

WASTE NOT

# Researchers Upcycling Kale, Plastic Waste Into Personal Care, Pharmaceutical Ingredients

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IMAGE: PLASTIC-BACKED FOILS SUCH AS API'S COULD GO ON TO BECOME COMPONENTS OF LIFE-SAVING PHARMACEUTICALS | [API FOILMAKERS](#)


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*Savvy scientists from Scotland and Singapore have developed sustainable ways to breathe new life into vegetable and plastic waste, as well as local manufacturing.*

## NTU Singapore scientists develop sustainable way to convert kale waste into products for health, personal care



Reshma Beauty is one of many personal-care brands that uses kale in its products | Image credit: [Reshma Beauty](#) 

Scientists from **Nanyang Technological University, Singapore (NTU Singapore)** have developed a technique to convert kale waste for use in health and personal care products, reducing food waste and emissions.

Millions of tonnes of food and vegetables are discarded globally every year. In the case of leafy vegetables such as kale and lettuce, [farmers cut off outer leaves](#) as they are harvested in order to sell perfectly sized and aesthetically pleasing vegetables with no signs of damage or yellowing. This commercial practice results in a significant amount of perfectly good, edible leaves being thrown away. In Singapore alone, some 817,000 tonnes of food waste were 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 health and personal-care products — including nutritional supplements such as **antioxidants** and **lutein**; as well as **face scrubs** and **shampoo** with kale extracts.

Current processes for extracting phytochemicals from kale are energy-intensive, requiring high pressure and temperatures, which contribute additional CO<sub>2</sub> emissions to the environment. Moreover, industrial extraction processes only target a single type of phytochemical each time.



Seeking a more sustainable and efficient method to turn vegetable waste into “treasure,” the NTU researchers looked to naturally derived **natural deep eutectic solvents (NADES)** — non-toxic liquids made up of plant-based compounds such as amino acid, sugar and vegetable oil by-product — for answers. While NADES have long been studied in separation technology for food and pharmaceutical industries, not much is known about their ability to extract different classes of bioactive compounds from vegetable waste.

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


Since there is no need to heat or pre-treat the kale waste — for example, by freeze drying — the costs, as well as the emissions, of the simpler extraction process are kept down. The NTU research team is confident their new method would be scalable and attractive, cost-wise, to the industry.

“The use of non-toxic and naturally derived solvents in our method makes it a food-safe technique,” said [Hu Xiao](#) , Professor at the NTU School of Materials Science and Engineering, Program Director of Sustainable Chemistry & Materials at **Nanyang Environment & Water Research Institute**, and lead author of the study. “At the same time, our method preserves the potency of the extracted active ingredients — making it highly attractive for industry adoption. The extracted nutrients can potentially be used for applications in personal-care products, cosmetics, food supplements and herbal extracts.”

The NTU research team said that their waste-to-resource approach tackles both food waste and carbon emissions, supporting the development of a zero-waste, [circular economy](#).

The [study](#) , published in the scientific journal *Separation and Purification Technology* in July, is aligned with the research pillar of [NTU 2025](#)  — the University’s five-year strategic plan which aims to leverage innovative research to mitigate human impact on the environment.

## Investigating approaches for use with other crop waste

The NTU team has filed a patent in Singapore for its non-toxic, high-yield extraction technique (learn more about it [here](#) ). 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, vegetables and medicinal plants such as dragon fruit, spinach and lettuce.

Kale waste for the study was provided by **Sustenir Agriculture**, a Singapore-based, high-tech urban-farming company. The kale leaves used for the research did not meet commercial quality standards and were intended to be discarded as waste.

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