Filtering Microplastics from Water with Lipids Extracted from Jackfruit Seeds

Puarisa Lathalo, Suphanwadee Maneesuphachat and *Burapha Saenwan*
Chulabhorn Science High School, Chiang Rai
345 Moo 2, Rob Wiang, Amphoe Mueang, Chiang Rai, 57000
Email: 04449_pawarisa@pcccr.ac.th

Abstract
This study explores a process that removes microplastics from water using lipids extracted from jackfruit seeds by fractional distillation. The lipids extract is applied to a sieve that is then used to filter a suspension of microplastics in water. Photographs of water samples taken with a microscope before and after filtering with and without the lipids extract showed that passing water through the lipid coated wire mesh removed 94.1 ± 0.5 % of the microplastic. Without lipids coating the sieve the rate of removal was 5.1 ± 0.2 %, showing that fatty coatings can greatly enhance the efficiency of microplastic capture in this setting.

Keywords: microplastics, lipids, Jackfruit seeds, fractional distillation

I. INTRODUCTION

Environmental protection is becoming a more pressing worldwide problem and developed countries are now aware of the need to control water quality and limit industrial waste. Various innovative methods are in development to reduce pollutants, including microplastics, which are now found in air, soil, water, and at every level in the food chain.

The highest density of environmental microplastics in the world has been identified in sediments in the Mediterranean Sea off the coast of Italy (Amos, 2020). Concerns that ocean currents that carry oxygen and nutrients to nourish deep sea creatures will become heavily contaminated with microplastics has stimulated research into their removal.

Treat -ment	Effluent type	Before (MP/L)	After (MP/L)	Removal (%)
DF1	Secondary	0.5±0.2	0.3±0.1	40.0
DF2	Secondary	2.0±1.3	0.03±0.01	98.5
RSF	Secondary	0.7±0.1	0.020±0.007	97.1
DAF	Secondary	2.00±0.07	0.10±0.04	95.0
BMR	Primary	5.9±1.0	0.005±0.004	99.9

DF1: disc filter with pore size 10 mm, **DF2:** disc filter with pore size 20 mm, RSF: rapid sand filters,
DAF: dissolved air flotation and **MBR:** use of a membrane bioreactor.

Table 1. Microplastic capture efficiencies from Yeo and Julaihi (2021).

Biofilms of yeasts including marine species of Candida are found to adhere to plastics. These films have been studied as a way to remove microplastics that adhere to the film (Pananusorn and Muangsuntorn, 2021). Adding magnetic nano-particles and oil to water containing microplastics is being investigated as another method of removing the particles from water (Table 1). (Yeo and Julaihi, 2021). Low surface tension oil acts as an adhesive between both types of particles, the aggregation can be removed with a magnet and the magnetic particles reused. Another possibility is the attachment of devices to boats to filter microplastics from the water.

Each of these methods separate microplastic particles from water but many have practical limitations. Biofilms are often toxic and magnetic nanoparticles may be harmful to living things.

The use of non-toxic fats extracted from plant material to trap microplastic particles avoids these limitations and is investigated here. Jackfruit (*Artocarpus heterophyllus*) is common in Thailand

Sample	Fat (%)
Jackfruit Pulp	1.49 ± 0.04
Jackfruit Seeds	4.29 ± 0.12
Jackfruit Leaves	0.73± 0.05

Table 2. Fat content of jackfruit parts (Amadi, 2018)

and has been selected as the source of organic fats. Table 2 shows that jackfruit seeds contain more fats than other parts of the plant. Lipids extracted from jackfruit seeds are non-polar and insoluble in water (Pollard, 2008) and might be able to be used as a coating to trap microplastic particles.

II. METHODS

Lipid extraction

Jackfruit seeds were cleaned and baked at 65°C for eight hours. The seeds were then ground to a powder that was soaked in 70 % Hexane for 48 hours. The hexane solution was filtered and lipids were extracted by fractional distillation at 90 - 100 °C. The crude extract was stored out of the sunlight at room temperature.

Suspending microplastic in water

Expanded polyethylene was shredded in a blender to chips with an average particle size of close to 25 µm. The blended microplastic was added to water at a concentration of 2 g/L and examined under a microscope. Measurements were made with the computer program ImageJ. Particles were counted down to a minimum size of 5 µm and mean size and total area were recorded.

Preparing a coated sieve

Five grams of lipid extract was applied to a sieve. Four hundred ml of microplastic suspension was poured through the sieve with and without the lipid coating. The procedure was repeated five times. Average particle sizes and percentages of plastic remaining after filtering were found with the microscope and ImageJ.

