

Inhibition of alpha-glucosidase by polysaccharides from water lettuce (*Pistia stratiotes*) leaf extracts with different extraction methods

by Herpandi Napis

Submission date: 07-May-2025 11:51AM (UTC+0700)

Submission ID: 2668890703

File name: a_stratiotes_leaf_extracts_with_different_extraction_methods.pdf (481.23K)

Word count: 3867

Character count: 21732

INHIBITION OF ALPHA-GLUCOSIDASE BY POLYSACCHARIDES FROM WATER LETTUCE (*Pistia stratiotes*) LEAF EXTRACTS WITH DIFFERENT EXTRACTION METHODS

Sabri Sudirman^{1*}, Aatikah Dewi Ghaisani¹, Indah Widiastuti¹, Herpandi¹, Yohana Novelina Sirat¹, Miftahul Janna²

Address(es): Dr. Sabri Sudirman

¹ Fisheries Product Technology, Faculty of Agriculture, Universitas Sriwijaya, Indralaya - 30862, South Sumatra, Indonesia.

² Master Program in Agribusiness, Faculty of Agriculture, Universitas Sriwijaya, Palembang City - 30139, South Sumatra, Indonesia.

*Corresponding author: sabri.sudirman@unsri.ac.id

<https://doi.org/10.55251/jmbfs.9805>

ARTICLE INFO

Received 12. 1. 2023

Revised 26. 9. 2023

Accepted 4. 10. 2023

Published 1. 2. 2024

Regular article



ABSTRACT

Diabetes mellitus (DM) is a metabolic disorder that has a significant impact on the quality of life and health. This condition is indicated by high blood glucose or hyperglycemia. Alpha-glucosidase is an important enzyme during carbohydrate digestion to obtain monosaccharides such as glucose. This study aimed to investigate the alpha-glucosidase inhibitory activity of polysaccharides from water lettuce (*Pistia stratiotes*) leaf with different extraction methods. The leaf was extracted by hot water extraction (HWE) and ultrasound-assisted extraction (UAE). The total sugar, crude fiber, and alpha-glucosidase inhibitory activity were analyzed *in vitro*, then an independent-sample t-test was used to analyze the statistically different. The UAE method showed a high yield of crude extract than the HWE method. However, the total sugar of HWE is higher than UAE, whereas no different of crude fiber level. The extract from the HWE method more effectively inhibits the alpha-glucosidase activity when compared to UAE. Therefore, hot water extraction is the suitable method to extract polysaccharides from a water lettuce (*Pistia stratiotes*) leaf. This condition also indicated polysaccharides extract potential to develop as an antidiabetes agent.

Keywords: Alpha-glucosidase, extraction methods, inhibitory activity, *Pistia stratiotes*, polysaccharides

INTRODUCTION

Diabetes mellitus (DM) is a metabolic disorder that has a significant impact on the quality of life and health. This condition is indicated by high blood glucose or hyperglycemia that is caused either by insufficient insulin secretion (Type I DM), insulin resistance (Type II DM) or both (ADA, 2009). Some treatments that have been used for DM management include non-pharmacological such as physical activity or exercise (Ravendran, 2018) and pharmacological treatments such as consuming antidiabetic drugs (Su et al., 2015). Acarbose is an alpha-glucosidase inhibitor (AGI) that is widely used for DM treatment (Gu et al., 2015; Liu et al., 2021). Alpha-glucosidase is an important enzyme during carbohydrate digestion that hydrolyzed polysaccharides, oligosaccharides, or disaccharides to monosaccharides such as glucose (Gong et al., 2020). As an AGI, acarbose inhibits carbohydrate digestion, therefore it can delay glucose absorption in the small intestine thus having a blood-glucose-lowering effect (van de Laar et al., 2005). However, despite the ability of antidiabetic drugs on the diabetes management, it has some adverse effects such as gastrointestinal diseases and cardiovascular risks (He et al., 2014; DiNicolantonio et al., 2015). Therefore, research to find alternative alpha-glucosidase inhibitors is an emerging field, such as using plant extract as either a food supplement or functional food.

