What does determine the sugars' sweetness?

Ludovica Ruggiero[1*], Armida Sodo[1], Fabio Bruni[1], Maria Antonietta Ricci[1]

[1] *Dipartimento di Scienze,Università di Roma Tre, Viale Marconi 446, I-00146 Roma,Italy*
[*] *ludovica.ruggiero@uniroma3.it*

During the past decade, commercial interest in the sensory properties of foods has led to a great increase in basic knowledge of the sense of taste [1-2].
Sweetness is a gustatory response evoked by most sugars, which is not unique to mankind. One of the challenges is finding the correlation between the molecular structures of those compounds and the sensations that they elicit.

What is still debated is why a sugar is perceived sweeter than another or elicits a bitter aftertaste. This is a quite intriguing question, given that substantial taste differences seem to be determined by apparently small differences in the molecular stereochemistry of sugars [3]. Actually, the "sweetness triangle" model is one of the most reliable for describing interaction between sugar molecules and taste receptors (Fig.1). In this model a sweet molecule needs to interact with the receptor via hydrogen bonds (HB) using a donor site (labeled AH) and an acceptor site (labeled B); the triangle is closed by a hydrophobic X site [4].

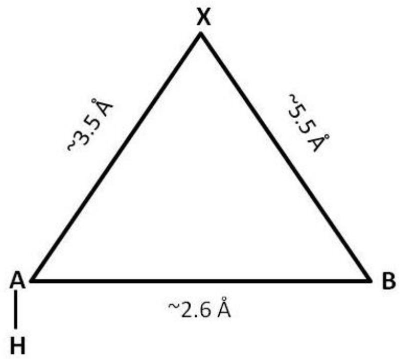

Fig.1 Sweetness triangle model

The rationale behind our work is that knowledge of the interaction of sugars with water at the atomistic level can allow identifying HB donor/acceptor candidate sites ready for interaction with the sweet receptor and possibly elucidating the origin of the sweetness ranking. In this work, the interaction of two monosaccharides, namely glucose and mannose, with water at atomic level is investigated from the structural and dynamical point of view by neutron diffraction [5] and Raman spectroscopy, respectively. Interestingly, the sweet taste of glucose is 0.75 relative to sucrose and that of mannose is 0.35. Interestingly, mannose in solution shows two anomeric structures, one sweet and the other bitter. The neutron diffraction experimental results show that both mannose anomers form less and weaker HB than glucose at the same sugar/water ratio.

Here we report a Raman spectroscopy investigation of these two sugars at different concentration in water. Vibrational bands carrying out the information on sugar-water bonds have been identified and interpreted [6].
In particular, while the Raman spectra of glucose-water solutions show a shift of some of the bands in the fingerprint vibrational regions with respect to the dry sugar powder, the same effect is not detected in the case of mannose-water solutions.
These observations confirm the different HB interactions glucose and mannose have with water and likely with the sweet taste receptor.

References

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