I COBBIND I CONGRESSO BRASILEIRO DE BIOTECNOLOGIA INDUSTRIAL
XXIV SINAFERM • XV SHEB • XV ENZITEC FLORIANÓPOLIS • 2024
Creating connections between biotechnology and industrial sustainability
August 25 to 28, 2024
Costão do Santinho Resort, Florianópolis, SC, Brazil
BIOPROCESS ENGINEERING

EXTRACTION OF PHENOLIC COMPOUNDS FROM BANANA PEEL USING NATURAL DEEP EUTETIC SOLVENTS

Rejane S. G. Ribeiro[1], Bruna M. Silva[1], Larissa D. da Silva[1], Sara G. Bosmediano[1], Sergio A. Fernandes[1] & Rita C. S. Sousa[1]*

[1] 1 Department of Chemistry, Federal University of Viçosa, Viçosa, Minas Gerais, Brazil.
** Corresponding author's email address: rita.sousa@ufv.br*

ABSTRACT

Banana (Musa spp) is a tropical fruit considered one of the most consumed in the world, which generates high waste production since the peel accounts for 40% of the total weight of the fruit. Banana peel contains bioactive compounds that have several biological activities. Natural deep eutectic solvents (NADES) are increasingly being used for the extraction of bioactive compounds, being an alternative to conventional organic solvents because they are less toxic, have a lower cost, are biodegradable and come from renewable sources. The present study aimed to optimize the extraction of total phenolics present in banana peel (Musa spp). The extracts were obtained from microwave-assisted extraction (MAE) and the response surface methodology was applied to evaluate the temperature, ratio (biomass/solvent) and concentration (water/solvent). The optimum point obtained was 66.73°C, 30% biomass in the solvent and a concentration of 58.42% addition of water in the solvent. The present study demonstrated that NADES are an effective alternative for extracting bioactive compounds from banana peel (Musa spp).

Keywords: Extration. Phenolic. Green solvent. Microwave-assisted extraction.

1 INTRODUCTION

Banana peel has high added value due to its richness in bioactive compounds such as pectin, flavonoids, and carotenoids.[1-4] In addition to being used in folk medicine as a healing age[5], the bark is rich in saponins, tannins and flavonoids that have hemostatic properties and promote healing.[6] Studies highlight the extraction of bioactive compounds from banana peel, using deep eutectic solvents (DES)[7,8], which are composed of a hydrogen bond acceptor (HBA) and donor (HBD) , with a lower melting point than the individual components. They have advantages over traditional organic solvents, being more sustainable, and economical.[9] The natural deep eutectic solvents (NADES) are a subclass of DES, which are gaining prominence due to their natural origin.[10] However, the extraction of phenolic compounds from banana peel using NADES is still limited but it has attracted increasing interest. Thus, this study is aimed to optimize the microwave-assisted extraction of phenolic compounds from banana peel, using NADES.

2 MATERIAL & METHODS

The study carried out at UFV, Viçosa, Minas Gerais, used banana peel as raw material. In the preparation of NADES, choline chloride [Ch]Cl as HBA and oxalic acid (AO) as HBD were used. Conventional solvent, ethanol (98%), was also tested for comparison purposes. The ripe bananas under were washed under running water to remove impurities. The peels were manually separated, dried at 45°C to avoid deterioration, cut and stored in a desiccator.

Chemical Physical Characterization: The moisture, ash, and fat content of the banana peel were determined, using the oven drying method for moisture, ash by the gravimetric method and the Soxhlet solid-liquid extraction method for fat.

Solvent Preparation (NADES): The NADES were prepared according Abbott et al.[11]. HBA and HBD were combined in specific proportions [Ch]Cl + AO (1:1) and heated at 80°C for 30 minutes.

Experimental Planning: The CCRD 2^3 experimental planning was undertaken with five levels and three variables (temperatures, solid/solvent ratio, and water/solvent concentration), using waste surface methodology to optimize the extraction of phenolic composts from banana peel. A Central Rotational Composite Design (CCRD) was used to assess the influence of three factors (extraction temperature, solid-solvent ratio, and ratio of water added to NADES) on the extraction. Thus, 17 experiments were carried out, these being 8 factorial points (+1 and -1), 6 axial points (α and –α) and 3 repetitions at the central point.

