Super Soy!

Medical uses for soy compounds may be on the horizon.

Tofu's no longer the only answer if you're after more soy in your diet. Today, the options have never been better. There are cereals and snack bars enriched with soy protein—or the salty taste of roasted soybeans and soy chips. Even a sweet tooth can find fulfillment with creamy, frozen deserts made from soy milk.

There's good reason for soy's recent surge in popularity. Despite the legume's rather dull seed exterior, tucked inside the seed are dozens of dazzling plant chemicals that could prove to be a boon to human health. As researchers across the country are finding, some of these compounds show potential to protect the heart, halt postmenopausal bone loss, and stave off certain cancers.

Stephen Boué, a chemist with ARS, studied soy's intriguing phytochemical makeup at the agency's Southern Regional Research Center (SRRC) in New Orleans, Louisiana. (Boué is temporarily at ARS in Oxford, Mississippi.) According to Boué, it's soy's phytoestrogens—estrogenlike compounds found in some plants—that could play an important role in human health.

"Because hormonal fluctuations in postmenopausal women can put them at an increased risk for developing cancer or experiencing bone loss," says Boué, "some plant-derived estrogens could possibly reduce that risk if they are included in the diet."

It's already known that populations eating a diet rich in soybean phytoestrogens have lower incidences of several diseases, including breast and prostate cancer.

But before health-conscious consumers go on a soybean binge, scientists first need to figure out which of the plant's compounds are most helpful to our health. After all, these potent chemicals can have a range of effects on the body.

SCOTT BAUER (D332-5)

Purified mixture of glyceollins induced from soybeans. These compounds are being investigated for anticancer activity in mice.

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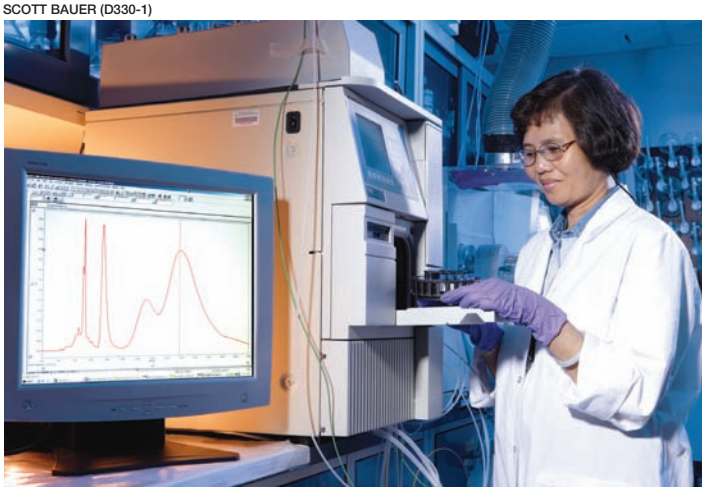

Using high-performance liquid chromatography, chemist Betty Shih monitors the purity and quantity of glyceollins produced by *Aspergillus sojae*-treated soybean seeds.

Another complicating factor: No matter how many soy-rich foods you eat, you may still be missing out on one of the bean's best offerings.

When Stress Is a Good Thing

The soy compounds of greatest interest to Boué are those called glyceollins *(GLY-cee-OH-lins)*.

Three years ago, he and collaborators at the Tulane-Xavier Center for Bioenvironmental Research in New Orleans discovered that, in lab tests, glyceollins can block the growth of hormone-dependent breast cancer cells. Their results were published in the *Journal of Clinical Endocrinology and Metabolism* in 2001.

But despite their promising powers, you won't find any glyceollins in soy products now on the market. Other good-for-you compounds may be missing, too.

The reason for their absence may strike you as odd. It's because today's soybeans plants aren't getting enough stress.

SCOTT BAUER (D333-2)

Biologist Carol Carter-Wientjes and microbiologist Ed Cleveland examine soybeans treated with the food-grade microorganism *Aspergillus sojae* to get the beans to produce glyceollins.

"Unlike their ancestors, today's soybean plants are grown in nice, clean, relatively disease-free fields," says Ed Cleveland, a microbiologist and research leader of SRRC's Food and Feed Safety Research Unit, temporarily based in Baton Rouge, Louisiana. "This means they're not being challenged by the pathogens and insects they'd normally encounter in nature.

