

## The Fascinating Science of Taste, Smell and Flavor

Many studies have shown that the flavor of food is by far the most important factor in determining what foods we choose to eat (1). The flavor of food is not something we actually sense but is created in our brain based on what we taste with our mouth and smell with our nose (2). Taste, smell, and flavor are therefore distinctly different from each other. Our sense of taste is built into our genes and can be observed in newborn children within six months of birth, whereas recognizing smells is a learned experience (2). There are five well-recognized tastes: Sweet, salt, sour, bitter, and umami (savory, meaty taste). There is also growing acceptance of fat as a sixth basic taste (3). The ability to sense each of these tastes is believed to have evolved for the survival of our earliest ancestors. The sweet taste of fruit indicates a source of sugars for energy. Umami is believed to have evolved as a means to detect protein and essential amino acids. Salt is required for regulating the level of bodily fluids. Sour indicates the presence of spoiled food as we might find in old milk. Many toxic compounds found in plants produce a very bitter taste. And fat is another important source of energy as well as essential fatty acids. Note that our sense of taste evolved to detect non-volatile molecules that we cannot smell.

In contrast to the small number of basic tastes, humans are able to recognize more than 10,000 different odors. Unlike taste, humans are amazingly sensitive to smell. We are able to detect the aroma of certain volatile compounds at the level of one part per trillion, and a few at levels even thousands of times lower. To give you a better “sense” of what this means one part per trillion is equivalent to one second in 32,000 years! Our exquisite sense of smell apparently evolved to help in locating food as well as avoid consuming spoiled food before tasting it. It also appears to be involved in communication between humans. You may have experienced your sensitivity to smell when you detected a natural gas leak. Gas companies add a trace of a very smelly volatile sulfur-containing compound called methyl mercaptan to natural gas so we can detect even very small leaks. Humans are able to detect this compound at 2 parts per billion, which is a very small amount, but still 1000 times more concentrated than one part per trillion. Some of the compounds we can smell at levels of a part per trillion and lower include those in green bell pepper, mold, and roasted oats. The lowest threshold recorded to date is a sulfur-containing compound formed in boiled seafood which we can detect in water at levels as low as  $10^{-5}$  parts per trillion, or 0.01 parts per quadrillion (4). To put this into perspective one part per quadrillion is equivalent to 2.5 minutes out of the age of the Earth (4.5 billion years old)!!

We sense the smell of food by two routes. Sniffing through our nose is called orthonasal smell, while the aroma released up through the back of our mouth into our nose when we chew and swallow food is called retronasal smell. Orthonasal and retronasal smell appear to be processed in different parts of the brain. The latter is the most important route for sensing the aroma of food and is believed to

account for as much as 80-85% of the flavor of food (2). That explains why we can't detect the flavor of food when we have a cold and our nose is blocked.

The taste and aroma of food are sensed through special receptors (proteins) on the surface of taste and olfactory cells in our mouth and nose. They provide a direct link between our brain and the outside world. While the number of taste receptors is limited, it is estimated there are about 400 different types of receptors for smell. Cells that contain the receptors for taste and smell are replaced every 10-30 days. As we age the total number of these cells decline, especially after age 70. Taste cells are clustered together in taste buds located throughout the mouth and back of the throat in structures called papillae. These are the visible bumps on your tongue. Some of the receptors for taste are linked together, such as sweet and umami, which probably explains why we like foods that are both sweet and savory. There are other interesting interactions. For example, salt helps mask bitterness (although bitterness does not mask salt), and saltiness is reduced by fat. When it comes to our health one very important recent discovery is that taste receptors, especially for sweet taste, are located throughout our gastrointestinal tract (5). Receptors for bitter and umami are also present (6). Sensing the presence of sugars, the sweet taste receptors in our gastrointestinal tract initiate glucose absorption, insulin secretion, gastrointestinal motility, and the release of hormones that generate signals to the brain that affect the feeling of fullness (satiety) and termination of the meal (7). It is still too early to say what role these receptors might play in weight gain, obesity and diabetes. But a recent study suggests that sweet taste receptors in the gut may enhance the rate of glucose absorption and accentuate blood glucose levels in type 2 diabetics following a meal (8). Our sense of taste has far more impact than simply determining what foods we like.