Water lettuce (*Pistia stratiotes*) is a floating aquatic plant that is commonly found in Indonesia. A recent study reported that the leaf of this plant contains some bioactive compounds that extracted by aqueous ethanol solvent, such as polyphenols, tannins, and flavonoids (Herpandi et al., 2021). Leaf is also containing other bioactive compounds including polysaccharides. As reported by the previous studies, polysaccharides were successfully extracted from the leaf of *Eucommia ulmoides* (Xu et al., 2018), *Nelumbo nucifera* (Song et al., 2020), *Talinum triangulare* (Yeh et al., 2021). These polysaccharides showed some biological activities including antioxidant activity (Xu et al., 2018), immunomodulatory effects (Yeh et al., 2021), and alpha-glucosidase inhibitor (Zhang and Li, 2015).

Various methods have been used for polysaccharides extraction such as hot-water extraction (Zhao et al., 2017), ultrasound-assisted extraction (Qu et al., 2013), microwave-assisted extraction (Xu et al., 2018), and freeze-thaw methods (Wang et al., 2018). Generally, hot water extraction is the most common method for extracting polysaccharides with the advantages of no special equipment required, low cost, simple operation, excellent quality of final product, and most suitable for preparation of acidic and neutral polysaccharides (Dong et al., 2016; Wang et al., 2021). However, all these methods show different effects on the yield, activity, and bioavailability of the polysaccharides. According to these conditions, we

hypothesized that the different extraction methods also affect to polysaccharides of water lettuce. Therefore, this study aimed to investigate the effect of hot-water and ultrasound-assisted extraction on the yield, total sugar, and crude fiber contents as well as alpha-glucosidase inhibitory activity of polysaccharides from water lettuce (*Pistia stratiotes*).

MATERIALS AND METHODS

Preparation and extraction

The water lettuce (*Pistia stratiotes*) was collected from Sukaraja Village, Indralaya, South Sumatra, Indonesia. The plant was transported to the Laboratory for preparation. Briefly, the leaf was cleaned with water to remove the unwanted substances then was cut to smaller pieces. After that, it was dried by oven-drying at 40°C for 12 h. The sample then was grounded to obtain powder form and kept for extraction process.

The polysaccharides were extracted from the water lettuce leaf by hot water extraction (Wang et al., 2018) and ultrasound-assisted extraction (Liu et al., 2014). Briefly, 10 g of dry sample was extracted by 400 mL of distilled water (dH₂O) in an Erlenmeyer flask. The extraction with hot water was used hot plate magnetic stirrer at 90°C for 8 h and stirring at 120 rpm. Whereas the ultrasound-assisted extraction was performed at 180 W, 40 kHz, and 50°C for 3 h. After that, the mixture was centrifuged at 4,300 rpm for 20 min. The supernatant of each extraction method was collected into a new collection tube and then the polysaccharides precipitated by using a 95% ethanol for 24 h at freeze temperature. The polysaccharides were collected by centrifugation at 4,300 rpm for 20 min. The polysaccharides extract was dried by using a freezer dryer to obtain dried-polysaccharides extract in powder form. It was then kept at cold temperature (4°C) for further analysis.

Total sugar, crude fiber, and FT-IR analysis

The total sugar was analyzed by the Phenol-Sulfuric acid methods (Nielsen, 2017). Briefly, 10 mL (5 mg/mL in 80% ethanol) of the sample was placed into water bath at 90°C for 10 min. After that, it was cooled at room temperature then 1 mL of the sample solution was pipetted into new reaction tube and mixed with 0.5 mL of 5% phenol (phenol in water, v/v). The mixture was added by 2.5 mL of 36 N sulfuric acid then incubated at room temperature for 20 min. After incubation time, the absorbance was measured by a UV-Vis spectrophotometer at 490 nm. The glucose was used as a sugar standard then the total sugar content was expressed as mg

glucose per g of dry sample. Whereas, the crude fiber was analyzed according to the AOAC Official Methods 978.10 (AOAC, 2005).

FT-IR analysis

The FT-IR analysis was used to detect the glycosidic linkage of polysaccharides. FT-IR spectra of water lettuce polysaccharide were obtained by mixing polysaccharide with potassium bromide, further it was pressed to form pellets. The analysis used a Fourier transform infrared (InfraRed Bruker Tensor 37) and performed according to previous methods (Bhateja et al., 2020).

