Scientists Solve Sour Taste Proteins

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A team led by Duke University Medical Center researchers has discovered two proteins in the taste buds on the surface of the tongue that are responsible for detecting sour tastes.

While the scientific basis of other primary types of flavors, such as bitter and sweet, is known, this is the first study to define how humans perceive sour taste, said team senior scientist Hiroaki Matsunami, Ph.D., an assistant professor of molecular genetics and microbiology.

The identification of these proteins, called PKD1L3 and PKD2L1, could lead to ways to manipulate the perception of taste in order to fool the mouth that something sour, such as some children's medicines or health foods, tastes sweet, he said.

The team's findings appear in the online edition of the Proceedings of the National Academy of Sciences and will be published in print in the August 15, 2006 issue of the journal. The work was supported by the National Institutes of Health.

Mammals, including humans, can detect five primary flavors: bitter, sweet, salty, sour, and umami (known to the West as the taste of monosodium glutamate or MSG). Each taste bud on the tongue contains separate, distinct subsets of cells that specifically detect each taste -- sweet cells respond to sweet substances, bitter cells to bitter substances, and so on. Taste receptors, proteins on the surface of these cells, are responsible for detecting the "taste" of a particular food or chemical and triggering signals sent to the taste centers of the brain.

A group of proteins called the transient receptor potential family, which includes PKD1L3 and PKD2L1, has been implicated in how people sense various stimulants, such as the "heat" and "pain" impulses felt when eating chili peppers. Scientists also know that 33 genes direct the production of proteins in this family. Matsunami and his colleagues found that in taste buds, two of the genes are "expressed" and direct the production of proteins.

In their study, the researchers used fluorescent tags to label the subsets of cells that are known to be responsible for bitter, sweet, and umami taste, as well as the subsets of cells that express PKD1L3 and PKD2L1. By "reading" the tags, they found no overlap between the subsets of cells involved in the first three tastes and the cells in which PKD1L3 and PKD2L1 are active. Matsunami said this result suggested that those proteins could be responsible for sensing either sour or salty taste.

In action, the two proteins combine to form "ion channels," porelike proteins in the membranes of taste cells, Matsunami said. These channels in turn control the flow of calcium ions, or electrically charged forms of calcium, in and out of the cells. This flow of ions essentially conditions the cell so that electrical signals can be sent to the brain in response to various stimuli.

The researchers stimulated mammalian cells expressing PDK1L3 and PKD2L1 with various taste chemicals to identify which stimuli caused the ion channels to open. To visualize the presence of calcium ions in the cell, the scientists loaded the cells with two calcium-sensitive fluorescent dyes -- one that glowed green when the calcium concentration was high, the other that glowed red when the concentration was low.

When they added sour-tasting acids to the cells, the ion channels went from closed to open, enabling calcium ions to flow in, increasing their concentration within the cell and changing the cells from red to green, Matsunami said. The channels remained closed when confronted with salt, sweeteners, or bitter solutions. The increased concentration of calcium in the cell may then trigger the signal that the brain eventually perceives as sour taste, he said.

Matsunami said he plans to use this finding to screen for chemicals that can block the function of these sour taste cells.

The research also could lead to a better understanding of how the sense of taste functions neurologically, he said.

"We still do not know what is happening in the brain -- that is, exactly how the brain would interpret the signals coming from the tongue to tell the difference between lemons and lemonade," Matsunami said. Future experiments using live animals as test models will be needed to answer remaining questions about taste sensation, he said.

Other researchers who contributed to the study include Yoshiro Ishimaru, Momoka Kubota and Hanyi Zhuang of Duke; Hitoshi Inada and Mokoto Tominaga of the National Institute of Natural Sciences, Okazaki, Japan.

Source: Duke University