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Science of Taste and Flavor Design

By Kimberly J. Decker, Contributing Editor

Sometimes, flavor technology starts with a physiological investigation of how the human body senses taste. Today, the science of taste has advanced far beyond mapping the areas of the tongue that sense sweet, salty and so on.

Cutting-edge taste technology

Investigations conducted by Senomyx, Inc., San Diego, CA, into a “lock and key” biological model of taste—where the tastant binds to the receptor and triggers the neurological response signaling a specific taste, or a “channel and pore” system where ions that create sour and salty move through pores to trigger the response—have netted the company partnerships with some of the industry’s leading players, including Nestlé, Coca-Cola, Campbell’s Soup, Ajinomoto, Cadbury Schweppes, Firmenich and Solae.

While the logistics of the company’s efforts may be mind-bending, the logic is downright intuitive. It all starts with the basic mediator of taste, the taste bud. Over the past 10 years, says Mark Zoller, Ph.D., chief scientific officer, Senomyx, the company has gained two key insights about this structure. “One is that a taste bud is composed of about 50 to 100 cells, and it appears that each taste has its own type of cell,” he explains. These cells intermingle within the taste buds, in contrast to the older “tongue map” model whereby we tasted sweetness exclusively at the front of the tongue, bitter at the back and so on. “You certainly can find that there’s prioritization of certain tastes in certain regions—for example, the tip of the tongue tends to be more sensitive to salty,” Zoller says. “But you can find salty-type protein receptors all over the tongue.”

The second new finding revealed there’s a cellular projection bearing characteristic proteins on the tip of each taste bud. “The proteins that we’re interested in are the taste receptors,” Zoller says, “and they fall into two different categories.” One physically binds the tastant, an example being the receptor that selects for sugar. In doing so, it “triggers the inside of the sweet cell to say, ‘I’ve been activated and now I release neurotransmitters that send signals to the brain that I’m tasting sweet,’” Zoller says. Some call this a lock-and-key system, with sugar the key and the receptor the lock, and it’s also the mechanism that describes our ability to taste bitter and umami compounds, as well.

“The other type of protein, rather than being a lock and key, is more like a channel, or pore,” Zoller continues. These channels permit the passage of the ions that generate salty and sour tastes. “So, if you think of something acidic, it would be a proton or something small like that going through this sour channel and triggering a sour cell to respond. And it’s the same with salt: Salt is sodium chloride, and the sodium ion goes through the ion channel into the salt cell, and that activates the signal that you’re tasting something salty.”

The artificial taste bud

What does all this mean for taste modulation? According to Zoller, it allows his team "to use those receptors to look for new things that are sweet or salty, or that block bitterness." By applying their understanding of the biomechanics of taste to actual mechanical instrumentation, Senomyx has built an "artificial taste bud" that can suss out substances that trigger specific sensations. "So we take a sweet receptor, we put it in a specialized cellular system, and then we can use that cell system to screen all of our different samples to see if we can find something that's sweet—something that triggers or enhances the sweet receptor," Zoller says.

Because a cellular system can't actually tell you when it tastes something sweet, Senomyx researchers have also developed a method for the artificial taste bud to signal what sensation it's picked up. "In the case of the receptors for sweet, bitter and umami," Zoller says, "if you trigger the receptor, it actually increases the intracellular concentration of calcium." By placing these cells in a calcium-sensitive fluorescent dye, the company can tell when they're binding a tastant by their degree of calcium-induced fluorescence. The ion channel mechanism works similarly. "You're increasing the intracellular ion concentration, and there are dyes that also change their fluorescence when that happens, too."

In this fashion, the company not only screens tastants accurately and precisely, says Zoller, but "we've been able to miniaturize it and automate it. We're translating biochemical activity into something that can be picked up by an instrument in a very high-throughput fashion." Such technology has given them an edge in two areas of taste modulation attracting heightened attention: sweetness and saltiness enhancement. And they're not just looking for an acceptable artificial sweetener or salt substitute; their goal is to improve the perception of the sweeteners and salt we already have.

The importance of balance

Taste doesn't just rely on these types of mechanics, or we'd be able to develop some sort of logarithm to develop flavors.

"Taste is a balance," says Mariano Gascon, vice president, R&D, Wixon Inc., St. Francis, WI. You need only consider the example of chocolate yogurt to appreciate this all-important factor of product design. Start with its taste profile. Yogurt "is sour just by its nature," he points out, yet "you don't think of chocolate as being sour." So toning down the tang is the first task. Playing around with ingredients that affect the final pH has its limits, so he suggests working those that "mask the perception of the acidity, but don't modify the pH, don't modify the tirtratable acidity. They leave your product exactly the same as before, but the perception of sourness is different."

Once the yogurt's sourness is in line, the sweetness might be out of whack. If it contains a high-intensity sweetener, the effect may be even stronger. "High-intensity sweeteners are normally of two types," Gascon says. While something like saccharin "is very nice up front," he says, "it takes so long to release that it gives you a perception of bitterness. Then you have others like sucralose that build very slowly, but then when they hit, they hit very high and then stay in your mouth for a long time."

The goal is to clear the sweet perception from the palate quickly and cleanly, without a bitter aftertaste. The flavor modulators that do this "let you taste the sweetness, but then they're going to block the lingering perception of sweetness," he says. "So, in your mind, you no longer taste the sweet. It's clean because we've modified the other perceptions."

If this yogurt also happens to be reduced-fat, you've got to address the missing fat's ability to carry flavors. This isn't just a matter of mimicking fat's mouthfeel with gums or hydrocolloids. But while texturizers improve body, "they're not going to hold the flavor," Gascon points out. "The way that fat coats your mouth—because it takes longer to dissolve from the tongue—holds the flavor longer." The residence time on the palate of a water-soluble substitute can't compare. "That's when we have to play with perception. One of our products is going to modify the flavor so that it stays longer in the mouth. It's going to give you a perception almost as if you had fat in your mouth, because the flavor's going to take longer to leave your mouth."

If designing a simple chocolate yogurt no longer sounds so simple, that's because it's not.

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