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The sweet side of life

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There are four basic tastes…so we are told. Any other taste is a mere combination of these four. Which four? Bitter, sweet, sour and salty. However, a fifth taste – of Asian heritage – is seeping into the Western World and gaining fast recognition: the umami (oo-mom-ee) taste. A taste qualified as meaty or savoury. All these tastes are recognised as such thanks to specific taste receptors and our brain. Some tastes are proteins and are already used in the industry as natural sweeteners, for example. Among such taste proteins, there is one in particular – miraculin – which lacks taste completely when absorbed on its own but has the power of modifying a disagreeable taste into a pleasant one.

Richadella dulcifica and its red berries

Courtesy of Ken Love

Miraculin is a rogue. Here is a protein which manages not only to shield a sour taste but also to make you believe that what you are eating or drinking is actually sweet! It is a 190 amino-acid glycoprotein and known as a super sweetener. Indeed, purified miraculin contains almost 14% sugar: glucosamine, mannose, galactose, xylose and fucose. It is found in the pulp of the fruit of the miracle berry, otherwise known as *Richadella dulcifica* or *Synsepalum dulcificum*, an evergreen shrub native to tropical West Africa.

The red fruit bears a single olive-shaped seed, is about 2 to 3 cm long, and is quite tasteless. But coat your tongue with the pulp of this fruit and you can swallow a litre of vinegar followed by a kilo of lemons without a wince. And the effect can last up to two hours. You will not be spared the consequences of so much sourness though and crops of ulcers will flourish. Anyway, who wants to drink vinegar and eat lemons? The issue is that the consumption of a miracle berry will modify a sour taste into a sweet taste. It is something the West Africans have long known and for years they have been using it in food and beverages to suppress sourness.

The protein itself was extracted in the 1960s and named miraculin after its miraculous powers. To understand how it works, you need to know the anatomy of a tongue. Our tongue – like all mammal tongues – is coated with papillae of different shapes and sizes. Within each papilla is wedged a taste bud, itself a haven for 50 to 100 taste receptor cells. These receptor cells bear taste receptors on their membrane that open ion channels once activated, which in turn transmit a taste message to the brain. Each taste has its receptor, i.e. a salty taste will activate the salty receptor and elicit a salty taste. So how does miraculin – which has no taste – elicit a sweet taste when it is, in effect, a sour one? Well…it tricks the brain by fooling the sweet taste receptor.

A structural model of the sweet-inducing protein and its binding to the sweet receptor has been suggested. Miraculin may bind to sweet receptors although, in the absence of sourness,

its active site does not. As a result, there is no sweet taste. However, when sour substances are presented to our tongue, the sweet receptors undergo a conformational change and, in doing so, give miraculin the opportunity to reposition its active site within the sweet receptor. The net result is a strong sweet taste in the mouth. And since miraculin binds particularly firmly to the receptor, the sweet fib can last a maximum of two hours. It is said that the actual taste of the food is kept yet the sourness is warded off. Hence, a slice of lemon would taste like lemon candy.

In a day and age when 'natural' substances are seated in the front row, miraculin could well have a bright future by replacing synthetic sweeteners already widely used. Pop a miracle berry into your mouth and the taste of low calorie sour food or beverages becomes bearable. Diabetics could also benefit from the effects of miraculin. The snag is production at the industrial scale. *Richadella dulcifica* – like so many other plants – is very particular as to the conditions in which it grows. What is more, protein purification directly from the plant is expensive. The expression of miraculin in recombinant hosts is being looked into although – so far – it has not met with much success mainly because it is very difficult to preserve the taste modifying properties of the naturally occurring miraculin protein. To turn a long story sweet can be a sour affair.

Cross-references to Swiss-Prot

Miraculin, *Richadella dulcifica*, (Miracle fruit) : P13087

References

1. Faus I.
   Recent developments in the characterization and biotechnological production of sweet-tasting proteins
   Appl. Microbiol. Biotechnol. 53:145-151(2000)
   PMID: 10709975

2. Kurihara Y.
   Characteristics of antisweet substances, sweet proteins, and sweetness-inducing proteins
   Crit. Rev. Food Sci. Nutr. 32:231-252(1992)
   PMID: 1418601

3. Witty M.
   Proteins pack muscle to modify taste
   http://www.preparedfoods.com/archives/1999/9905/9905proteins.htm

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