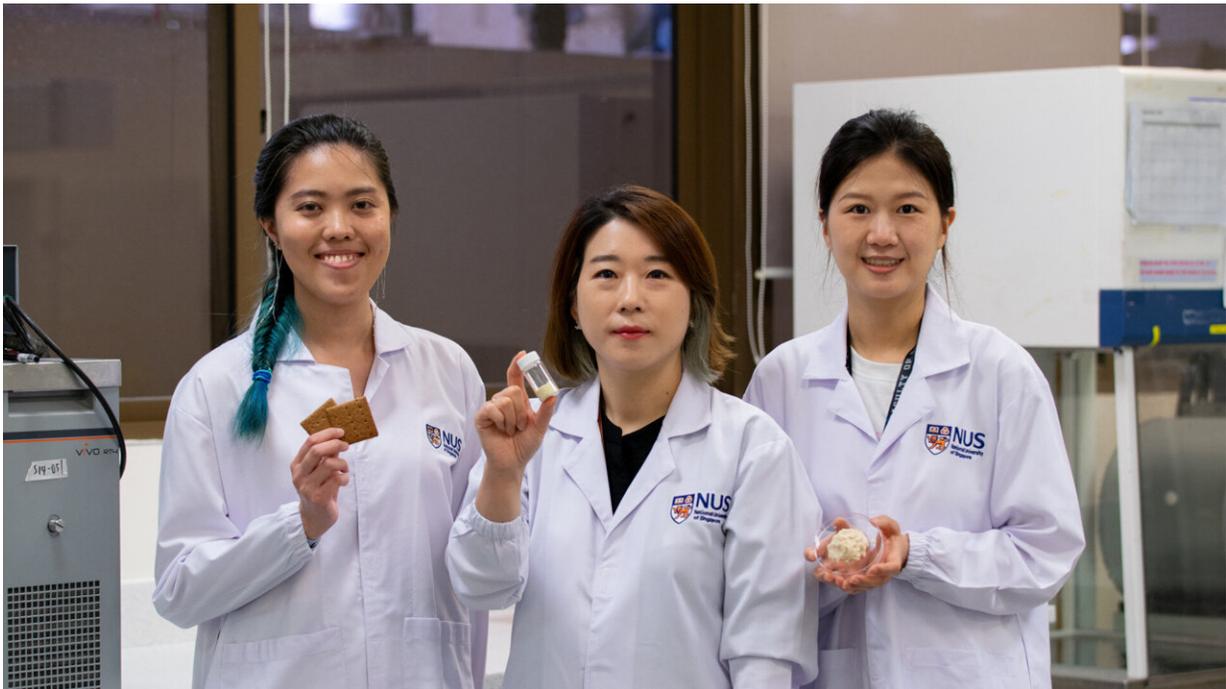


Study recommends improving gut health with okara biscuits

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Asst. Prof. Kim Jun Eun (center) together with Dr. Delia Lee (left) and PhD student Ms. Xu Yujing (right) developed biscuits containing okara. A by-product of tofu production, okara is high in dietary fiber and improves overall gut health. Credit: National University of Singapore

Soy milk and tofu are common in Asian diets. However, the production of these soy-based products results in a solid by-product known as okara. About 4 million tons of okara are produced each year in China, Japan,

and Korea alone. Commonly used as livestock feed, okara is becoming an ingredient of interest for food due to its high fiber content.

While okara could be a good source of dietary fiber at a low cost, its fibrous texture and lack of flavor mean that more has to be done for this by-product to become an appealing ingredient for consumers to benefit from its nutritional value.

As many Singaporeans fail to meet the recommendations for fiber intake of 26 grams and 20 grams of dietary fiber for men and women, respectively, finding ways to incorporate okara into our daily diet could help enhance the well-being of the population.

To address this challenge, Assistant Professor Kim Jung Eun and her research team from the NUS Department of Food Science and Technology under the Faculty of Science embarked on a series of studies to improve the attractiveness of consuming okara as a source of dietary fiber and to provide scientific evidence of the health benefits of okara.

