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SCIENTISTS ARE DEVELOPING A SUSTAINABLE WAY TO CONVERT KALE WASTE INTO HEALTH AND PERSONAL CARE PRODUCTS

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The NTU process first takes kale waste, turning it into a paste or powder, before mixing it with a specially formulated natural deep eutectic solvent. The mixture is then filtered to extract the beneficial compounds from the kale waste. Credit: Nanyang Technological University

Scientists at Nanyang Technological University in Singapore have developed a new technique to convert kale waste into health and personal care products, reducing food waste and emissions.

Millions of tons of food and vegetables are thrown away every year around the world. In the case of leafy vegetables like kale and lettuce, farmers cut off the outer leaves as they harvest, in order to sell vegetables that are perfectly sized and look good, with no signs of damage or yellowing. This business practice results in the rejection of a significant amount of perfectly good edible leaves.

In Singapore, some 817,000 tonnes of food waste was generated in 2021, almost half of which was fruit and vegetables.

Phytochemicals found in plants are known to prevent damage to cells in the body and are widely used in consumer products. They include health-promoting supplements such as antioxidants and lutein, as well as facial scrubs and hair shampoos with kale extracts.

Current processes for extracting phytochemicals from kale are energy-intensive, requiring high pressure and temperatures, which contribute to the production of additional CO₂ emissions into the environment. Moreover, industrial extraction processes only target a single type of phytochemical each time.

In search of a more sustainable and efficient method of turning plant waste into “treasure”, NTU researchers turned to Naturally Derived Natural Deep Eutectic Solvents (NADES), non-toxic liquids composed of plant compounds such as amino acids, sugar, and vegetable oil byproduct – for the answers.

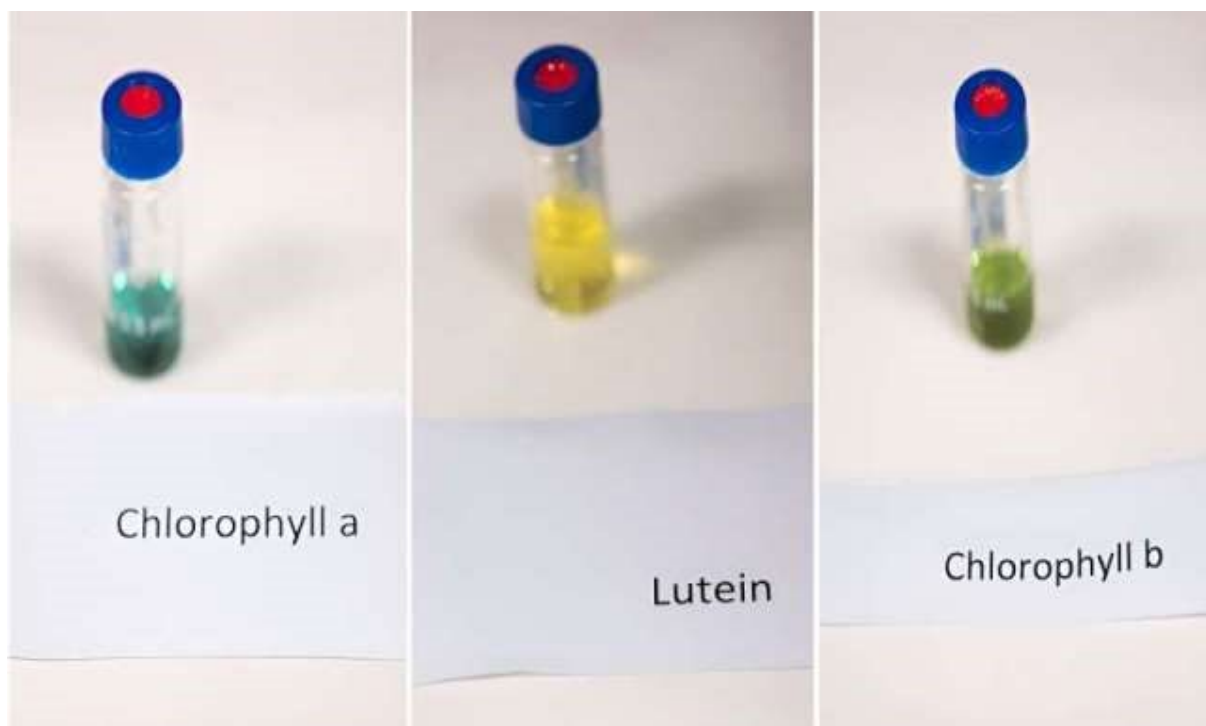
While NADES have long been studied in separation technology for the food and pharmaceutical industries, not much is known about their ability to extract different classes of bioactive compounds from plant waste.