Alpha-glucosidase inhibitory activity assay

The inhibitory of α -glucosidase activity was analyzed according to previous methods (Sancheti et al., 2009). Briefly, the test sample was diluted at a serial concentration (0, 20, 40, 60, 80, and 100 ppm). Then, 50 μ L of 0.1 M phosphate buffer and 25 μ L of 0.5 mM 4-nitrophenyl α -D-glucopyranoside (dissolved in 0.1 M phosphate buffer) was added with 10 μ L of the sample solution in a 96-wells microplate. The mixture was added with α -glucosidase solution (0.04 Units/mL, pH 7.0). The mixture was incubated at 37°C for 30 min and then was terminated by the addition of 100 μ L of 0.2 M Na_2CO_3 solution. After that, the absorbance was measured at 410 nm by using a microplate reader.

RESULTS AND DISCUSSION

Extraction yields

The ultrasound-assisted extraction (UAE) showed a highly significant ($p<0.05$) yield when compared to hot water extraction (Figure 1). The extraction yield of UAE is about $9.16\pm 2.14\%$ and hot-water extraction is about $4.41\pm 0.36\%$. A previous study also reported that the UAE method (2.97%) showed high extraction yield when compared to hot-water extraction (1.58%) (Chen et al., 2019). The hot-water extraction is commonly used for polysaccharides extraction due to being safe and simple, but takes a long time of extraction, whereas UAE is reducing the consumption of solvents and shorten the extraction time. The UAE method also can increase the yield of extraction than hot-water extraction (Wang et al., 2015). This condition is due to ultrasound-assisted resulting disruption of the cell wall by generating cavitation through wave migration, whereas hot-water extraction exerted low damage on the cell wall (Lu et al., 2013).

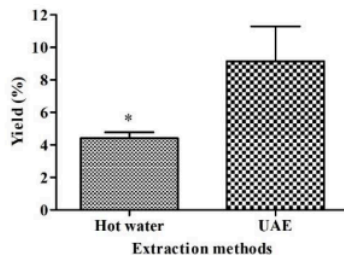


Figure 1 The extraction yield of polysaccharides extracts from water lettuce (*Pistia stratiotes*) with different extraction methods. Data shown as mean \pm SD ($n=3$). Significantly difference at $*p<0.05$ vs UAE. UAE, ultrasound-assisted extraction.

Total sugar and crude fiber

Figure 2 showed that the hot water extraction (538.29 ± 17.45 mg glucose equivalent/g of dry sample) method has a highly significant ($p<0.05$) of total sugar when compared to the UAE method (370.35 ± 46.38 mg glucose equivalent/g of dry sample). However, in the crude fiber value, there is no significant difference between the hot water extraction ($6.49\pm 1.18\%$) and UAE ($6.20\pm 0.37\%$). A previous study reported that crude fiber from *Moringa oleifera* leaf was about 9.20% (Asghar et al., 2022) and *Ficus carica* leaf from 6.53% (Teruel-Andreu et al., 2022). The total sugar analyzes by the Phenol-Sulfuric acid method. This method is commonly used in the analysis of total sugar content during polysaccharides studies, whereas polysaccharides are composed of monosaccharides which linkage by glycosidic bonds (Yue et al., 2022). Polysaccharides have been reported that it shows α -glucosidase inhibition activities (Bisht et al., 2013; Zhang and Li, 2015). A previous study reported that total carbohydrate of hot-water extraction (73.31%) was highly when compared to ultrasound-assisted extraction (61.17%). This condition is due to some monosaccharides being easy to destroy, especially by acid, alkali, and ultrasound treatment. It also reported that the monosaccharides content also increased in hot-water extraction when compared to the UAE method (Chen et al., 2019). Additionally, a previous study also reported that extraction methods not affected the monosaccharides composition, but affected its contents (Wang et al., 2010).

Additionally, hot water extraction is the most common method for extracting polysaccharides with the advantages of no special equipment required, low cost, simple operation, excellent quality of final product, and most suitable for preparation of acidic and neutral polysaccharides (Dong et al., 2016; Wang et al., 2021).

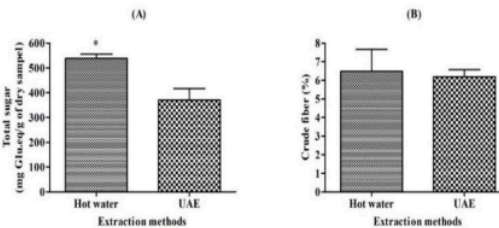


Figure 2 Total sugar content (A) and crude fiber (B) of polysaccharides extracts from water lettuce (*Pistia stratiotes*) with different extraction methods. Data shown as mean \pm SD ($n=3$). Significantly difference at $*p<0.05$ vs UAE. UAE, ultrasound-assisted extraction.

