Can scientists help food producers offer healthier food choices that consumers actually want to eat? Food producers are under pressure to offer a wider variety of healthier choices. But many consumers are averse to food made with whole grains or with reduced salt, sugar, or fat.

Helping solve that conundrum is the life’s work of Devin Peterson, whose Flavor Research and Education Center (FREC) at the University of Minnesota is bringing together a consortium of food producers to investigate the chemical pathways that are responsible for the flavor of food.

The results of his research, conducted using GERSTEL technology, could change the way food is made, leading to more healthy, yet tasty, options — and, perhaps, to a healthier world. Consumer acceptability is known as one of the main factors influencing food choice. Consequently, improvements in the flavor quality of healthier food options would be a viable strategy to promote a healthier lifestyle.

Peterson and his colleagues use analytical techniques such as gas chromatography and mass spectrometry to search for and identify sources of flavors in food, including unpalatable flavors that can arise naturally from foods or are produced during processing, storing, or shipping. “We focus on flavor discovery,” Peterson said. “What makes food great, that you want to eat. There’s a lot of opportunity in the food industry for simpler labels on food, to improve flavors, and to create food that’s formulated in more ideal ways.”

Peterson laments that over the past few decades, the food industry hasn’t advanced as rapidly as other fields, such as medical research or even crop genetics and technology. “The food industry isn’t very far along in regards to knowledge,” he said. “If you want to create a whole grain product, for example, it’s hard not to add sugar or salt in order to create a product people want to eat. Salt and sugar are very economical, but today, we don’t want that. We want less processed, more holistic and simpler foods. It’s harder to do this because our food ingredients have been developed for yield (economics) and not flavor quality.”
The shortcomings of food additives have had a direct impact on human health. Added sugar and salt all have adverse health effects. Obesity has been linked to excess consumption of sugars as well as fats, particularly in processed foods, and its occurrence has been steadily rising since the 1980s. Today, about 38 percent of Americans, 21 percent of Europeans, and 30 percent of the planet's human population is obese. A recent study shows that 10 percent of Americans get 25 percent of their daily calories from added sugar — a habit that makes them twice as likely to die from heart disease.

Excess salt can also cause problems, including heart disease, cancer, and osteoporosis. Currently, Americans get about 75 percent of their salt from additions to processed foods. But people can only taste between 10 and 20 percent of that added salt, Peterson said, meaning that the other 80 to 90 percent is digested without having been tasted. By finding ways to alter salt release so more of it is released in the mouth, affecting taste, food makers could reduce added salt by as much as 50 percent, Peterson said. Likewise FREC is working with industrial partners to find

ways to reduce blandness, off-flavors, and natural degradation of flavor that necessitates added salt and sugar in food formulations.

A NEW FIELD IS BORN: FLAVOROMICS

Peterson and the FREC team are working to provide just that combination. One new area, partly the creation of Peterson and his colleagues, is flavoromics. In this emerging field, researchers use the volatile compound prints from GC/MS, including GERSTEL technology such as Dynamic Headspace Sampling, to look for changes in flavor. Then, scientists can conduct untargeted research to find out everything in a food product that’s contributing to its flavor or what makes some foods taste stale, and otherwise change the character of foods.

These efforts, like the field of metabolomics, isolate and analyze thousands of chemicals and statistically associate them with different flavors. By analyzing fermentation, Maillard (heat-induced browning) and other reactions, the researchers can start untangling the complex chemical pathways that produce certain flavors.

Obesity has been linked to excess consumption of sugars as well as fats, particularly in processed foods, and its occurrence has been steadily rising since the 1980s.
By understanding these pathways, chemists can then find ways to shut down those that produce undesirable flavors, and enhance those that produce desirable ones. This could be done by introducing chemicals that slow undesirable reactions. In addition, plant breeding could introduce new varietals in which the desirable pathways have been preserved or enhanced (and enzymes could create barriers to pathways that create unwanted flavors).

Understanding how these pathways work requires isolating and purifying the chemicals at various stages of the flavor generation process. Then, the pathway itself can be reconstructed to see how each chemical changes its structure and function along the way. The reconstructed pathways can point to chemicals known for producing certain flavors, as well as for previously unknown flavor-producing chemicals. “It’s a new way to look at taste and aroma,” Peterson said.

FREC is conducting its food research in several key areas:

**Juice**

Once bottled, juices begin chemically degrading, which includes color and flavor changes, so that fresh juice always tastes differently from processed juice. Consumers want juice that’s as fresh as possible, but juice is highly unstable, and doesn’t remain safe to drink for very long without processing.

