Indo. J. Pure App. Chem. 9 (2), pp. 105-109, 2026

Indonesian Journal of Pure and Applied Chemistry
journal homepage: http://jurnal.untan.ac.id/index.php/IJoPAC

ULTRASOUND-ASSISTED EXTRACTION OF INULIN-TYPE CARBOHYDRATES FROM *Musa acuminata*

Gladeva Yugi Antari[1], Diah Miftahul Aini[2*], Riwayati Malika[1]

[1]*Department of Midwifery, Faculty of Health, Universitas Qamarul Huda Badaruddin Bagu, Central Lombok 83371, Indonesia*
[2]*Department of Chemistry, Faculty of Mathematics and Natural Science, Universitas Mataram, Mataram 83115, Indonesia*

[*]*Corresponding author: mita@staff.unram.ac.id*
Phone contact: +6285158224093

DOI: https://doi.org/10.26418/indonesian.v9i2.104278

ARTICLE INFO

Article history:
Received 21 January 2026
Accepted 13 July 2026
Available online
13 August 2026

Keywords:
banana, extraction, inulin, *Musa acuminata*, ultrasonic

ABSTRACT

Bananas (*Musa acuminata*) are a plentiful and underutilized tropical resource that has the potential to serve as an alternative source of inulin-type carbohydrates. The main objective of this study was to assess the effectiveness of ultrasonication in improving the yield and quality of inulin-type carbohydrates extracted from banana biomass. The extracted products are used at 40 kHz and 50 W for 15 min at 70 °C. Then, the samples were characterized using Fourier Transform Infrared (FTIR) spectroscopy and carbohydrate content determination to confirm the presence of inulin-type structures. The results demonstrated that the ultrasonication extraction efficiency was 10.914% and 33.57% for moisture contents of 10.914% and 33.57%, respectively. Spectral analysis confirmed the presence of characteristic functional groups associated with fructan-based carbohydrates, indicating successful extraction. In conclusion, ultrasonic-assisted extraction is a promising technology for the efficient recovery of inulin-type carbohydrates from banana biomass. Prospects include process optimization at pilot scale, integration with microwave-assisted extraction, and evaluation of the functional and prebiotic properties of the extracted inulin for food and biomedical applications.

1. Introduction

Inulin-type carbohydrates are functional fructan polymers that play a crucial role in improving gut health through their prebiotic activity, including selective stimulation of beneficial gut microbiota and production of short-chain fatty acids[1]. The growing demand for inulin in functional foods, nutraceuticals, and pharmaceutical formulations has led to increasing reliance on conventional plant sources such as chicory and Jerusalem artichoke[2],[3]. However, the limited geographical distribution, seasonal availability, and competition with food crops associated with these sources highlight the urgent need to explore alternative, sustainable, and locally available raw materials for inulin production[4]. Bananas (*Musa acuminata*), one of the most abundant tropical crops, produce significant biomass that remains largely untapped and has great potential as a renewable source of inulin-type carbohydrates[5],[6].

Recent developments in extraction technology increasingly emphasize environmentally friendly and energy-efficient approaches to enhance the recovery of bioactive compounds. Among these, ultrasonic-assisted extraction (UAE)[7] has gained considerable attention because ultrasonic waves generate cavitation that disrupts plant cell walls and accelerates mass transfer, thereby facilitating the release of target compounds. This technique has been widely applied to extract polyphenols, pectins, and oligosaccharides from various plant materials, offering benefits such as shorter processing times, reduced solvent consumption, and better protection of heat-sensitive compounds. However, research specifically focused on the application of ultrasonication to extract inulin-type carbohydrates from banana biomass remains relatively scarce[7],[8].

The key research gap is the lack of systematic studies that optimize UAE operating parameters for the selective recovery of inulin-type carbohydrates from bananas, as well as the limited structural characterization of the resulting fructans. Most existing investigations rely on conventional hot-water extraction[9],[10] or concentrate on other carbohydrate fractions, which may fail to fully exploit the advantages of ultrasonication in improving extraction yield and product quality.

Accordingly, this study aims to assess the effectiveness of ultrasonic-assisted extraction for extracting inulin-type carbohydrates from banana biomass, to optimize critical extraction conditions, and to characterize the extracted products. The outcomes are expected to support the development of sustainable alternative sources of inulin.