FT-IR spectra of polysaccharides

Figure 3 showed that the spectra of polysaccharides of water lettuce. The spectra were obtained from 5000 cm^{-1} to 400 cm^{-1} . The O-H stretching vibration was detected at 3422.37 cm^{-1} whereas the C-H linkage was at 2918.98 cm^{-1} . The carbonyl (C=O) stretching was appeared at 1642.90 cm^{-1} , whereas the glycosidic linkage C-O-C at 1076.56 cm^{-1} . The functional group was analyzed according previous reference (Coates, 2000) as shown in Table 1. A previous study also detected the O-H stretching (3430.6 cm^{-1}), C-H linkage (2940.3 cm^{-1}), carbonyl stretching (1630.4 cm^{-1}), and glycosidic linkage (1030.5 cm^{-1}) from *Acacia tortilis* polysaccharides (Bhateja et al., 2020).

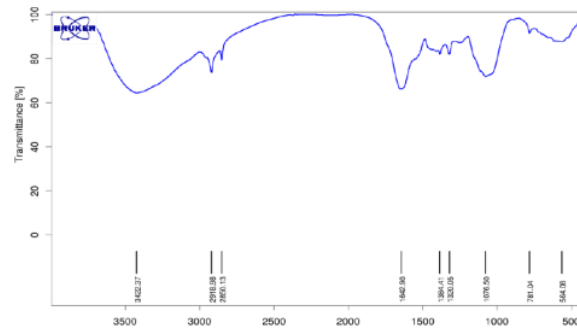


Figure 3 The FT-IR spectra of polysaccharides of water lettuce (*Pistia stratiotes*).

Table 1 The wave number of polysaccharides of water lettuce (*P. stratiotes*)

Functional groups	Wavenumber (cm^{-1})	
	<i>P. stratiotes</i>	Reference*
O-H	3422.37	3570-3200
C-H	2918.98	3095-2850
C=O	1642.90	1680-1620
C-O	1076.56	~1050

* According to previous method (Coates, 2000).

Alpha-glucosidase inhibitory activity

Figure 4 showed that hot water extraction more significantly ($p<0.05$) effectively inhibits the α -glucosidase when compared to UAE. The half-maximal inhibitory concentration (IC_{50}) of hot water extraction is about 394.84 ± 10.92 mg/mL, whereas UAE is about 490.78 ± 20.87 mg/mL. This condition is due to the hot-water extraction composed of high polysaccharides when compared to UAE. Therefore, its α -glucosidase inhibition activity is also higher than in UAE. A lower IC_{50} value indicated the potential inhibition activity is more effective and vice versa (Matuszewska et al., 2018). However, this value lower than other plant extract, such as from polysaccharides from *Artocarpus heterophyllus* (IC_{50} 10.52 mg/mL) (Zhang et al., 2017). The highest of α -glucosidase inhibition of hot-water extraction when compared to UAE was shown in polysaccharides from *Fructus mori* (Chen et al., 2019). Previous studies reported that in-vitro analysis of polysaccharides from *Camellia oleifera* fruit (Zhang and Li, 2015) and *Acacia tortilis* gum exudate (Bisht et al., 2013) inhibit α -glucosidase activities. According to these conditions, bioactive polysaccharides can be used as novel alternative of anti-diabetic agent. A previous study reported that polysaccharides as α -glucosidase inhibitor has ability to prolong and increase the glucagon-like

peptide-1 (GLP-1) secretion in normal and type-2 diabetes patients (Bhateja et al., 2020).

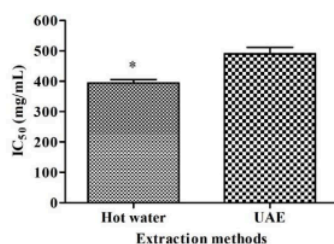


Figure 4 The alpha-glucosidase inhibitory activity of polysaccharides extracts from water lettuce (*Pistia stratiotes*) with different extraction methods. Data shown as mean \pm SD ($n=3$). Significantly difference at $*p<0.05$ vs UAE. UAE, ultrasound-assisted extraction.

CONCLUSION

In this study, we successfully extracted polysaccharides from water lettuce (*Pistia stratiotes*). The hot-water extraction shows a high number of polysaccharides and inhibition of alpha-glucosidase activity. Therefore, polysaccharides from water lettuce can be used as an alternative of novel antidiabetic agent.

