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LETTER

The Discovery of Umami

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Sweet, bitter, salty and sour are the four taste qualities upon which the human sense of taste is based. But is this really all? Is there room for more basic tastes on the human tongue? Well, there is. Strangely, though, while people tasted it daily, the fifth taste long remained unknown and unnamed. Its final discovery, made nearly a century ago, was due entirely to a single man, a chemistry professor at the Imperial University of Tokyo, Kikunae Ikeda.

It was Ikeda's insight and endurance alone which powered this early work. The tedious chemical isolation and identification of the new taste substance was done without the help from postdoctorates or students, as would be usual today, aided only by one technician. The investigation was based on an observation concerning the dominant taste of dashi, a Japanese soup base. The taste of dashi is mild but, according to Ikeda, clearly distinct from that of the four basic tastes. Ikeda proceeded to isolate the principal taste substance from a main ingredient of dashi, the seaweed *Laminaria japonica*. This was done with the procedures of classical chemistry, aqueous extraction, removal of large-scale contaminants (mannitol, NaCl, KCl) by crystallization, lead precipitation and numerous other steps of preparative chemistry. Finally, low-pressure evaporation resulted in the slow crystallization of a single substance with the mass formula $C_5H_9NO_4$: glutamic acid. Its taste was named umami, a word derived from the Japanese adjective *umai* (delicious). It has taken root as a scientific term internationally.

The scientific community received this discovery with moderate applause only. Many, especially in English-speaking countries, remained unconvinced. One hindrance for the accceptance may have been that the detailed publication of Ikeda's work appeared in Japanese (Ikeda, 1909). Other hindrances were that umami taste is mild even at high concentrations of the tastants. Furthermore, high concentrations of glutamate, an anion, are necessarily accompanied by cations, the salty or sour taste of which confused the issue. Umami research proceeded on a larger scale especially since about 1980. The umami substances L-glutamate, inosine 5′-monophosphate (IMP) and guanosine 5′-monophosphate (of which the latter two enhance the glutamate taste) were defined, and taste responses to them were investigated in humans and animals. Animal models, however, were of limited use as the responses of different species, even of different strains of mice, were at variance.

Today a search in PubMed (MedLine) for papers concerned with taste and containing the term 'umami' retrieved 86 references. (For comparison, 'sweet taste' retrieved 10 times more references published since 1980.) A search with the Google engine found >4000 web pages containing the phrase 'umami'. Some of these pages were from restaurants advertising umami food. Others dealt with the misconception that glutamate contained in food might be harmful. But foremost among them were pages reprinting newspaper articles about the discovery of umami receptors.

The discovery of umami receptors, taste receptors for L-glutamate, using methods of molecular biology is one of the recent highlights of taste research. In 2000, a modified glutamate receptor of the brain was found, the taste-mGluR4. It is a G protein-coupled (metabotropic) receptor. The taste variety of mGluR4 has a truncated N-terminal to which L-glutamate still binds, albeit with reduced affinity. Presumably, therefore, the truncation adapted the receptor to the high glutamate concentration in food (Chaudhari *et al.*, 2000). More recently, another umami receptor was discovered. Interestingly, this one is a heteromere built of the G protein-coupled receptors T1R1 and T1R3. In mice this heteromere responds to many amino acids contained in food, but in humans its response is preferentially to L-glutamate and is enhanced by IMP (Nelson *et al.*, 2002).

Shortly after Nelson *et al.*'s publication, these results were strongly confirmed by another group (Li *et al.*, 2002). The sequencing and functional expression of a human taste receptor for glutamate determined by these studies provides a first molecular basis for Ikeda's pioneering work.

Humans consume high-calory food as fat, polysaccharides and proteins. All of these are tasteless but elicit taste sensations through cleavage products. Sweet taste is the taste of mono- and disaccharides, and guides us to the consumption of starch. Umami taste is elicited by the most common amino acid, L-glutamate, a cleavage product of all proteins. Such argues Ikeda in his article.

An English translation of Ikeda's paper 'New seasonings' from 1909 is made available in this issue of *Chemical Senses*. We would like to thank the journal for this contribution to the history of our science. The publication of the translation, late though it may seem, is timely in view of the recent discovery of umami taste receptors.

References

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