2. Methods

2.1. Materials and Sample Preparation

Barangan bananas (*Musa acuminata*) at semi-ripe maturity were collected from local plantations in Lombok, Indonesia. The fruits were peeled, sliced thinly, and dried in an oven at 60 °C for 6 h. The dried material was milled and sieved through a 100-mesh sieve to obtain banana flour. Moisture content was determined gravimetrically to ensure sample stability prior to extraction[8].

2.2. Ultrasonic-Assisted Extraction (UAE)

Inulin-type carbohydrates were extracted using an ultrasonic-assisted extraction approach, with modifications to reported methods[8]. The initial stage is the production of banana extract. Banana powder is extracted by combining extraction techniques with ultrasonication[11] at 40 kHz and 50 W for 15 min at 70 °C. Then the process continues with the extraction and evaporation phases. The solvent used is ethanol at a 1:3 (sample:solvent) ratio. The resulting extract was then filtered through filter paper, placed in a beaker, and evaporated using a rotary evaporator at 60 rpm, 50°C, and 100 mbar. Evaporation was stopped when the banana extract reached a concentrated state. The extraction process was repeated twice, and then the residues were extracted with water (1:20 w/v). Then the vacuum drying was performed. The yield was calculated by comparing the mass of the dried extract to the initial mass of the banana sample used in the extraction[10].

2.3. Characterization of Inulin

Structural characterization of the extracted inulin was performed using Fourier Transform Infrared (FTIR) spectroscopy. For FTIR analysis, dried inulin was mixed with KBr (1:300, w/w), pressed into pellets, and scanned over 4000–400 cm^{-1} to identify functional groups[9].

3. Results and Discussion

3.1. Moisture Content and Sample Quality

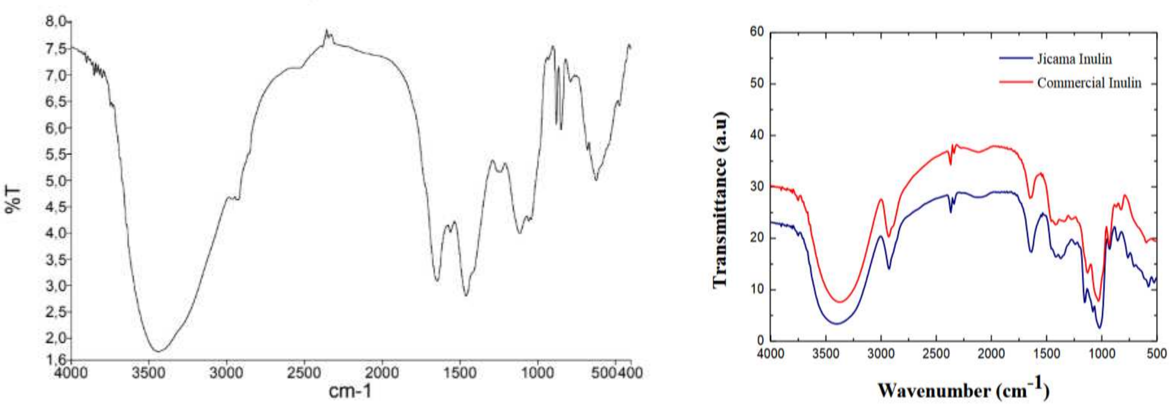
The average moisture content of bananas was 10.914%. This result was higher than that found in study[12], which was around 7.644% for bananas at an oven temperature of 60 °C and a drying time of 7 hours. The moisture content analysis of banana flour showed that the water evaporation rate varied with each drying treatment applied. Evaporation is the process of removing water from dried foodstuffs to obtain a stable dry product. Various factors can cause differences in banana moisture content, both internal (within the fruit itself) and external. Internally, the type or variety of banana greatly affects the moisture content. Barangan bananas tend to have a higher moisture content than Kepok Bananas. In addition, the ripeness of the banana also has an effect: unripe bananas generally contain more starch and have a lower moisture content than ripe bananas, whereas starch is converted into sugar, accompanied by an increase in moisture content. In fact, the moisture content can vary slightly between different parts of the fruit, such as the tip, middle, and base. Meanwhile, external factors such as the growing environment also play a significant role. Bananas grown in areas with high rainfall or high humidity tend to have higher water content.

