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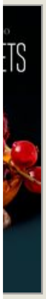

The Oxford Companion to Sugar and Sweets

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olfaction,

the sense of smell, contributes noticeably to perceptions of sweetness. Sweet is generally considered to be one of the five principal qualities of the sense of taste—or *gustation*—along with sour, salty, bitter, and umami (umami refers to the savory taste, associated with glutamates, whether naturally occurring or synthetic). Sweet taste sensations arise primarily from the activation of specialized receptors on cells located in taste buds on the tongue. Yet people also perceive sweet notes in certain odors: in the fragrances of flowers and perfumes, and, significantly, in the aromas of foods. Many food aromas seem distinctly sweet—consider, for instance, the sweet scent of a ripe banana. So how does olfaction contribute to the sweet flavors of foods and beverages?

When we chew a morsel of food or sip a beverage, the resulting perception of flavor arises in part from the activation of gustatory receptors in the tongue and oral cavity, but more substantially from the activation of olfactory receptors in the nose (and from the activation, in the oral cavity, of somatosensory receptors, which convey information about texture, pungency, and temperature). When we take food in the mouth, airborne molecules reach olfactory receptors in the nose by an indirect route, traveling *retronasally*, through the back of the mouth. (When we sniff, the odor-producing molecules reach the olfactory receptors directly, traveling *orthonasally*, through the nostrils.) The critical role that olfaction plays in the perception of flavor becomes apparent when the sense of smell is taken away or blunted—for instance, when a head cold or allergy blocks our nasal passages, preventing the airborne molecules from reaching olfactory receptors and thereby dampening flavors. In a related vein, the tendency for elderly people to report that, over the years, foods “lose” their flavor largely reflects the substantial decline with age in olfactory sensitivity.

The role of olfaction can be easily demonstrated by filling a small cup with an assortment of different fruit-flavored jelly beans. See JELLY BEANS. Shut your eyes to avoid color cues and, with one hand, pinch your nose closed. Then, with eyes still shut and nose still pinched, pick out one jelly bean, put it in your mouth, and bite into it. As long as your nose remains closed, the jelly bean will have little flavor beyond sourness or sweetness, which comes from gustation, or pungency, which comes from somatosensation. Lacking direct olfactory information or indirect color cues about the flavor, it is difficult to identify the fruit by gustation alone. Unpinching your nose, however, releases a torrent of flavor, making it much easier to identify the fruit—as berry or peach, grape or banana. Further, with nasal passages open, the jelly bean, now full-flavored, may appear notably sweeter.

Odors that are themselves described as sweet can augment or enhance sweet tastes, even though the odors produce no sweetness through the gustatory sense. Adding a few drops of sweet-smelling vanilla to morning coffee, for example, makes the coffee taste sweeter, even though pure vanilla evokes no gustatory sweetness. This can be confirmed by pinching the nostrils to block olfaction while sipping the coffee and then comparing sweetness, now from gustation alone, with and without the added vanilla. See VANILLA. Robert Frank and Jennifer Byram showed that adding strawberry odor enhanced the sweetness of a sugary food but adding peanut butter odor did not. On the other hand, adding strawberry odor did not enhance the saltiness of a salty food. Odors enhance taste qualities when the qualities of the odors and tastes are similar. This is not surprising. But what makes odor qualities and taste qualities similar? Why, for example, are certain odors, such as vanilla, perceived as sweet?

Sweet tastes are first and foremost associated with the presence of sugars in foods, and hence with calories—and an adequate intake of calories is critical to health and well-being. Consequently, sweet tastes presumably evolved to be intrinsically pleasurable and rewarding. Although sugars can weakly stimulate the olfactory sense, the rich flavors of milk, fruits, and other foods arise mostly from the large number of odorous molecules that are specific to each food and that give each food its characteristic flavor. To the extent that some of the odorous molecules are associated with the presence of sugars in foods, olfactory receptors that respond to these molecules may have evolved an intrinsic capacity to produce pleasant, rewarding, sweet sensations.

An alternative explanation, however, does exist. When people experience particular odors in close conjunction with particular tastes, the odors may take on the associated taste qualities. In support of this hypothesis, Richard Stevenson, Robert Boakes, and John Prescott showed that after pairing a previously tasteless odor with a sweet taste, the odor itself appeared sweet. In a similar vein, using behavioral training and testing methods, Shree Gautam and Justus Verhagen showed that in rats, as in humans, odors became sweet only after the odors were paired with sugar. And using methods of neuroimaging, Dana Small and her colleagues observed, in regions of the human brain associated with flavor perception (insula, orbitofrontal cortex, and anterior cingulate cortex), especially significant neural responses to mixtures of perceptually similar olfactory and gustatory stimuli, such as vanilla and sugar.

A final observation: experiencing vanilla together with sugar makes vanilla taste sweet like sugar, but it does not make sugar taste like vanilla. In general, taste donates while olfaction receives. This asymmetry doubtless evolved from the natural capacity of sugars, and other sweet-tasting substances, to be pleasurable and rewarding, and of the biological advantage to having a flavor system that can effectively learn which odors are consistently associated with these sweet stimuli. Analogous processes likely mediate the association of other odors with bitter tastes, which often characterize the presence of poisonous substances. The inverse is not true, as there is no equivalent biological basis for taste qualities to signal odors. The brain appears to be so configured that it readily allows one-way transfers of qualities, such as sweetness, from taste to odor.

See also AROMA; SWEETNESS PREFERENCE; and VISION.

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