inhibitory activity assay results were expressed as a percentage of inhibition (Table 4), which was then linked to a series of samples or standard concentrations to produce a curve, as shown in Figure 4. The regression equation of acarbose and ethanol extract of *Phaleria macrocarpa* fruit peel with treatments A, B, C, and D obtained were y = 0.4946x + 22.38; y = 14.789x + 26.394; y = 14.862 + 23.582; y = 57.62x + 23.877 and y = 15.554x + 29.282, respectively. From this equation, the IC_{50} values for acarbose, treatment extracts A, B, C, and D were 55.84 ± 0.2, 1.60 ± 0.04, 1.78 ± 0.001, 0.45 ± 0.007, and 1.33 ± 0.03 mg/L, respectively.

The IC_{50} value of *Phaleria macrocarpa* fruit peel ethanol extract was lower than the acarbose standard, meaning that the ethanol *Phaleria macrocarpa* fruit peel extract had higher alpha-glucosidase inhibiting activity than the acarbose standard. The high alpha-glucosidase inhibitory activity of *Phaleria macrocarpa* fruit peel extract was correlated with antioxidant activity. Based on the research, the most active activity resulted in extract C of 0.45 ± 0.007 followed by extract D of 1.33 ± 0.03. Therefore, the optimum condition chosen for this extraction was an extraction time of 45 minutes with an amplitude of 60% (C).

The antioxidant and anti-diabetic properties of natural material are related to the presence of phenolic compounds that can donate hydrogen atoms to free radicals to become less reactive. By acting as competitive inhibitors of carbohydrate-digesting enzymes, phenolic compounds can also inhibit alpha-glucosidase. As a result, it takes longer for carbohydrates to be hydrolyzed into glucose molecules.[15]

CONCLUSION

Based on the results of the study, it can be concluded that the *Phaleria macrocarpa* fruit peel extract in all treatments had strong antioxidant activity using either the FRAP or CUPRAC methods. In addition, it is very active as an antidiabetic by inhibiting alpha glucosidase. The optimum extract selected was extract C (extraction time was 45 minutes and amplitude 60%) with IC_{50} values for antioxidant activity in the FRAP method of 77.37 ± 0.8 mg/L and the CUPRAC method of 39.63 ± 0.009 mg/L, while the inhibition of alpha glucosidase was 0.45 ± 0.007 mg/L. It can be concluded that the ethanol extract of *Phaleria macrocarpa* fruit peel has the potential as a source of antioxidants and anti-diabetic.

ACKNOWLEDGEMENT

This work was supported by the Industrial Resources Development Agency of the Ministry of Industry, Indonesia.

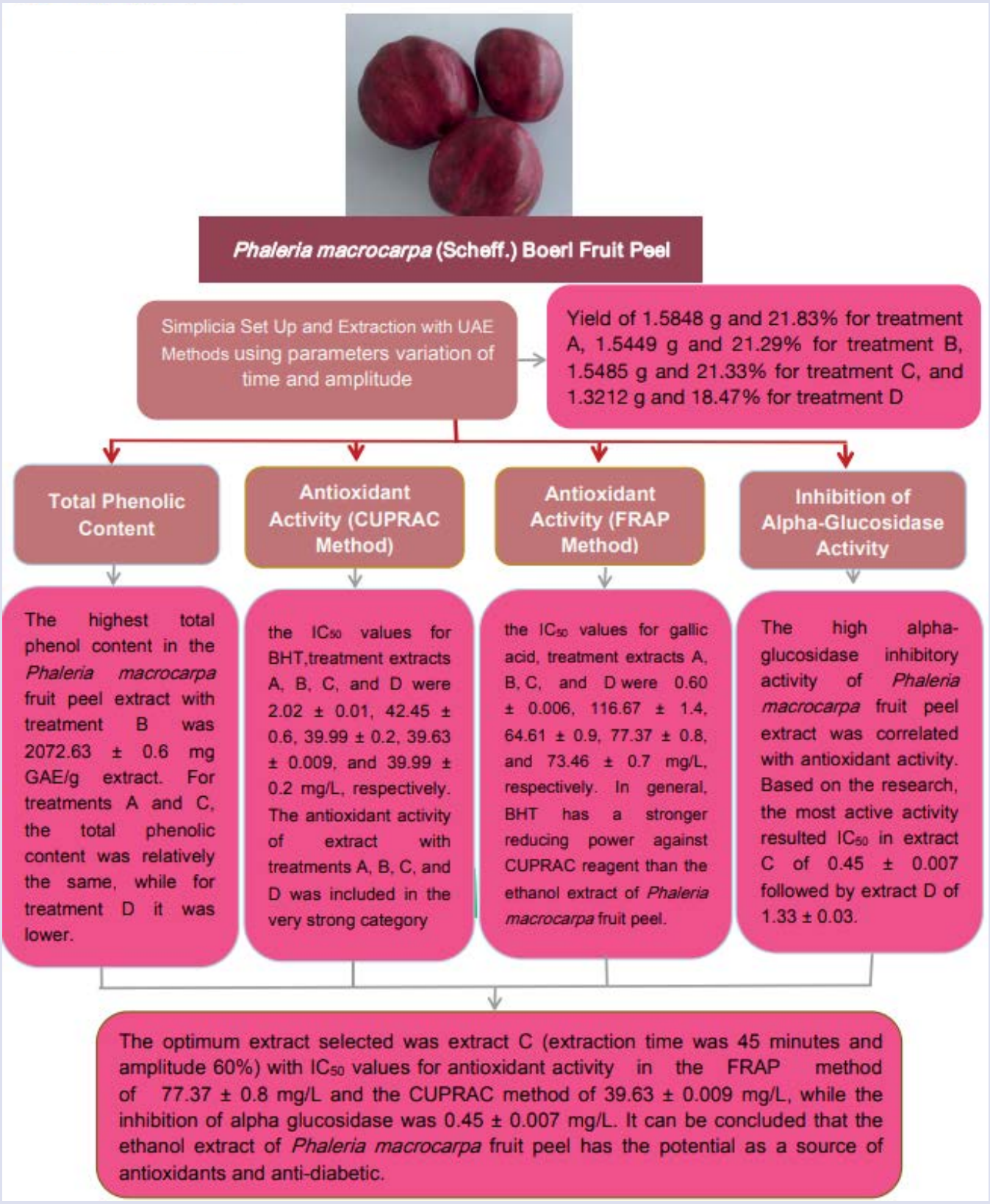
CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