"When confronted with disease or stress, soybeans—like most plants—will rev up their natural defenses and pump out protective compounds," he adds. "It's these plant-guarding chemicals that are showing such potential in human health studies."

So what would it take to get soybeans to naturally produce higher levels of the beneficial glyceollins? According to Cleveland, "You'd have to grow soybeans in fields that were fungi-infested, diseased—basically under conditions that could destroy the crop."

It Takes a Fungus

But Boué discovered a way to elicit this chemical response in the laboratory, without all the mess.

Along with biologist Carol Carter-Wientjes, he found just the right fungus to mimic the kind of disease threat needed to put soybean plant cells on high alert—and produce impressive amounts of glyceollins.

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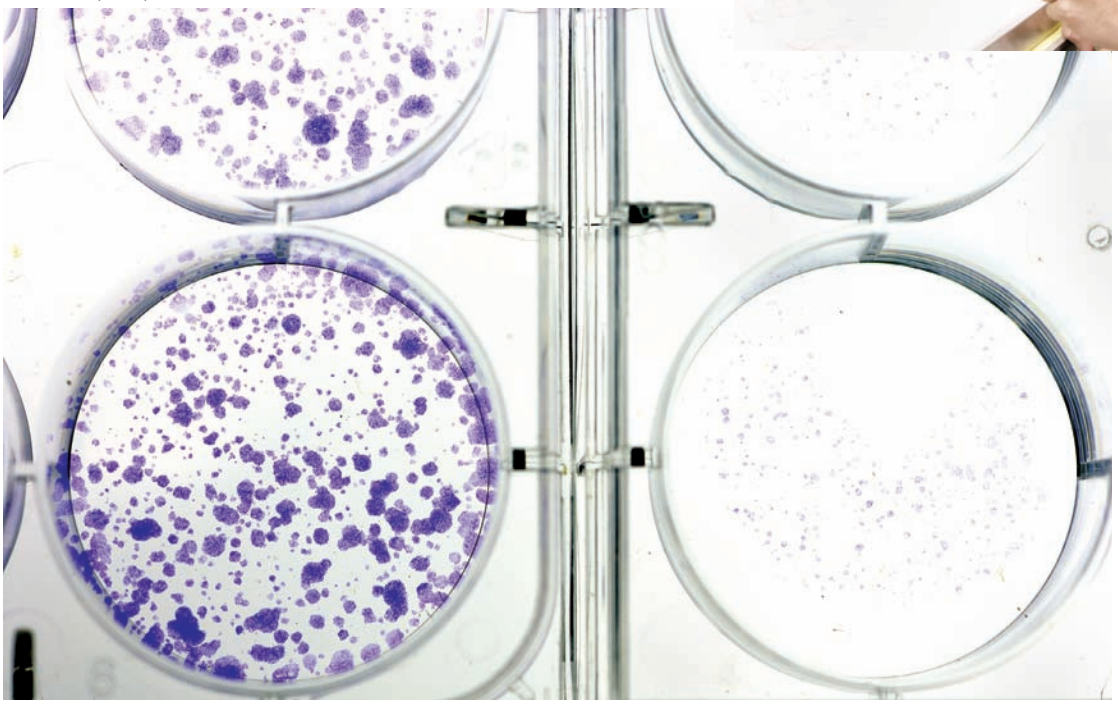

Above: ARS chemist Stephen Boué (left) and Tulane University biologist Matthew Burow examine results of breast cancer cells combined with different concentrations of glyceollins.

Left: Plate wells are stained so that individual breast cancer cell colonies become visible for counting. Glyceollins decreased cell colony numbers (right) versus controls (left), indicating potential inhibition of cancer cell proliferation.

They found their answer in an unexpected place: soy sauce. That's because their best performer is the fungus used to ferment soybeans for making soy sauce. The fungus is known as *Aspergillus sojae*.

Cleveland and other researchers studying *Aspergillus* species at SRRC had already proven that the fungus is innocuous enough for food production—indicating that it would be safe for Boué and Carter-Wientjes's studies.

And almost right away, the researchers got a good sign from their treated soybeans. After soaking soybeans for a few hours to get the seeds close to germination, the researchers sprinkled a dried version of *A. sojae* onto cut surfaces of the legumes.