Extraction Mechanism: 0.2 g of dry biomass was combined with NADES in a test tube, followed by microwave-assisted extraction (MAE) modelo Discovery System nº 908005, série nº DU9203, at 30 W during 5 min and temperature according to CCRD.

Characterization of Extracts: Total phenolic compounds were determined according to Singleton and Rossi[12], which was adapted with the Folin-Ciocalteu reagent. Colorimetric analysis used a gallic acid calibration curve. After preparing the diluted extract, distilled water and Folin-Ciocalteu were added, followed by the sodium carbonate solution. After two hours, the absorbance was measured on a spectrophotometer at 760 nm.

3 RESULTS & DISCUSSION

Chemical Physical Characterization: The moisture content of dried banana peel was 89.6% ± 0.9. Thus, the moisture can degrade active ingredients by accelerating enzymatic activity and the growth of microorganisms.[13] The extraction of banana peel oil was 16.8% ± 1.4 similar to Rosso[14] and Silva et al.[15] Moreover, the oil contains phytosterols and polyunsaturated fatty acids, which are beneficial for health. Analysis of ash was 9.4% in banana peel reveals essential minerals for health. These minerals, such as copper, sodium, and potassium, promote health and quality of life like previous studies Ijaz et al.[16]

Optimization of Total Phenolics Extraction: A CCRD was used to assess the influence of three factors (extraction temperature, solid/solvent ratio, and ratio of water added to NADES) on the phenolic extraction. For the adjustment of the model, the coded data of the variables were used to calculate the regression and obtain the mathematical model using software STATISTICA 7.0, with analysis of variance (ANOVA) to estimate the statistical parameters. The effects of each variable, as well as the effects of interactions between them, were calculated. The model constructed was adequate ($p<0.05$), since the effects point to a significant relationship between the concentration of the total phenolic and the factors tested. The R^2 value was consistent. Furthermore, with the significant ANOVA test, the non-significant lack of fit and the random distribution of residues, the model can be considered consistent to assess the relationship between phenolic concentration in extracts and the independent variables tested. Linear parameters of three factors were statistically significant ($p=0.05$). The effects of temperature, solid/solvent ratio, and ratio of water added to NADES express a positive character in phenolic extraction, so the higher the values of these factors, the higher the concentration of the phenolics in the extracts. The solid-solvent ratio was the variable that most affected the phenolic extraction. The optimal conditions for extracting total phenolics with NADES were: i) temperature: 66.73 °C; ii) solid/liquid ratio: 30% (w/w); iii) water/solvent concentration: 58.42% (w/w). Figure 1 presents the response surfaces.

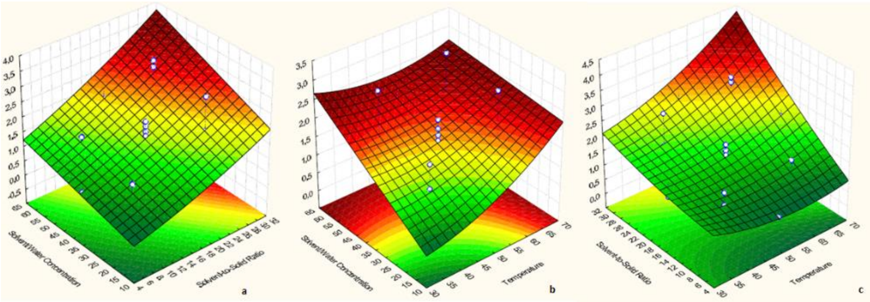

Figure 1 Response surface for phenolic concentration in the extracts as a function of: a) ratio of water added to NADES x solid/solvent ratio plot; b) ratio of water added to NADES x temperature plot; c) solid/solvent ratio x temperature plot.