III. RESULTS AND DISCUSSION

Particle area under the microscope is a measure of the total plastic present per litre. Average particle size and total area after passing water through each type of sieve, with and without lipid coating, is shown in table 3. Microplastic in the pre-filtered water had a mean size of 25.4 ± 2.9 µm. That was not significantly reduced by filtering without the lipid coating (25.2 ± 3.6 µm) and the total plastic content per litre was reduced slightly from a relative area of 0.86 ± 0.02 to 0.81 ± 0.01.

After filtering with a lipid coated sieve, the mean particle size was reduced by around 12%, from 25.4 ± 2.9 to 21.1 ± 1.0 µm, and the plastic content per litre was greatly reduced from a relative area of 0.86 ± 0.02 to 0.051 ± 0.004. Comparing values in table 4 with Yeo and Julaihi's results in Table 1, the percentage reduction in total plastic per litre is equivalent within errors to the dissolved air flotation method, DAF.

Testing Condition	Mean size (µm)	Area (Rel. units)
Before filtering	25.4 ± 2.9	0.86 ± 0.02
After filtering with an uncoated sieve	25.2 ± 3.6	0.81 ± 0.01
After filtering, with a lipid coated sieve	21.1 ± 1.0	0.051 ± 0.004

Table 3. Mean size and relative area before and after filtering.

A lipid coated sieve removes more microplastic because the surface of a coated sieve is more viscous and rougher than that of an uncoated one. Viscosity and roughness increase the capture efficiency (Yeo and Julaihi, 2021). A sieve coated with jackfruit seed lipid extract is more effective in trapping microplastic than an uncoated sieve.

This result provides proof of concept: a viscous insoluable coating may capture microplastic particles suspended in water, but there is no indication that the capture is reliable over the long term.

In practical applications, thickeners such as ethyl cellulose or carboxymethyl cellulose (Arancibia, 2016), which have the property of increasing viscosity, could be added. They are insoluble in water and will increase particle adhesion. A more concentrated hexane solution could be used to shorten the time required for the extraction of the lipid mixture in large quantities. The properties of other natural extracts, such as latex (Kientz et al., 1996), or saturated fat extracts from other plants, could also investigated.

Sieve type	Microplastic Removed (%)
Uncoated	5.1 ± 2.9
Lipid-coated	94.1 ± 0.5

Table 4. Microplastic removed by filtering.

IV. CONCLUSION

Sieves coated with lipid extract from jackfruit seeds reduced the concentration of microplastic in the water by 94% compared to a very small reduction of only 5% when using an uncoated sieve, indicating that effective filtering of microplastics can in principle be achieved with lipid coatings.

V. REFERENCES

Amadi, J., Ihemeje, A., & Afam-Anene, A. (2018). Nutrient and phytochemical composition of jackfruit (Artocarpus heterophyllus) pulp, seeds and leaves. International Journal of Innovative Food, Nutrition and Sustainable Agriculture, 6(3), 27-32.

Amos, J. (1 May, 2020). High microplastic concentration found on ocean floor. BBC News. Retrieved from https://www.bbc.com/news/science-environment-52489126

Arancibia, C., Navarro-Lisboa, R., Zúñiga, R. N., & Matiacevich, S. (2016). Application of CMC as thickener on nanoemulsions based on olive oil: Physical properties and stability. International Journal of Polymer Science, 2016.

Kientz, E., Charmeau, J., Holl, Y, & Nanse, G. (1996). Adhesion of latex films. Journal of Adhesion Science and Technology, 10(8), 745-759.

Moreira, C. J. S., Bento, A., Pais, J., Petit, J., Escórcio, R., Correia, V. G., Pereira, C. S. (2020). An ionic liquid extraction that preserves the molecular structure of cutin shown by nuclear magnetic resonance. Plant physiology, 184(2), 592-606.

Pollard, M., Beisson, F., Li, Y., & Ohlrogge, J. B. (2008). Building lipid barriers: biosynthesis of cutin and suberin. Trends in plant science, 13(5), 236-246.

Trilokesh, C., & Uppuluri, K. B. (2019). Isolation and characterization of cellulose nanocrystals from jackfruit peel. Science Reports, 9(1), 1-8.

Yeo, L., & Julaihi, M. (2021). Magnetic Ferrous Fluid for Microplastics Extraction Application. Materials Science Forum (Vol. 1030, pp. 138-145). Trans Tech Publications

Pannanusorn, S. & Muang-soonthorn, N. (2021). A study of biofilm formation and hydrophobic properties of Candida parapsilosis. Thai Journal of Science and Technology, 10(1).

Acknowledgments

The authors would like to thank our advisor, Jirawat Waropas for your support during this project. We would also like to thank the National Science and Technology Development Agency, and the National Research Office, for the award of scholarships to support this project.