3.2. Extraction Yield

The yield obtained from barangan bananas was 33.57%. This result was higher than that obtained in study[13], which found a yield of 27.52% for barangan bananas. Meanwhile, according to [14], the yield of raw barangan banana peel extract was 31.33%, and that of concentrated barangan banana peel extract was 29%. The enhanced yield can be attributed to acoustic cavitation generated during ultrasonication, which disrupts plant cell walls and increases solvent penetration, thereby facilitating the release of intracellular carbohydrates. These results confirm the effectiveness of ultrasonication as a green and efficient extraction technique for banana-derived carbohydrates.

3.3. FTIR Characterization

Solid inulin was mixed with KBr at a 1:300 ratio. The mixture was compacted into pellets and analyzed by FTIR over the wavenumber range of 4000–400 cm^{-1}.



(a) (b)

Figure 1. FTIR spectra of inulin samples: (a) isolated banana inulin and (b) jicama inulin compared with commercial inulin (Sigma)

Table 1. Comparison of FTIR absorption bands of inulin samples from different sources

Banana (Isolated inulin)	Jicama (Yan Tuber) Inulin	Commercial Inulin (Sigma)	Functional group
3435	3402.43	3371.57	Alcohol (OH stretch)
2930	2924.09	2931.80	C–H
1634	1635	-	Absorbtion of water
1460	1427	1427	Alkane (–CH_3), pryranose ring
1334	1334	1334	β–OH
1113	1157.29	1126.43	C–O–C glycosidic bonds

The FTIR analysis results for isolated banana inulin, jicama (yam tuber) inulin, and commercial inulin are presented in Table 1. A broad absorption band was observed at 3435 cm^{-1} for isolated banana inulin, 3402.43 cm^{-1} for jicama inulin, and 3371.57 cm^{-1} for commercial inulin. This band indicates the presence of O–H stretching vibrations of hydroxyl groups. The FTIR spectra also show characteristic molecular vibrations associated with alkane C–H stretching, observed at 2930 cm^{-1} for isolated banana inulin, 2924.09 cm^{-1} for jicama inulin, and 2931.80 cm^{-1} for commercial inulin. An absorption band at 1634 cm^{-1} was observed in isolated banana inulin and is attributed to water absorption, given the hygroscopic nature of polysaccharides[15]. The absorption bands in the 1500–900 cm^{-1} region are associated with C–C stretching vibrations in the pyranose ring. Additional absorption bands at 1126.43 cm^{-1} in commercial inulin, 1157.29 cm^{-1} in jicama inulin, and 1113 cm^{-1} in isolated banana inulin correspond to C–O stretching vibrations. These characteristic absorption bands confirm the presence of typical carbohydrate functional groups in banana-derived inulin[16].

4. Conclusion

In conclusion, Barangan Banana (*Musa acuminata*) can serve as a promising alternative source of inulin-type carbohydrates, yielding 33.57% extract with a moisture content of 10.914%. Ultrasonic-assisted extraction improved efficiency while preserving the structural characteristics of inulin, as confirmed by FTIR analysis. Further studies are recommended to optimize the process, scale up production, and evaluate its prebiotic activity.

Acknowledgement

This work was supported by the Ministry of Research, Technology, and Higher Education of the Republic of Indonesia (KEMENRISTEKDIKTI) through the scheme of PDP Contract Number 129/C3/DT.05.00/PL/2025.

References

[1] Wang Y., Tian L., Fabi J.P., and de Vos P. (2025). The potential of prebiotics, probiotics, and synbiotics for ameliorating intestinal barrier dysfunction and modulating inflammatory responses as dietary supplements in diabetes mellitus management. *Food Bioscience*, 107539, doi: 10.1016/j.fbio.2025.107539.

[2] Meral H.D., Özcan F.Ş., Özcan N., Bozkurt F., and Sağdiç O. (2024). Determination of prebiotic activity and probiotic encapsulation ability of inulin type fructans obtained from Inula helenium roots. *Journal of Food Science*, 89(9):5335-5349, doi: 10.1111/1750-3841.17261.