Characterization of Extracts: Evaluating the results obtained for the concentration of total phenolics, under optimal conditions, in the NADES and ethanol extracts, the values of 3.59 ± 0.16 $g.L^{-1}$ and 1.87 ± 0.03 $g.L^{-1}$, respectively, were found. It is observed that the extractions performed with NADES solvents obtained higher yields than ethanol, proving to be a good alternative to conventional solvents. The higher yield obtained with NADES may be linked to the wide range of polarity that the solvents hold, that is, they have affinity for polar and non-polar compounds, which expands the extraction range.[10] DAI et al.[17,18] used different NADES in the extraction of phenolics in Safflower, a plant used in the development of medicines. The authors observed that NADES obtained superior results for phenolic compounds compared to extraction performed with ethanol and water, reaching up to 95% yield.

4 CONCLUSION

The study was aimed at optimizing the extraction of total phenolics from banana peel using MAE with NADES. NADES proved to be superior to traditional solvent. The CCRD 2^3 experimental design validated NADES as promising solvents for bioactive compounds, highlighting their renewable origin, low toxicity, and biodegradability. New research is suggested to explore its potential in natural cosmetics and pharmaceuticals.

REFERENCES

1. SIDHU, J. S.; ZAFAR, T. A. 2018. Food Quality and Safety. 2(4). 183-188.
2. KHAMSUCHARIT, P., LAOHAPHATANALERT, K., SRIROTH, K., SANGSEETHONG, K. 2018. Food Science and Biotechnology. 27(3). 623-629.
3. YAN, L., WARNAKULASURYA, M. A. D. B., BRENNAN, M., BRENNAN, C. S., LAYASENA, V., COOREY, R. 2016. International Journal of Food Science and Technology. 51(6). 1449-1456.
4. ZHANG, J. W., WANG, J. H., WANG, C. C., HUANG, R. Q. 2019. Acta Alimentaria, 48(4). 525-537.
5. VON ATZINGEN, D. A. N. C. et al. 2013. Acta Cirurgica Brasileira. 28(1). 33.
6. NOVAK, F., ALMEIDA, A. G. J., DE SOUZA SILVA, R. 2003. Jornal de Pediatria. 79(3). 221-226.
7. TANG, B., BI, W., ZHANG, H., Ho ROW, K. 2014. Chromatographia. 77(3). 373-377.
8. TANG, B., ZHANG, H., ROW, K. H. Journal of Separation Science. 2015. 38(6). 1053-1064.
9. LI, X., ROW, H. R. 2016. Journal of Separation Science. 39(18). 3505-3520.
10. VANDA, H. et al. 2018. Comptes Rendus Chimie, 21(6). 628–638.
11. ABBOTT, A. P., BOOTHBY, D., CAPPER, G., DAVIES, D. L., RASHEED, R. K. 2004. Journal of the American Chemical Society. 126(29). 9142-9147.
12. SINGLETON, V. L.; ROSSI, J. A. 1965. American Journal of Enology and Viticulture, 16(3). 144–158.
13. BORGO, J., XAVIER, C. A. G., MOURA, D. J., RICHTER, M. F., SUYENAGA, E. S. 2010. Revista Brasileira de Farmacognosia. 20(1).
14. PEREIRA, A.; MARASCHIN, M. Journal of Ethnopharmacology. 2015. 160.149-153.
15. SILVA, V. ARQUELAU, P. B., SILVA, M. R., AUGUSTI, R., MELO, J. O. F. 2020. Química Nova. 43.5.
16. IJAZ, N., AFZAAL., M., NIAZ, B., SAEED, F. 2023. International Journal of Food Properties. 26(1). 1636–1644.

[17] DAI, Y., SPRONSEN, V. J., WITKAMP, GJ., VERPOORTE, R., CHOI, Y. H. 2023. Analytica Chimica Acta. 766. 61-68.
[18] DAI, Y., WITKAMP, GJ., VEPOORTE, R., CHOI, Y. H. 2013. L. Analytical Chemistry. 85(13). 6272–6278.

ACKNOWLEDGEMENTS

The authors are grateful Fundação de Amparo à Pesquisa do Estado de Minas Gerais – Brazil (FAPEMIG), Conselho Nacional de Desenvolvimento Científico e Tecnológico - Brazil (CNPq) and Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brazil (CAPES).