Chitin from crustaceans, insects, mushrooms engages the immune system during digestion

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Who can forget the stomach-churning moments when "Survivor" contestants forced down crunchy insects, among other unappetizing edibles, for a chance to win $1 million? In daring culinary challenges,

the TV show's contestants exhibited gastronomic bravery as viewers watched in discomfort.

Digesting a crunchy critter starts with the audible grinding of its rigid protective covering—the exoskeleton. Unpalatable as it may sound, the hard cover might be good for the metabolism, according to a new study, in mice, from Washington University School of Medicine in St. Louis.

The researchers, led by Steven Van Dyken, Ph.D., an assistant professor of pathology & immunology, found in mice that digesting chitin, an abundant dietary fiber in insect exoskeletons and also mushrooms and crustacean shells, engages the immune system. An active immune response was linked to less weight gain, reduced body fat and a resistance to obesity. The study is published Sept. 7 in *Science*.

"Obesity is an epidemic," Van Dyken said. "What we put into our bodies has a profound effect on our physiology and on how we metabolize food. We're investigating ways to counteract obesity based on what we learn about how the immune system is engaged by diet."

The immune system is well known for safeguarding the body against various threats, including bacteria, viruses, allergens and even cancer.

The researchers found that a particular arm of the immune system also is involved in chitin digestion. Stomach distention after chitin ingestion activates an innate immune response that triggers stomach cells to ramp up production of enzymes, known as chitinases, that break down chitin. Of note, chitin is insoluble—incapable of being dissolved in liquid—and thus requires enzymes and harsh acidic conditions to digest.

Do-Hyun Kim, Ph.D., a postdoctoral research associate and first author on the study, performed the experiments in germ-free mice lacking intestinal bacteria. His results show that chitin activates immune

responses in the absence of bacteria.

"We think chitin digestion mainly relies on the host's own chitinases," Van Dyken said. "The stomach cells change their enzymatic output through a process we refer to as adaptation. But it is surprising that this process is happening without microbial input, because bacteria in the gastrointestinal tract are also sources of chitinases that degrade chitin."

Van Dyken noted that in mice with intestinal bacteria, dietary chitin altered the bacterial composition in the lower gastrointestinal tract, suggesting that gut bacteria also adapt to chitin-containing food after it leaves the stomach.

The research team found that the greatest impact on obesity in mice occurred when chitin activated the immune system but was not digested. Mice fed a high-fat diet also were given chitin. Some mice lacked the ability to produce chitinases to break down chitin. The mice that ate chitin but couldn't break it down gained the least amount of weight, had the lowest body fat measurements and resisted obesity, compared with mice that didn't eat chitin and with those that did but could break it down.

If the mice could break down chitin, they still benefited metabolically, but they adapted by overproducing chitinases to extract nutrients from chitin.

Van Dyken and his team next plan to follow up on their findings in people, with a goal of determining whether chitin could be added to human diets to help control obesity.

"We have several ways to inhibit stomach chitinases," he said. "Pairing those approaches with a chitin-containing food might have a very real metabolic benefit."

More information: Do-Hyun Kim et al, A type 2 immune circuit in the stomach controls mammalian adaptation to dietary chitin, *Science* (2023). DOI: 10.1126/science.add5649.
www.science.org/doi/10.1126/science.add5649