Thinking Globally: the Science of Sensory Experience

Highlights from the Second Annual Flavor, Fragrance and Perception Conference at Rutgers University.

Members of the flavor and fragrance industry, academia and more recently gathered at Rutgers University for the Second Annual Flavor, Fragrance and Perception Conference in Piscataway, New Jersey, to learn more about the science of the sensory experience.

Future Opportunities and Challenges for the Flavor Industry

Keynote speaker Matthias Guentert, president of Symrise's flavor and nutrition division, North America, explained the opportunities and challenges for the flavor industry.

GC-olfactometry, which is used to determine the odor activity of volatile compounds, has been used in the discovery of new odor molecules. Screening technology for non-volatile tastants can be used to find new taste molecules, Guentert explained.

"An estimated 12,000 volatile components have been structurally identified in foods and beverages," he said.

Guentert also mentioned that bitter taste, which is detected by a person's G-protein coupled receptors (GPCRs), is one of the continual challenges that flavor industry faces.

Matthias Guentert (Symrise) was the keynote speaker at the Second Annual Flavor, Fragrance & Perception Conference.

"Bitterness has been an issue in the last 10 years or more," he said. "For us, as an industry, it is extremely important for us to be able to mask certain off notes—and bitter is certainly one of those off notes."

For sweet taste, Guentert said the challenge is "to find the right taste modulators to optimize the overall sweetness taste."

As far as opportunities in flavor and health are concerned, he said oleocanthal found in olive oil "is responsible for the tingling [sensation] at the back of your mouth." A major part of the Mediterranean diet, he said olive oil may play an important role in helping Alzheimer's patients.

"The world of taste molecules still offers a lot more discoveries," he said.

Guentert explained how marketing and consumer insights are crucial for a company's success, and how partnering with a global market research firm is important. In addition, he noted, "there's a huge focus on food safety," explaining that the huge change in the regulatory environment in Europe requires the registration of all new flavor components.

Total quality management is extremely important, said Guentert. From supply chain to the finished product, he explained, "in today's world, you have to deliver the whole package."

Finally, Guentert explained that regulatory bodies need to adapt to fast innovation cycles, and that transparency and advocacy need to increase between the supplier and customer base.

"This is a global flavor industry," he said. "At the end of the day, the challenge is to really think globally … [T]oday's emerging markets will evolve into developed markets."

> For non-tasters, perceived pungency of cinnamaldehyde was positively correlated with pleasantness, and that the molecule "consistently elicited positive moods in all subjects," according to Rutgers' Beverly Tepper.

Taste Receptors

Next, Thomas Hofmann, chair of the food science department at the University of Munich, launched his presentation talking about a strong dose of Gouda cheese.

He first illustrated the sweet taste receptor, which is a heterodimer, a protein comprising two polypeptide chains differing

From left: Natalie Hinden-Kuhles (Agilex) and Avery Gilbert (Synesthetics).

From left: Stephen Dente (Robertet) and Laurie Welsh (Coty).

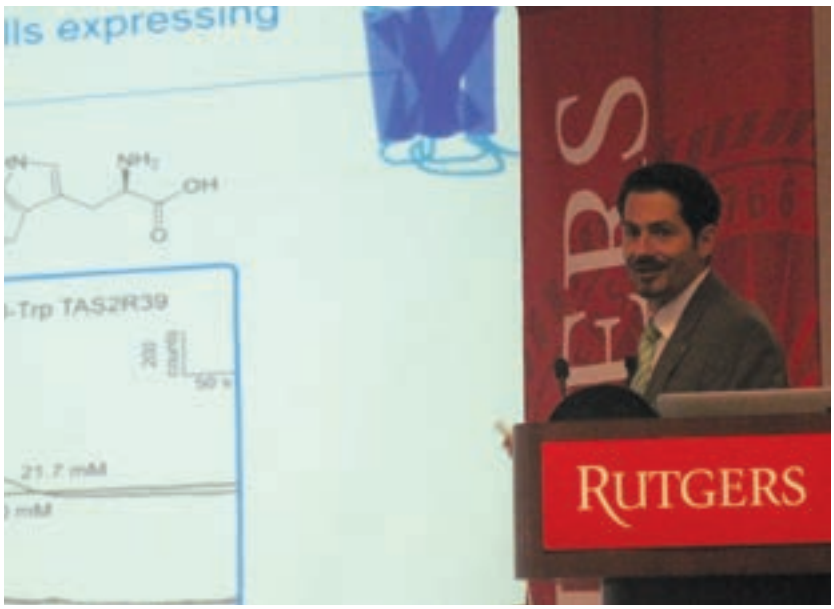
in composition in the order, number or kind of their amino acid residues, of T1R2/T1R3 receptors. In one study, Hofmann and his research partner examined molecular targets though a sensomics approach: structure determination, targeted analysis of basic taste molecules, taste re-engineering and sensory analysis, and sensory-guided fractionation.

Hofmann found that through a taste engineering study, in which they examined maturing Gouda up to 44 weeks, the taste was more intense than earlier maturity dates. Specifically, γ-glutamyl dipeptides were found to induce the kokumi flavor of matured Gouda cheese. The study also found some of the highest γ-glutamyl peptide concentrations in Parmesan and blue cheese. Interestingly, he said, γ-glutamyl dipeptides can't be found in pasteurized milk.

Research in Progress

James Simon, a co-founder (plant biology and pathology) of Rutgers Sensory Sciences & Innovation (SSI), spoke about some of the research that has been done through the project.