Focusing on the bioactive compounds in kale, the NTU research team explored a range of NADES, mixing them with processed kale waste to observe how the molecules reacted to each other.

After repeated testing, researchers established the best NADES solvent for optimal extraction of bioactive compounds. The NTU team found that when the mixture of kale waste and NADES is stirred and set aside, it naturally separates into layers, facilitating easy extraction of kale phytochemicals (polyphenols, carotenoids and chlorophylls) without the need for heating.

Since there is no need to heat or pretreat kale waste, such as freeze-drying, the costs of the simpler extraction process are reduced. The NTU research team is confident that their newly developed method would be scalable and cost-attractive to industry.

The study's lead author, Professor Hu Xiao of the NTU School of Materials Science and Engineering (MSE) and Program Director, Sustainable Chemistry & Materials, Nanyang Environment & Water Research Institute (NEWRI), said: "The use of non-toxic materials and naturally derived solvents in our method make it a food safe technique. At the same time, our method preserves the potency of the extracted active ingredients, making it very attractive for industry adoption. The extracted nutrients can potentially be used for personal care applications, products, cosmetics, food supplements and plant extracts."



The NTU method extracts phytochemicals from kale, including chlorophylls and lutein, without the need for heating. Credit: Nanyang Technological University

NTU's research team said its waste-to-resource approach both tackles food waste and reduces emissions, supporting the development of a waste-free circular economy, as set out in the Paris Agreement. United Nations.

The study, published in the journal *Separation and purification technology* in July, is aligned with the research pillar of NTU 2025, the University's five-year strategic plan that aims to leverage innovative research to mitigate human impact on the environment.

A NON-TOXIC TECHNIQUE WITH HIGH YIELD

Established industrial methods for extracting beneficial compounds from plants involve the use of harmful chemicals like methanol, which can pose significant health and safety risks. In contrast, the NTU research team's approach uses naturally occurring NADES that are non-toxic.

The newly developed process involves first blending kale waste into a paste (or freeze-dried and ground into a powder). The researchers then mixed the kale paste (or powder) with their

specially formulated NADES solvent and mechanically stirred it at room temperature, before straining the mixture to extract the beneficial compounds. The whole process with low energy consumption, unlike current industrial methods that require high heat, is also fast and can be completed in 30 minutes.

Since bioactive nutritional compounds are temperature sensitive and degrade with heating, the NTU method helps avoid degradation, the researchers said.

In lab experiments, the team found that their approach resulted in an extract 2.2 times richer in polyphenols, compared to conventional methods using methanol. Additionally, the bioactive phytochemicals remained “active” after storage at four degrees Celsius for 30 days, displaying excellent shelf life.

First author Dr. Lee Sze Ying, a researcher at NEWRI’s Center for Environmental Chemistry and Materials at the time of the study, said, “Our extraction approach is unique in that it allows for the simultaneous recovery and separation of multiple valuable compounds from vegetable waste in a single process without using heat. Additionally, the polyphenol-rich extract remained stable in the extraction solvent, meaning manufacturers can simply add the extract directly into their cosmetics formula without further processing, reducing production time. .

Co-author Dr. Liang Yen Nan, Principal Investigator at NEWRI’s Center for Environmental Chemistry and Materials, explained, “Our method essentially manipulates the chemical nature of NADES and other green solvents to maximize the efficiency of extraction of bioactive compounds found in kale. ”

“This approach induces the simultaneous recovery of several phytochemicals from kale and can easily be adapted for use in other types of vegetable and fruit waste. Additionally, we have demonstrated that our approach remains viable even if we were to eliminate the energy-intensive freeze drying of kale waste, making our technology greener, cheaper and scalable for industrial use.”

The team filed a patent in Singapore for the innovation. For their next steps, the researchers are investigating the feasibility of applying their newly developed method to extract beneficial compounds from other types of fruits and vegetables, and herbal medicines like dragon fruit, spinach and lettuce.

More information:

Sze Ying Lee et al, One-Step Extraction of Bioactive Compounds from Cruciferous Vegetable (Kale) Waste Using Natural Deep Eutectic Solvents, *Separation and purification technology* (2023). DOI: 10.1016/j.seppur.2023.123677

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