Author's contribution: Ghaisani, Sirait, and Ja [5] carried out the research, wrote and revised the article. Sudirman and Herpandi designed the research, supervised research progress; Sudirman and Widiastuti anchored the review, revisions and approved the article submission.

Conflict of Interest Statement: The authors agree that this research was conducted in the absence of any self-benefits, commercial or financial conflicts and declare absence of conflicting interests with the funders.

Acknowledgements: The research/publication of this article was funded by the DIPA of the Public Service Agency of Universitas Sriwijaya 2022. SP DIPA-023.172.677515/2022, on November 13, 2021. In accordance with the Rector's Decree Number: 0109/ UN9.3.1/SK/2022, on April 28, 2022.

REFERENCES

ADA. (2009). Diagnosis and Classification of Diabetes Mellitus. *Diabetes Care* 32, S62-S67.

Asghar, N., Aziz, A., Farooq Azhar, M., El-Sharnouby, M., Irfan, U., Rafiq, I., Farooq, H., Ishaq Asif Rehmani, M., I. Sakran, M., Altalhi, A., M. Alzuair, F., & El Sabagh, A. (2022). Assessment of phytochemical analysis, nutritional composition and antimicrobial activity of *Moringa oleifera*. *Phyton*, 91, 1817-1829. <https://doi.org/10.32604/phyton.2022.020790>.

Bhateja, P.K., Kajal, A., & Singh, R. (2020). Amelioration of diabetes mellitus by modulation of GLP-1 via targeting alpha-glucosidase using *Acacia tortilis* polysaccharide in streptozotocin-nicotinamide induced diabetes in rats. *Journal of Ayurveda and Integrative Medicine*, 11, 405-413. <https://doi.org/10.1016/j.jaim.2019.06.003>.

Bisht, S., Kant, R., & Kumar, V. (2013). α -D-Glucosidase inhibitory activity of polysaccharide isolated from *Acacia tortilis* gum exudate. *International Journal of Biological Macromolecules*, 59, 214-220. <https://doi.org/10.1016/j.ijbiomac.2013.04.057>.

Chen, C., Wang, P.-p., Huang, Q., You, L.-J., Liu, R.H., Zhao, M.-m., Fu, X., Luo, Z.-G. (2019). A comparison study on polysaccharides extracted from *Fructus mori* using different methods: Structural characterization and glucose entrapment. *Food & Function*, 10, 3684-3695. <https://doi.org/10.1039/c9fo00026g>.

Coates, J. (2000). Encyclopedia of Analytical Chemistry. In: Meyers, R. (Ed.), Interpretation of Infrared Spectra: A Practical Approach. John Wiley & Sons Ltd., Chichester, pp. 10881-10882.

DiNicolantonio, J.J., Bhutani, J., & O'Keefe, J.H. (2015). Acarbose: safe and effective for lowering postprandial hyperglycaemia and improving cardiovascular outcomes. *Open Heart* 2, e000327. <https://doi.org/10.1136/openhrt-2015-000327>.

Dong, H., Lin, S., Zhang, Q., Chen, H., Lan, W., Li, H., He, J., & Qin, W. (2016). Effect of extraction methods on the properties and antioxidant activities of *Chuanminshen violaceum* polysaccharides. *International Journal of Biological Macromolecules*, 93, 179-185. <https://doi.org/10.1016/j.ijbiomac.2016.08.074>.

Gong, L., Feng, D., Wang, T., Ren, Y., Liu, Y., & Wang, J. (2020). Inhibitors of α -amylase and α -glucosidase: Potential linkage for whole cereal foods on prevention of hyperglycemia. *Food Science & Nutrition*, 8, 6320-6337. <https://doi.org/10.1002/fsn3.1987>.

Gu, S., Shi, J., Tang, Z., Sawhney, M., Hu, H., Shi, L., Fonseca, V., & Dong, H. (2015). Comparison of glucose lowering effect of metformin and acarbose in type

2 diabetes mellitus: A meta-analysis. *Plos One*, 10, e0126704. <https://doi.org/10.1371/journal.pone.0126704>.

He, K., Shi, J.-C., & Mao, X.-M. (2014). Safety and efficacy of acarbose in the treatment of diabetes in Chinese patients. *Therapeutics and Clinical Risk Management*, 2014, 505-511. <https://doi.org/10.2147/tcrm.S50362>.