For instance, he explained that the West African black pepper plant has a mild spicy flavor that is different from traditional



Thomas Hofmann (University of Munich) talks about molecular targets for flavor innovation.

black pepper. Simon suggested that applications could include blending the pepper with traditional pepper for new mild spicy flavor options. His group also has helped to breed a plant, which he called a lemon-scented "super catnip" plant. The plant, he said, is rich in nepetalactone (70%), which can be used as a natural mosquito repellent to replace n,n-diethyl-meta-toluamide (DEET). The group also found evidence of hibiscus' potential applications as an anti-hepatitis C agent.

Beverly Tepper, director of SSI's sensory evaluation laboratory, detailed a pilot study (although not definitive) around pungency, which can define the sensory profile of an aroma or flavor, and have a profound effect on a product's pleasantness and acceptability. She explained how the objective is to segment individuals by perceived intensity of propylthiouracil (PROP) status, a phenotypic marker of bitter taste sensitivity, to find out the differences in the sensory impact and emotional experiences of aromatic compounds.

"There are large individual differences in consumer reactions to aromas, but the basis of these differences is poorly understood," Tepper noted.

In the early study, she said the PROP super-tasters were found to be more sensitive to bitterness, sweetness, oral pungency, astringency and fat texture, whereas the non-tasters were less sensitive to these qualities and showed higher preferences for foods with these qualities. For non-tasters, perceived pungency of cinnamaldehyde was positively correlated with pleasantness, and the molecule "consistently elicited positive moods in all subjects." She said further studies are needed to examine other factors that could impact the taste response such as moods, gender and ethnicity.

Consumer Behaviors and Emotions

Batool Batalvi, a strategic psychologist who has worked with some of the world's top consumer products companies, discussed the impact of consumer behavior and sensory-related emotions. She took the psychoanalytical approach that the experience of taste perception is connected to a person's mother; in other words, the "mother imbibes culture."

Genetics and Olfaction

Terry McGuire, a genetics professor at Rutgers, said that based on sequence data there are 1,000 human olfactory genes. Only about 250–350 are still active, he explained, and the regions with olfactory genes tend to have high numbers of large deletions and insertions of DNA.

Each olfactory neuron expresses only a single allele of a single gene, he noted, adding, "How this is accomplished is still a mystery—however, recent research suggests that it is epigenetic."

McGuire also highlighted humans' combinatorial approach to recognizing and processing odors: "Different patterns of olfactory glomerular (which relates to the glomerulus, a spherical structure located in the olfactory bulb of the brain), activity might function as 'odor images.'"

Odor and the Brain

Jay Gottfried, associate professor of Neurology at Northwestern University Feinberg School of Medicine, showed how odor information can be measured in the brain. He mentioned lesion studies, electrophysiological studies and functional neuroimaging.

Gottfried, speaking about olfactory functional magnetic resonance imaging (fMRI), showed how fMRI brain scans revealed that odors such as carvone, phenethylamine (PEA), amyl acetate and citronellol can be perceived quite differently from person to person. He also showed that the temporal pole of the human brain is located adjacent to the olfactory center, which indicates a connection to language and smell. In studies of individuals with primary progressive aphasia, a syndrome which impairs a person's language abilities, many of the respondents were better able to name the odor when provided with a picture cue or a word cue. This, said Gottfried, suggests that when it comes to smelling odors, "you're smelling what you expect to sniff."

He added that just because a person can't name a smell, doesn't mean he or she lacks the knowledge about the smell:

From left: Teresa Mattessich, Katie Eaches and Karen Garcia (all Symrise).

"This suggests that the use of odor identification tasks per se may not provide definitive data regarding how subjects perceive flavors and fragrances."

Odor cues in sleep have previously been used to enhance episodic and procedural memories, Gottfried added, citing a study by Hauner et al. (unpublished). Gottfried further explained that fear memories learned in the presence of a background odor are weakened when that same odor is presented in sleep, which suggests that odors can target specific memories. He also said it is possible that certain fragrances may have a greater potential for inducing targeted reactivation in sleep and could be a research focus for identifying fragrances with sleep-interactive effects.

Mandarin Orange

Finally, Mary Lu Arpaia, a botanist from the University of California Riverside, talked about her collaborative mandarin flavor project with David Obenland of the U.S. Department of Agriculture Agricultural Research Service. She explained that citrus is mostly now found in the San Joaquin and Sacramento Valleys of California, and that the state is one of the largest lemon producers in the world. But when preserving quality of taste is concerned, she said, "in the citrus world, mandarins are the problem children."

The mandarin orange, *Citrus reticulata* Blanco, has increasing importance to the California industry, and there is continued effort in looking for new varieties. However, it can be problematic in a post-harvest environment because it is easily damaged and prone to peel disorders and off-flavor development. During storage, Arpaia said mandarins often develop off-flavor. Respondents in the study used words like "not fresh," "spoiled," "over ripe" and "strange aftertaste" to describe the flavor. Since citrus is typically not refrigerated at retail or food service, the study at the UC Kearney Agricultural Center examined the impact of warm temperatures. It found that warm temperature was the main cause of flavor loss and that time spent in cold storage influences response. Taste also changed after being harvested. Researchers also found the change in taste was not related to sugar or acidity levels. Arpaia said heat intensifies ethyl acetate, which creates a fruity, or a pineapple, solvent-like aroma. The large increase in ethyl acetate, she said, is prevented by cold storage and that the cold chain is crucial to maintain good eating quality.

In conclusion, she said the loss in acceptability was tied to gas exchange characteristics (peel) and changes in ethanol and ester compounds.

"After fruit is harvested and waxed, it happens almost automatically," said Arpaia.

Looking ahead to further studies of preserving flavor in citrus, Arpaia said the group is aiming to spend more time looking at other mandarin citrus populations to better improve their understanding of how to improve selection of new varieties.
