INL/MIS-24-79610-Revision-1

Extraction of Value-Added Products from Food Processing Waste Using Dimethyl Ether

August 2024

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Extraction of Value-Added Products from Food Processing Waste Using Dimethyl Ether

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COMBINING DEWATERING & EXTRACTION OF WET BIOMASS

BACKGROUND

- Valuable compounds are extracted from biomass for cosmetics, fuel, medicine, agriculture, etc., but traditional extraction methods require pretreatment, drying, and cell disruption[1]
- Industrial food processing companies discard biomass (e.g. potato peels, precipitated calcium carbonate, avocado pits) and wastewater biomass (e.g. algae) that contain valuable compounds[2]
- Liquified dimethyl ether (DME) has unique properties (e.g. dissolves organic compounds, miscible with water, environmentally compatible, non-carcinogenic, etc.) that makes it an excellent extractant[1]
  - No pretreatment or drying used while maintaining similar extraction rates as traditional methods[3]

What compounds can be extracted, using DME, from wet biomass that would be otherwise wasted?

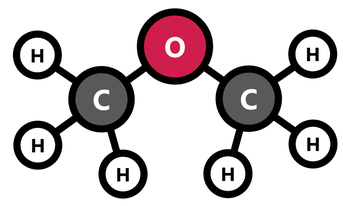

Figure 1 | Dimethyl ether (DME).

METHODS

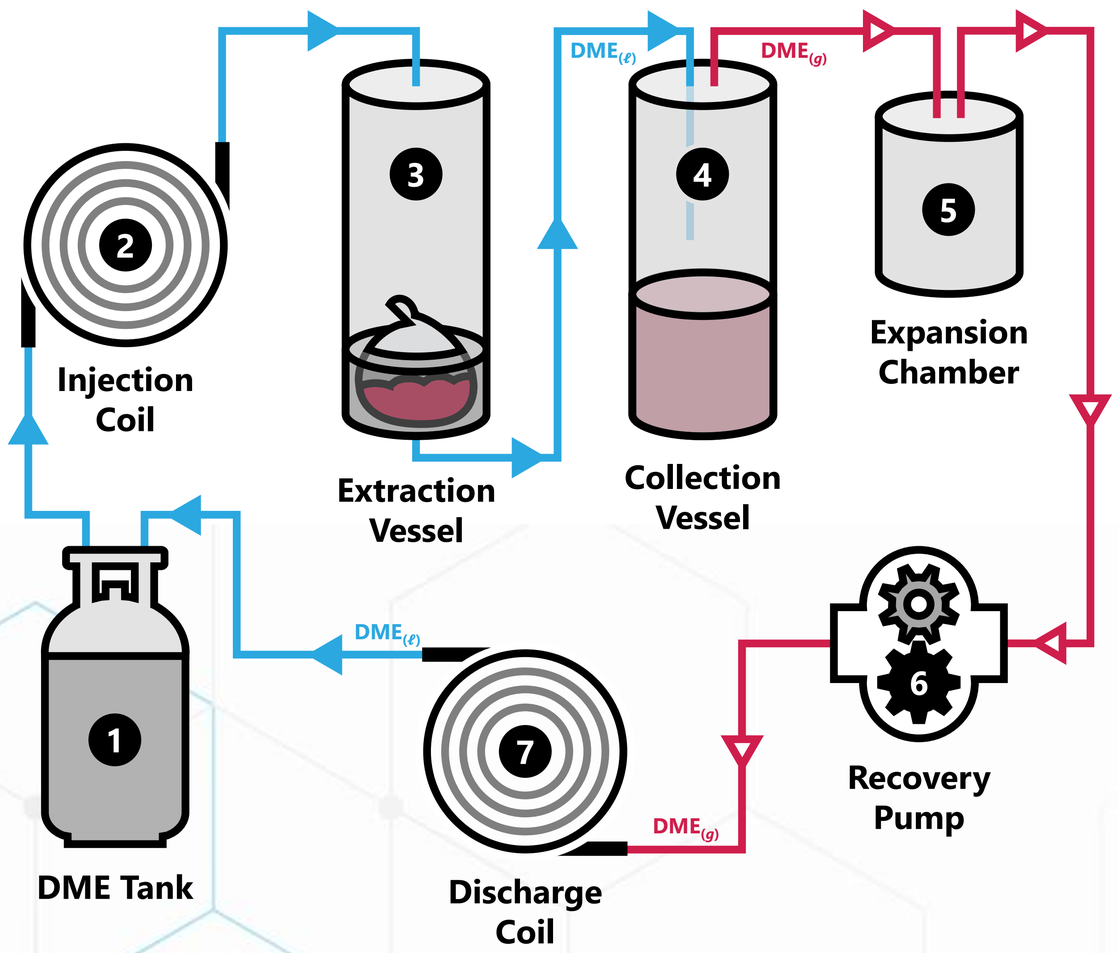

Figure 2 | Schematic of DME extraction. *The blue, closed arrows represent liquid DME, and red, open arrows represent gaseous DME. (1) Liquid DME from the operating tank flows into the (2) injection coil and then into (3) the extraction vessel. This vessel contains the bagged, solid sample, and it steeps in the liquid DME for a specified duration (~30 min). The liquid then flows into (4) the collection vessel. The extracted substances remain here while DME evaporates and flows into (5) the expansion chamber. The now purified, gaseous DME then flows into (6) the recovery pump and then the (7) discharge coil, where it is compressed back into a liquid and recycled into the main (1) DME operation tank.*