GERSTEL technology, including Twister extraction and automated processes for flavor analysis, is being used to determine what chemicals contribute to degradation, and changes in flavor quality, and may even point to ways for preserving the flavors of freshness.

Knowing how these degradation pathways work will help determine ways to preserve freshness without including food additives such as sugars.

“We want to understand how juice can solve its own problems, and protect itself from degrading,” Peterson said.

**Milk**

To determine if the stability and freshness of milk could be extended, Peterson and his colleagues have used the GERSTEL Thermal Desorption Unit and Thermal Desorption System to understand the off-flavor attributes of these products. The 2D GC/MS and systems for GC fraction collection was utilized to recreate flavor compounds that accompany milk storage. One compound they discovered was not commercially available, but GERSTEL products were able to analyze the compound and get a better understanding of its chemical structure and presumed function.
The team used GERSTEL fraction collection technology to purify an off-flavor compound that was not commercially available. Peterson has been studying how phenols can influence key intermediates (carbonyls) of the Maillard reaction, a key pathway of off-flavor development in aseptic milk. They discovered that the polyphenol epicatechin can lower carbonyl loads and reduce off flavors when it’s added to raw milk before processing into high-temperature (aseptic) milk.

**Whole Grains**

As described in a 2013 study published in the journal *Food Chemistry*, FREC researchers discovered a number of chemicals in the crumb and crust of whole grain bread that contribute to the bitter taste commonly noted by many consumers. That bitterness has deterred many from altering their preferences for processed white flour.

The researchers found that the bitter taste stems from reactions related to two different sources: Maillard reactions from heating in the crust, and from the hydration of flour in the bread’s interior, which triggers a series of enzymatic reactions that created bitterness. The bitter compounds identified included novel compounds, Acortatarin C and Acortatarin A, located in the crust and 9,12,13-trihydroxy-trans-10-octadecenoic acid. By changing processing, or even plant breeding of the cereal grains, whole wheat bread could possibly be made to be more palatable, requiring less salt and sugar that are commonly used to mask bitterness.

**ANALYTICAL CHALLENGES**

For chemists involved in flavoromics, the biggest analytical challenge is discovering the markers that cause off-flavors. Once markers — proteins, enzymes, and certain stages of chemicals that produce an aroma or flavor — are found, then it’s easier to determine the pathways that are generating these markers.
Further, chemists might be able to alter chemistries of food to inhibit degradation pathways, or just the pathways that until now made manufacturers add too much sugar or salt. Carbon 13-labeled glucose can help trail the degradation of those sugars, and match precursors with flavors produced by each step of a pathway. Precursor compounds, in addition, help researchers connect the dots: “What’s degrading, what are the pathways involved, and how can we minimize these changes?” said Peterson.

According to Peterson, GERSTEL technologies have lent themselves well to this new approach to food chemistry.

“We’re using GERSTEL technology, and the nice thing is that it’s geared toward flavor analysis, geared toward automation, and geared to be reproducible in ways that allow us look at this niche part of food chemistry,” he explained. “For understanding the flavor changes in apple and orange juice, we’ve used Twister analyte extraction technology. We’ve used GERSTEL instrumentation on milk to determine how it can maintain its freshness for months. To see how we can preserve milk, and make it stable, we’ve used technology like the TDU and TDS units to understand vapor prints. That’s a great story for us, because we were trying to recreate off flavor compounds that come with milk storage.”

**A NEW MODEL FOR INDUSTRY, RESEARCH**

Food research has not often been conducted by major universities. The total budget for food quality research from the U.S. government is a paltry $3 million, with most research conducted by private industry. “But every company has a limit. They don’t have open checkbooks,” said Peterson, making it difficult or impossible for private industry to fund food quality research on its own.

In response to this need, FREC offers an open innovation platform, in which companies and University researchers work together to address global problems such as food supply, and find solutions. Costs are shared, as well as research results, which all help increase understanding in a poorly understood field.

Peterson believes that his university/industry consortia, and the work of FREC and other institutions, will help give this field a badly needed boost. Currently, most consumers don’t eat enough whole grains or fruits and vegetables, according to U.S. National Institutes of Health, instead consuming more processed foods that may have excess amounts of added fat, sugar, and salt. The challenge then, is to understand how healthier processed foods can have better flavor. “We just don’t have that knowledge today, to make things really fresh, nutritious, and good-tasting.”
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