This brings us to genetic differences in our ability to taste food. It has been known for many years that some people are extremely sensitive to the taste of bitter substances, while others perceive little or no bitter taste. The former were called super-tasters and the latter non-tasters. In the middle was everyone else. The terms super-taster and non-taster are attributed to Linda Bartoshuk, now a professor at the University of Florida, and a pioneer in studying the genetic differences of taste (9). Using a well-known bitter tasting chemical named 6-n-propylthiouracil, or PROP for short, professor Bartoshuk found that about 25% of the population is extremely sensitive to the taste of this chemical, while an equal portion (25-30%) cannot taste it. That leaves about 45-50% of the population to be "average" in their ability to taste PROP. Whereas super-tasters cringe at the taste of even the smallest amount of PROP, average tasters perceive only a faint bitter taste. The reason for this difference turns out to be fairly simple and obvious. Super-tasters have many more visible taste papillae than tasters and non-tasters. This is illustrated in the figure below. This means they have many more taste cells with receptors for bitter taste. Super-tasters are also more sensitive to sweet, salty and umami tastes, but to a lesser extent (10).

It would seem that super-tasters might have an advantage over everyone else in their ability to taste and enjoy food. Unfortunately, this is not the case. Because they are so sensitive to bitter they tend to be very picky eaters and dislike many foods. They do not like hot, spicy foods because the receptors for pain surround the taste cells, so they also have more pain receptors. Non-tasters like hot spicy foods, and usually require more seasoning to make it taste good. This is true except for salt. Because salt masks bitterness, super-tasters tend to consume more sodium than non-tasters (11). Average tasters tend to like most foods. They are not repelled by food that tastes overly bitter and unpleasant, yet their sense of taste is keen enough that they can enjoy most food without drowning it with salt or sriracha sauce. In the case of taste it might be better to be average.

Genetic variation in taste clearly affects food liking, diet and health (10). Super-tasters with greater sensitivity to PROP tend to eat fewer vegetables because of their bitter taste and have been found to have higher colon polyp counts, both of which are potential risk factors for colon cancer (12). On the positive side super-tasters, especially female super-tasters have a reduced preference for sweet, high-fat foods, a lower body mass index (BMI) and tend to have superior cardiovascular profiles (13). Non-tasters have a clear preference for high-fat, sweeter foods. They also show the greatest alcohol intake and a higher rate of alcoholism (14). Super-tasters tend not to like alcohol and are less likely to smoke. Interestingly those with the lowest PROP thresholds tend to be thin while those with the highest thresholds tend to be heavier (15). These conclusions have not gone unchallenged (16), but numerous correlations of health outcomes with sensitivity to PROP and bitter taste demonstrate a strong relationship between our sense of taste and smell and overall health status. PROP test strips are safe and easy to use and available online if you would like to determine your taste status. Or simply try examining your tongue in the mirror.

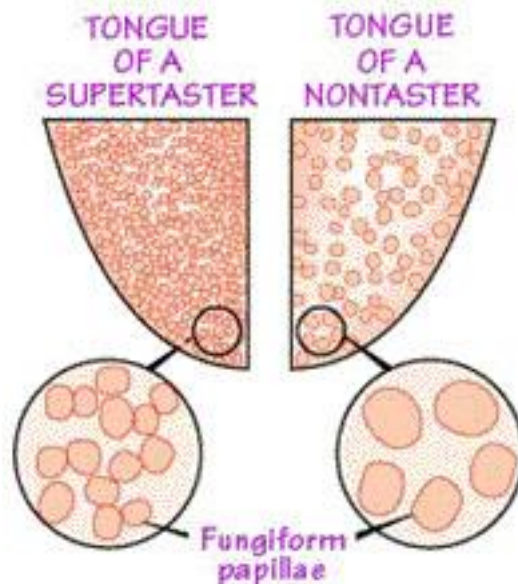


Figure of super-taster and non-taster tongues

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