REFERENCES

1. Gong Y, Hou Z, Gao Y, Xue Y, Liu X, Liu G. Optimization of extraction parameters of bioactive components from defatted marigold (*Tageteserecta* L.) residue using response surface methodology. Food Bioprod Process. 2012;90:9-16.
2. Kumar S, Kumar D, Singh N, Vasisht BD. *In vitro*, free radicals scavenging and antioxidant activity of *Moringa Oleifera* pods. J Herbs Med Toxicol, 2007;1:17-22.
3. Sufi A. Lignans in *Phaleria macrocarpa* (Scheff.) Boerl. and in Linum flavum var compactum L. Faculty of Mathematics and Natural Sciences, Heinrich-Heine-University Dusseldorf, Mataram, Indonesia. 2007;104.
4. Kurnia D, Akiyama K, Hayashi H. Norcucurbitacin derivative isolated from Indonesian medicinal plant, *Phaleria macrocarpa* (Scheff.) Boerl. Biosci Biotechnol Biochem. 2008;72(2):618-620.
5. Ali RB, Atangwho IJ, Kaur N, Abraika OS, Ahmad M, Mahmud R, *et al*. Bioassay-guided antidiabetic study of *Phaleria macrocarpa* fruit extract. Molecules. 2012;17(5):4986-5002.
6. Hendra R, Ahmad S, Sukari A, Shukor MY, Oskoueian E. Flavonoid analyses and antimicrobial activity of various parts of *Phaleria macrocarpa* (Scheff.) Boerl fruit. Int J Mol Sci. 2011;12(6):3422-31.
7. Hendra R, Ahmad S, Oskoueian E, Sukari A, Shukor MY. Antioxidant, antiinflammatory and cytotoxicity of *Phaleria macrocarpa* (Boerl.) Scheff fruit. BMC Complementary Altern Med. 2011;11:110.
8. Dontha S. A review on antioxidant methods. Asian J Pharm Clin Res. 2016;9(2):14-32.
9. Badarinath AV, Rao K, Chetty CMS, Ramkanth S, Rajan TVS, Granaprakash K. A review on *in-vitro* antioxidant methods: comparisions, correlations and considerations. Int J PharmTech Res. 2010;2(2):1276-1285.
10. Uttara B, Singh, AV, Zaboni P, Mahajan MT. Oxidative Stress and Neurodegenerative Diseases: A review of upstream and downstream antioxidant therapeutic options. Curr Neuropharmacol. 2009;7(1):65-74.
11. Joon K, Takayuki S. Antioxidant assays for plant and food components. J Agric. Food Chem. 2009;57(5):1655-1666.
12. International Diabetes Federation. IDF Diabetes Atlas. 10th edition, International Diabetes Federation. 2021, https://diabetesatlas.org/.
13. Goyal R, Jialal I. Diabetes mellitus type 2. in: StatPearls [Internet], Treasure Island (FL): StatPearls Publishing, 2021. https://www.ncbi.nlm.nih.gov/books/NBK513253/
14. Önal S, Timur S, Okutucu B, Zihnioğlu F. Inhibition of α-glucosidase by aqueous extracts of some potent antidiabetic medicinal herbs. Preparative Biochem Biotech. 2005;35(1):29-36.
15. Patil P, Mandal S, Tomar SK, Anand S. Food protein-derived bioactive peptides in management of type 2 diabetes. Eur J Nutr. 2015;54(6):863-880.
16. Irawan C, Elya B, Hanafi M, Saputri FC. Application of ultrasound-assisted extraction on the stem bark of *Rhinachantus nasutus* (L.) Kurz, total Phenolic, and Its potential as antioxidant and inhibitor of alpha-glucosidase enzyme activity. Pharmacogn J. 2021;13(5):1-7.
17. Irawan C, Utami A, Styani E, Putri ID, Putri, RK, Dewanta A, *et al*. Potential of Ethanolic Extract from Ripe *Musa balbisiana* Colla Fruit Using Ultrasound-Assisted Extraction as an Antioxidant and Anti-Gout. Pharmacogn J. 2021;13(6):1332-1340.
18. Budiarso FS, ElyA B, Hanafi M, Forestranla RC. The potential of stem bark of kayu sarampa (*Xylocarpus moluccensis* (Lam.) M. Roen) as α-glucosidase inhibitor. Pharmacogn J. 2020;12(6):1368-1376.
19. Barbero GF, Liazid A, Palma M, Barroso CG. Ultrasound-assisted extraction of capsaicinoids from peppers. Talanta. 2008;75(5):1332-1337.
20. Luque-García JL, Luque de Castro MD. Ultrasound: A powerful tool for leaching. TrAC Trends Anal Chem. 2003;22:41-47.
21. Mulinacci N, Prucher D, Peruzzi M, Romani A, Pinelli P, Giaccherini C, *et al*. Commercial and laboratory extracts from artichoke leaves: Estimation of caffeoyl esters and flavonoidic compounds content. J Pharm Biomed Anal. 2004;34(2):349-357.
22. Pourmorad F, Hosseinimehr SJ, Shahabimad N. Antioxidant activity, phenol and flavonoid contents of some selected Iranian medicinal plants. Afr J Biotechnol. 2006;5(1):1142-1145.
23. Lee KW, Kim YJ, Lee HJ, Lee CY. Cocoa Has More Phenolic Phytochemical and A Higher Antioxidant Capacity than Teas and Red Wine. J Agric Food Chem. 2003;51(25):7292-7295.
24. Huang D, Ou B, Prior RL. The chemistry behind antioxidant capacity assays. J Agric Food Chem. 2005;53(6):1841-1856.
25. Mathew S, Abraham TE, Zakaria ZA. Reactivity of phenolic compounds towards free radicals under in vitro conditions. J Food Sci Technol. 2015;52(9):5790-5798.
26. Chiorcea-Paquim AM, Enache TA, De Souza GE, Oliveira-Brett AM. Natural phenolic antioxidants electrochemistry: towards a new food science methodology. Compr Rev Food Sci Food Saf. 2020;19(4):1680-1726.
27. Jun M, Fu HY, Hong J, Wan X, Yang CS, Ho CT. Comparison of antioxidant activities of isoflavones from kudzu root (*Pueraria lobate* Ohwi). J Food Sci. 2006;68(6):2117-2122.
28. Nurliyana R, Syed Zahir I, Mustapha SK, Aisyah MR, Kamarul RK. Antioxidant study of pulps and peels of dragon fruits: a comparative study. Int Food Res J. 2010;17:367-375.
29. Osawa T. Novel natural antioxidants for utilization in food and biological systems. Post-harvest biochemistry of plant food materials in the tropics. Japan Scientific Societies Press. 1994;241-251.
30. Apak R, Guclu K, Demirata B, Ozyurek M, Celik SE, Betasoglu B, *et al*. Comparative evaluation of various total antioxidant capacity assay applied to phenolic compounds with the CUPRAC assay. Molecules. 2007;12(7):1496-1547.