"Just a couple of days after treatment," says Carter-Wientjes, "we saw the soybeans' wound surfaces turning this deep red. We knew that a biochemical reaction was taking place and that glyceollins were being churned out."

With further analysis, Boué confirmed that glyceollins are indeed being produced by the soybeans. Another SRRC researcher, chemist Betty Shih, isolated enough of the compounds from the laboratory procedure for use in health studies. Boué shared glyceollin samples with medical researchers, including Matthew Burow at Tulane-Xavier.

Fruitful Findings

So far, results from the medical studies are promising. For their research, Burow's team at Tulane injected mice with breast cancer cells and then treated the animals with glyceollins.

"My Tulane collaborators are finding that the glyceollins from our soybeans are stopping cancer cells from proliferating," says Boué. "This research could lead to a drug or therapeutic treatment for breast cancer."

Boué and his SRRC colleagues also produced a soy protein isolate from their induced soybeans. Also containing the promising glyceollins, the soy protein could be the basis for future health foods, like soy protein bars. Another group of medical researchers is working with Boué to monitor the effects on primates fed a diet of the induced-soybean protein.

If collaborators continue to unveil positive results, the next step for Boué and colleagues will be to devise an effective method for treating soybean seeds on a large scale.

"It may involve finding the genes involved in producing glyceollins," Boué says, "or developing sprays or elicitor treatments that can be safely applied to soybean plants themselves."—By **Erin Peabody,** ARS.

This research is part of Food Safety (#108) and Human Nutrition (#107), two ARS National Programs described on the World Wide Web at www.nps.ars.usda.gov.

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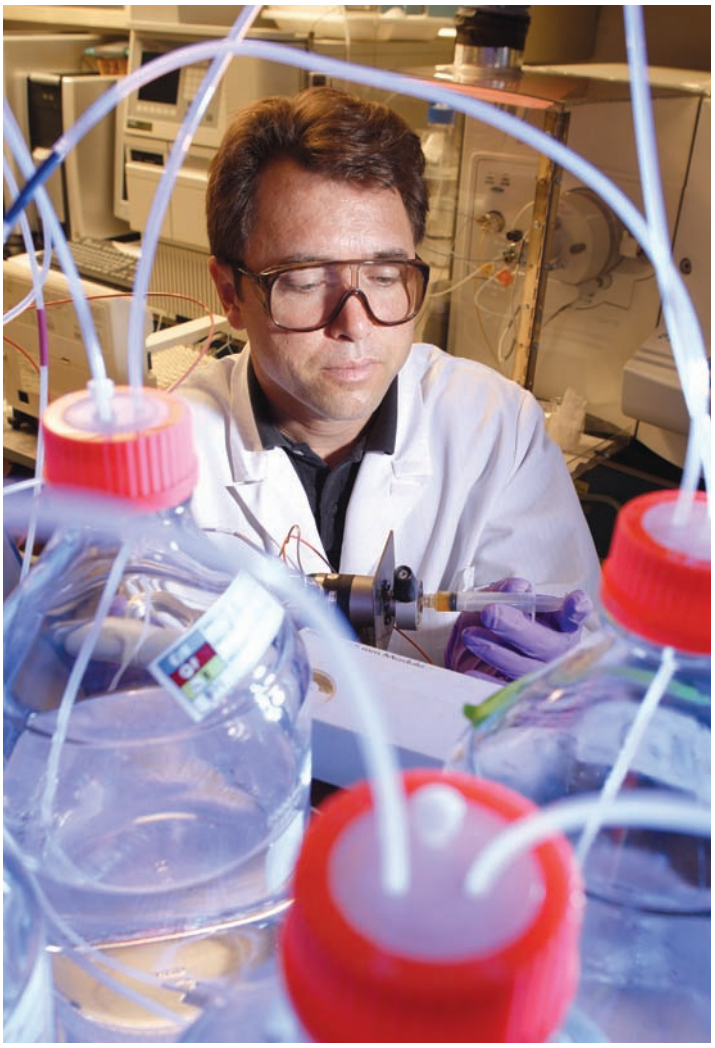

Using prep-scale high-performance liquid chromatography, Stephen Boué isolates glyceollins from a methanolic extract of Aspergillus sojae*-treated soybean seeds.*