Herpandi, Lestari, S.D., Bastian, & Sudirman, S. (2021). Antioxidant activity of the fractions from water lettuce (*Pistia stratiotes*) extract. *Food Research*, 5, 451-455. [https://doi.org/10.26656/fr.2017.5\(2\).578](https://doi.org/10.26656/fr.2017.5(2).578).

Liu, C., Liu, Q., Sun, J., Jiang, B., & Yan, J. (2014). Extraction of water-soluble polysaccharide and the antioxidant activity from semen cassiae. *Journal of Food and Drug Analysis*, 22, 492-499. <https://doi.org/10.1016/j.jfda.2014.01.027>.

Liu, S.-K., Hao, H., Bian, Y., Ge, Y.-X., Lu, S., Xie, H.-X., Wang, K.-M., Tao, H., Yuan, C., Zhang, J., Zhang, J., Jiang, C.-S., & Zhu, K. (2021). Discovery of new α -glucosidase inhibitors: Structure-based virtual screening and biological evaluation. *Frontiers in Chemistry*, 9, 639279. <https://doi.org/10.3389/fchem.2021.639279>.

Lu, J., You, L., Lin, Z., Zhao, M., & Cui, C. (2013). The antioxidant capacity of polysaccharide from *Laminaria japonica* by citric acid extraction. *International Journal of Food Science & Technology*, 48, 1352-1358. <https://doi.org/10.1111/ijfs.12072>.

Matuszewska, A., Jaszek, M., Stefaniuk, D., Ciszewski, T., & Matuszewski, L. (2018). Anticancer, antioxidant, and antibacterial activities of low molecular weight bioactive subfractions isolated from cultures of wood degrading fungus *Cerrena unicolor*. *Plos One*, 13, e0197044. <https://doi.org/10.1371/journal.pone.0197044>.

Nielsen, S.S. (2017). Total Carbohydrate by Phenol-Sulfuric Acid Method. *Food Analysis Laboratory Manual*, pp. 137-141.

Qu, C., Yu, S., Luo, L., Zhao, Y., & Huang, Y. (2013). Optimization of ultrasonic extraction of polysaccharides from *Ziziphus jujuba* Mill. by response surface methodology. *Chemistry Central Journal*, 7, 160. <https://doi.org/10.1186/1752-153x-7-160>.

Raveendran, A.V. (2018). Non-pharmacological treatment options in the management of diabetes mellitus. *European Endocrinology*, 14, 31-39. <https://doi.org/10.17925/ee.2018.14.2.31>.

Sancheti, S., Sancheti, S., & Seo, S.-Y. (2009). *Chaenomeles sinensis*: A potent α - and β -glucosidase inhibitor. *American Journal of Pharmacology and Toxicology*, 4, 8-11. <https://doi.org/10.3844/ajptsp.2009.8.11>.

Song, Y.-R., Han, A.-R., Park, S.-G., Cho, C.-W., Rhee, Y.-K., & Hong, H.-D. (2020). Effect of enzyme-assisted extraction on the physicochemical properties and bioactive potential of lotus leaf polysaccharides. *International Journal of Biological Macromolecules*, 153, 169-179. <https://doi.org/10.1016/j.ijbiomac.2020.02.252>.

Su, B., Liu, H., Li, J., Sunli, Y., Liu, B., Liu, D., Zhang, P., & Meng, X. (2015). Acarbose treatment affects the serum levels of inflammatory cytokines and the gut content of bifidobacteria in Chinese patients with type 2 diabetes mellitus. *Journal of Diabetes*, 7, 729-739. <https://doi.org/10.1111/1753-0407.12232>.

Teruel-Andreu, C., Sendra, E., Hernández, F., & Cano-Lamadrid, M. (2022). How does cultivar affect sugar profile, crude fiber, macro- and micronutrients, total phenolic content, and antioxidant activity on *Ficus carica* leaves? *Agronomy*, 13. <https://doi.org/10.3390/agronomy13010030>.

van de Laar, F.A., Lucassen, P.L., Akkermans, R.P., van de Lisdonk, E.H., Rutten, G.E., & van Weel, C. (2005). α -glucosidase inhibitors for patients with type 2 diabetes. *Diabetes Care*, 28, 154-163. <https://doi.org/10.2337/diacare.28.1.154>.