GRAPHICAL ABSTRACT



ABOUT AUTHORS

Candra Irawan is a Lecturer at the Department of Food Nanotechnology, Politeknik AKA Bogor, Indonesia. He has research experience in the field of Phytochemistry and Natural Product.

Maman Sukiman is a Lecturer at the Department of Industrial Waste Treatment, Politeknik AKA Bogor, Indonesia. He has research experience in the field of Natural Product and Chemical Environment.

Ismail is a Doctoral Natural Resources and Environmental Management Student at IPB University, Bogor, West Java 16143, Indonesia and Lecturer at Chemical Analysis Department, Politeknik AKA Bogor. He has research experience in field of Natural Resources.

Imalia Dwi Putri a lecturer at D-IV Department of Food Nanotechnology, Politeknik AKA Bogor, Indonesia. Research focus in functional foods, antioxidants from various plant extracts, and halal food.

Andita Utami is a Lecturer at the Department of Chemical Analysis, Politeknik AKA Bogor, Indonesia. She has research experience in the field of Natural Product and Antioxidants.

Andrean Nur Pratama is a Researcher at the Research and Development Planning Agency, Tanggamus District, Lampung, Indonesia. He has research experience in statistics.

M. Ilham Kumala Zalni is a college student at Politeknik AKA Bogor. He participates in research on natural products.

Cite this article: Irawan C, Sukiman M, Ismail, Putri ID, Utami A, Pratama AN, et al. Antioxidant Capacity and Potential as an Alpha-Glucosidase Inhibitor in *Phaleria macrocarpa* (Scheff.) Boerl Fruit Peel Ultrasonic Extract. Pharmacogn J. 2022;14(4): 305-312.