"Conversion of food by-products has garnered attention globally in recent years as a way to achieve sustainable food systems through discovering alternative uses and value of these by-products. Our studies demonstrate the value of incorporating nutritious okara into foods, and regular consumption of okara can improve the quality of an individual's daily diet through meeting the recommended fiber intake while additionally providing health benefits," said Kim.

Tasty okara biscuits

In an [earlier study](#) published in *LWT* in 2020, Kim and her research team successfully enhanced the texture and flavor of okara-containing biscuits through fungal fermentation. Fermentation is commonly used in food production like in bread and wine-making. Fungal fermentation

breaks down large fiber molecules and undesirable flavor molecules in okara, producing biovalorised okara, which is characterized by nutritional improvements such as greater content of soluble fiber, free amino acids, and greater anti-oxidant activity.

Biscuits made with biovalorised okara powder were sweeter, crispier and less hard than biscuits made with regular, non-biovalorised okara.

Building on these promising findings, the NUS team decided to examine further the positive effects of consuming okara biscuits on fiber intake and gut health.

Increasing fiber intake with okara biscuits

In the follow-up study, 15 healthy, middle-aged participants alternated between consuming biovalorised okara, non-biovalorised okara and control biscuits that did not contain okara, over 16 weeks. The participants also recorded their 3-day food intake for the researchers to understand their dietary habits during the study.

"We used fermentation with food-safe microorganisms to incorporate okara into a palatable food product. In our study, we provided our participants with okara that can be readily consumed in the form of biscuits without major interference to their habitual lifestyle and diet," said Dr. Delia Lee, the first author of the study.

The research team found that participants who consumed biovalorised okara biscuits had increased their total soluble fiber intake to the recommended levels. In contrast, participants who consumed regular biscuits recorded nearly 10% lower soluble fiber intake.

Better gut health

Dietary fiber acts as food for our gut bacteria, which break down dietary fiber to produce short-chain fatty acids (SCFA)—these are molecules essential for maintaining gut health as well as overall health status.

To determine whether biovalorised okara biscuits were beneficial to gut health, the NUS team analyzed SCFA levels of the participants after consuming the biscuits. They discovered that consuming biscuits with biovalorised okara brought about significantly higher SCFA levels in the [blood stream](#) compared to consuming biscuits with non-biovalorised okara. This was paired with a reduction in secondary bile acids, which are known to be harmful to cells in the gut. The researchers also found that consuming biscuits with biovalorised okara increased the abundance of Bifidobacterium, a bacterium ubiquitous in the gut which wield health-protective effects.

"We assessed the SCFA levels in both the blood and fecal sources to discover the presence of a higher concentration of SCFA circulating in the blood post-intervention compared to SCFA that is found in fecal samples, demonstrating potential anti-inflammatory health benefits," said Dr. Lee.

Next steps

In this recent study published in the journal [Molecular Nutrition and Food Research](#), Kim and her team have obtained positive results to support the integration of okara into meals to augment the nutritional quality of people's diet. They also found that biovalorisation is an attractive processing option to enhance okara's nutritional profile.

"Based on our current study, we observed an improvement of gut health after regular consumption of okara-containing biscuits. We hope to further examine the effect of okara-containing foods in individuals with metabolic syndrome (MetS)," said Kim. MetS is a cluster of conditions

characterized by impaired fasting glucose, abdominal obesity, high blood pressure, and imbalance of lipids in the blood and it is often accompanied by an imbalance of microorganisms in the gut.

Additionally, Kim and her research team are investigating the potential of brewer's spent grain (BSG) in controlling blood glucose level in adults with metabolic impairment. BSG is a key by-product of the beer brewing process, and it has been found to be rich in dietary proteins, dietary fiber and certain bioactive compounds.

"By identifying evidence of [health benefits](#) conveyed by food by-products, we hope to support a healthier Singapore and also reduce food waste to achieve a circular economy of [sustainable food systems](#)," said Kim.

More information: Delia Pei Shan Lee et al, Regular Consumption of Biovalorized Okara-Containing Biscuit Improves Circulating Short-Chain Fatty Acids and Fecal Bile Acids Concentrations by Modulating the Gut Microbiome: A Randomized Controlled Crossover Trial, *Molecular Nutrition & Food Research* (2023). [DOI: 10.1002/mnfr.202200756](#)

Provided by National University of Singapore

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