RESULTS

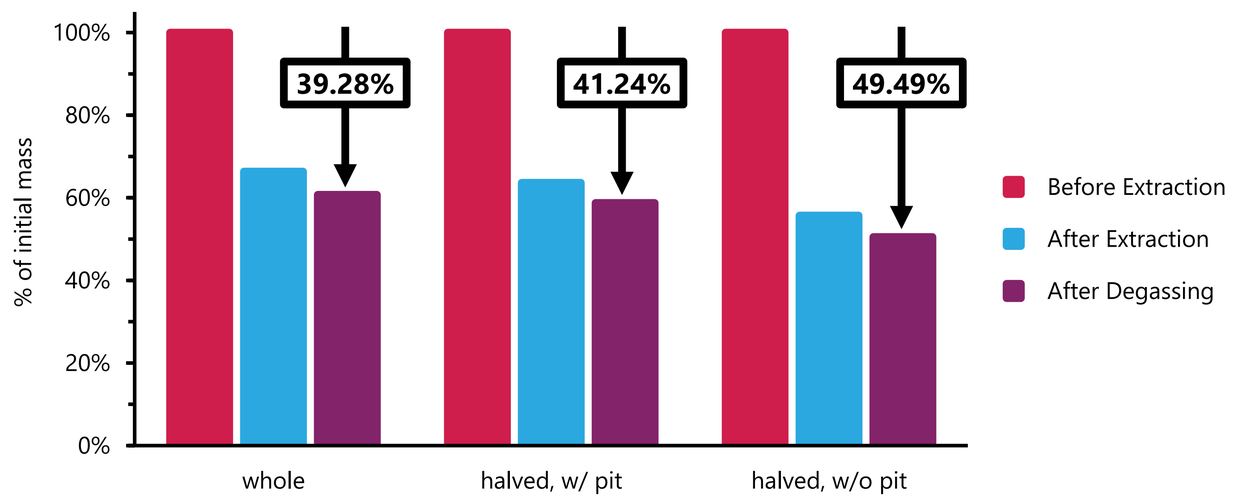

Figure 3 | Mass difference after DME extraction. *Whole and halved cherries were massed before and after DME extraction, and then after degassing overnight. The arrows represent the percent mass lost through extraction.*

Figure 4 | Before DME extraction. *Fresh red cherries, pitted and halved.*

Figure 5 | After DME extraction. *Extracted red liquid (water + intracellular compounds) and the shriveled, dewatered cherries.*

- Cherries were prepared to test extraction efficacy on fruit tissue
- Sample was exposed to a total of 28.8 mL DME/g cherry over 4 hours (4 cycles of exposure with 1 L DME each)
- Largest available surface area → most mass removed
- **DME extraction effectively removed water and pigment compounds without the need for pretreatment**

CONCLUSIONS & FUTURE WORK

CONCLUSIONS

- DME extraction is effective on fruit tissue, indicating it will likely be effective on other foodstuff and waste biomass
- More available surface area → better extraction efficiency

FUTURE WORK

- Measure initial moisture content (~90 wt% water for a cherry)
- Establish drying kinetics (initial vs. steady state)
- Vary the mass ratio of DME to biomass

REFERENCES & ACKNOWLEDGEMENTS

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[1] Zheng, Q.; Watanabe, M. Advances in low-temperature extraction of natural resources using liquefied dimethyl ether. *Resources Chemicals and Materials* **2022**, *1* (1), 16-26. DOI: 10.1016/j.recm.2022.01.001.

[2] Khanal, S.; Karimi, K.; Majumdar, S.; Kumar, V.; Verma, R.; Bhatia, S. K.; Kuca, K.; Esteban, J.; Kumar, D. Sustainable utilization and valorization of potato waste: state of the art, challenges, and perspectives. *Biomass Conversion and Biorefinery* **2023**. DOI: 10.1007/s13399-023-04521-1.

[3] Wang, T.; Zhu, L.; Mei, L.; Kanda, H. Extraction and Separation of Natural Products from Microalgae and Other Natural Sources Using Liquefied Dimethyl Ether, a Green Solvent: A Review. *Foods* **2024**, *13* (2). DOI: 10.3390/foods13020352 From NLM PubMed-not-MEDLINE.

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