Wang, B., Liu, Q., Huang, Y., Yuan, Y., Ma, Q., Du, M., Cai, T., & Cai, Y. (2018). Extraction of polysaccharide from *Spirulina* and evaluation of its activities. *Evidence-Based Complementary and Alternative Medicine* 2018, 1-8. <https://doi.org/10.1155/2018/3425615>.

Wang, N., Dai, L., Chen, Z., Li, T., Wu, J., Wu, H., & Xiang, W. (2021). Extraction optimization, physicochemical characterization, and antioxidant activity of polysaccharides from *Rhododorus* sp. SCSIO-45730. *Journal of Applied Phycology*, 34, 285-299. <https://doi.org/10.1007/s10811-021-02646-2>.

Wang, W., Ma, X., Xu, Y., Cao, Y., Jiang, Z., Ding, T., Ye, X., & Liu, D. (2015). Ultrasound-assisted heating extraction of pectin from grapefruit peel: Optimization and comparison with the conventional method. *Food Chemistry*, 178, 106-114. <https://doi.org/10.1016/j.foodchem.2015.01.080>.

Wang, Y., Yang, Z., & Wei, X. (2010). Sugar compositions, α -glucosidase inhibitory and amylase inhibitory activities of polysaccharides from leaves and flowers of *Camellia sinensis* obtained by different extraction methods. *International Journal of Biological Macromolecules*, 47, 534-539. <https://doi.org/10.1016/j.ijbiomac.2010.07.007>.

Xu, J., Hou, H., Hu, J., & Liu, B. (2018). Optimized microwave extraction, characterization and antioxidant capacity of biological polysaccharides from *Eucommia ulmoides* Oliver leaf. *Scientific Reports*, 8, 6561. <https://doi.org/10.1038/s41598-018-24957-0>.

Yeh, S.-H., Hsu, W.-K., Chang, Z.-Q., Wang, S.-H., Hsieh, C.-W., Liou, G.-G., Lee, H.-B., Jiang, B.-H., Tsou, H.-K., & Tsai, M.-S. (2021). Purification and characterization of fractions containing polysaccharides from *Talinum triangulare* and their immunomodulatory effects. *Processes*, 9, 709. <https://doi.org/10.3390/pr9040709>.

- Yue, F., Zhang, J., Xu, J., Niu, T., Lü, X., & Liu, M. (2022). Effects of monosaccharide composition on quantitative analysis of total sugar content by phenol-sulfuric acid method. *Frontiers in Nutrition*, 9, 963318. <https://doi.org/10.3389/fnut.2022.963318>.
- Zhang, L., Tu, Z.-C., Xie, X., Wang, H., Wang, H., Wang, Z.-X., Sha, X.-M., & Lu, Y. (2017). Jackfruit (*Artocarpus heterophyllus* Lam.) peel: A better source of antioxidants and α -glucosidase inhibitors than pulp, flake and seed, and phytochemical profile by HPLC-QTOF-MS/MS. *Food Chemistry*, 234, 303-313. <https://doi.org/10.1016/j.foodchem.2017.05.003>.
- Zhang, S., & Li, X.-Z. (2015). Inhibition of α -glucosidase by polysaccharides from the fruit hull of *Camellia oleifera* Abel. *Carbohydrate Polymers*, 115, 38-43. <https://doi.org/10.1016/j.carbpol.2014.08.059>.
- Zhao, C., Li, X., Miao, J., Jing, S., Li, X., Huang, L., & Gao, W. (2017). The effect of different extraction techniques on property and bioactivity of polysaccharides from *Dioscorea hemsleyi*. *International Journal of Biological Macromolecules*, 102, 847-856. <https://doi.org/10.1016/j.ijbiomac.2017.04.031>.

Inhibition of alpha-glucosidase by polysaccharides from water lettuce (Pistia stratiotes) leaf extracts with different extraction methods

ORIGINALITY REPORT

23%
SIMILARITY INDEX

24%
INTERNET SOURCES

12%
PUBLICATIONS

2%
STUDENT PAPERS

MATCHED SOURCE

5 jssm.umt.edu.my
Internet Source

2%

2%
★ jssm.umt.edu.my
Internet Source

Exclude quotes On
Exclude bibliography On

Exclude matches < 2%

Inhibition of alpha-glucosidase by polysaccharides from water lettuce (*Pistia stratiotes*) leaf extracts with different extraction methods

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

/100

PAGE 1

PAGE 2

PAGE 3

PAGE 4