[3] Wan X., et al. (2020). The physiological functions and pharmaceutical applications of inulin: A review. *Carbohydrate Polymers*, 246:116589, doi: 10.1016/j.carbpol.2020.116589.

[4] Xie Z., He W., Gobbi A., Bertram H.C., and Nielsen D.S. (2024). The effect of in vitro simulated colonic pH gradients on microbial activity and metabolite production using common prebiotics as substrates. *BMC Microbiology*, 24(1):83, doi: 10.1186/s12866-024-03235-2.

[5] Anyasi T.A., Jideani I.I.O., and Mchau G.R.A. (2013). Functional properties and postharvest utilization of commercial and noncommercial banana cultivars. *Comprehensive Reviews in Food Science and Food Safety*, 12(5):509-522, doi: 10.1111/1541-4337.12025.

[6] Dion R., Wijanarka W., and Pujiyanto S. (2022). Inulinase Producing Yeast Isolated from Kepok Banana Peels (*Musa acuminata* x balbisiana). *Biosaintifika*, 14(2):236, doi: 10.15294/biosaintifika.v14i2.37117.

[7] Li, S., Lei, D., Zhu, Z., Cai, J., Manzoli, M., Jicsinszky, L., Grillo, G. and Cravotto, G. (2021). Complexation of maltodextrin-based inulin and green tea polyphenols via different ultrasonic pretreatment. *Ultrasonics Sonochemistry*, 74:105568, doi: 10.1016/j.ultsonch.2021.105568.

[8] Kusmiyati N., Wahyuningsih T.D.W.I., and Widodo. (2018). Extraction and identification of inulin-type fructo-oligosaccharides from *Dahlia pinnata* L. *Asian Journal of Chemistry*, 30(2):355–358, doi: 10.14233/ajchem.2018.20965.

[9] Mudannayake D.C., Meegahawaththa W.K., Illippangama A.U., Pitawala H.M.J.C., Wimalasiri K.M.S., and Silva K.F.S.T. (2025). Extraction, purification and structural characterization of

inulin-type fructans from different selected Asparagus species. *Bioactive Carbohydrates and Dietary Fibre*, 34:100486, doi: 10.1016/j.bcdf.2025.100486.

[10] Mangguali M., M M., and Syarifuddin A. (2024). Study of inulin content and extractions methods in several types of tubers. In *BIO Web of Conferences*: Vol. 96 (p. 01031). EDP Sciences, doi: 10.1051/bioconf/20249601031.

[11] Kaur B., Venkatrao K.B., Panesar P.S., Chopra H.K., and Anal A.K. (2022). Optimization of ultrasound-assisted enzymatic extraction of resistant starch from green banana peels and its structural characterization. *Journal of Food Science and Technology*, 59(12):4663-4672, doi: 10.1007/s13197-022-05546-6.

[12] Asyhari L., Fertiasari R., and Tritisari A. (2021). Pengujian Kadar Air Dan Umur Simpan Tepung Pisang. *Agrofood*, 3(1):15–20., doi: 10.63848/agf.v03n1.3.

[13] Sibuea P. and Sitanggang D.L. (2023). Aktivitas antioksidan dari ekstrak buah pisang barangan dan potensinya sebagai pengawet bakso. *Jurnal Riset Teknologi Pangan dan Hasil Pertanian (RETIPA)*, 8–17, doi: 10.54367/retipa.vi.3195.

[14] Arista N. and Siregar M.R. (2024). Uji aktivitas antioksidan ekstrak kulit pisang Barangan (*Musa acuminata* Linn) dengan metode DPPH. *Nautical: Jurnal Ilmiah Multidisiplin Indonesia*, 1(12):1477-1484, doi: 10.55904/nautical.v2i12.632.

[15] Petkova N.T., Sherova G., and Denev P.P. (2018). Characterization of inulin from dahlia tubers isolated by microwave and ultrasound-assisted extractions. *International Food Research Journal*, 25(5):1876.

[16] Alexander I.J., Bulan R., Zaidar E., Silaban R., Soripada T.A., and Sirait G. (2023). The Analysis of Inulin From Yam Tubers using FTIR (Fourier Transform Infra Red). *International Journal of Computer Applications Technology and Research*, 12(03):53-55doi: 10.7753/ijcatr1203.1012.