SWEETNESS

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1. INTRODUCTION.

Sweetness is universally regarded as pleasurable. In all languages the equivalent word for the English "sweet" is also used to denote that which is agreeable, pleasant, desirable, precious and so on. In fact in many languages, the latter meanings were the original ones, with the reference to taste a later and more specialised usage.

The love of sweetness is probably present from the moment of birth and is claimed by many to be innate.

Things which are universally desirable are often beneficial or even necessary. The liking for sweetness probably served a biological function in tempting primitive humans (and many other forms of life) to eat fruit, berries and honey: good sources of energy and essential micronutrients.

If the liking for sweetness was a biological necessity for primitive humans, it is less so today, but the liking itself survives undiminished.

2. FACTORS AFFECTING THE LIKING FOR SWEETNESS.

In common with all pleasurable sensations, the pleasure of sweetness cannot be increased or prolonged indefinitely. For any sweet substance or sweet food there is a preferred level of sweetness (it has been called the "bliss point") above or below which that substance or food is felt to be too sweet or not sweet enough. This preferred level is not the same for all people and for an individual is not the same at all times or in all circumstances.

The preferred level of sweetness is affected by:

- Composition. For example, a preferred level of sucrose as a simple solution in water would not be the preferred level if present in the form of an acidulated beverage.

- Satiety. If a person is sated with sweetness, having just previously consumed a lot of sweet food, a further intake of sweet food would be felt less pleasant or even unpleasant. Conversely, a person sated with savoury food would probably prefer a higher level of sweetness than if not so sated. This phenomenon, known as "sensory specific satiety", has been studied in depth.

- Hunger. The appetite for either food in general or for a particular food is partly the response to physiological need. If the body is short of a particular nutrient, the liking for the taste of food which supplies that nutrient usually increases.

- Age. The liking for sweetness changes with age in a complex fashion. In general, the liking for sweetness among males decreases from early childhood onward. Among females it generally increases up to adolescence and then declines.

- Social environment. A preference for more or less sweetness can be conditioned (as can any other taste) by prevailing custom and social or economic pressures.

- Mood. There is indirect evidence that in some individuals, depression increases the liking for sweetness.

- Metabolic disorder. As well as being affected by normal variations in metabolic status, the liking for sweetness is affected by some (possibly most) metabolic disorders. It has been found that people with clinical hypoglycaemia (low blood-sugar) prefer higher concentrations of sucrose - though not of saccharin - when their blood-sugar level is lower.

- Individual characteristics. It is a matter of common observation that individuals vary widely in the way they react to any kind of stimulus. The pleasure associated with a particular level of sweetness is, in this sense, no different from any other reaction and no more likely ever to be fully explained.

3. FACTORS AFFECTING THE PERCEPTION OF SWEETNESS.

"Perception" is not the same thing as "liking" although the two are related.

The relationship between the intensity of a sensation and the magnitude of the stimulus which produces it, is expressed by the "Weber-Fechner rule". This rule, which dates from 1860, is applicable to all sensory phenomena of whatever kind. The rule appears in variously modified forms of which the simplest is

$$I = KS^{n}$$

where I is the intensity of sensation (necessarily a subjective judgement); K is a parameter, i.e. a number which is constant for the particular stimulus considered but may be different for other stimuli; S is the magnitude of the stimulus; n is an exponent, in this case a number which varies from one person to another and from one set of circumstances to another.

In plain language, the rule states that unless n=1, the intensity of a sensation is not directly proportional to the magnitude of the stimulus. For most people, for most stimuli, n is less than one.

In such cases, if the magnitude of a stimulus is increased by a certain amount, the intensity of the sensation it evokes is increased by some smaller amount.

In the case of the sweetness elicited by sucrose, a mean value of n has been found to be 1.3, but with values in individual trials ranging from 0,46 to 1.8.

This means that if the concentration of sucrose is increased, most tasters under most conditions will experience a disproportionately greater sensation of sweetness, unlike what happens in the case of most taste (and other) sensations. Some tasters under some conditions will however experience a disproportionately smaller sensation of sweetness.

This intensity with which sweetness is perceived is affected by:

- Age. The concentration of sucrose which can just be detected is, on average 0.68 % for children, 0.41 % for young adults and 1.23 % for elderly people.

- Temperature. The intensity of sweetness increases as temperature rises.

- Colour. Strongly coloured solutions of a sweetener are rated sweeter than less strongly coloured or colourless solutions of the same concentration.

- Viscosity. Increase in viscosity lowers the perception of the sweetness of sucrose solutions, if the concentration of sucrose is low.

- Metabolic status. Subjects whose level of blood-sugar is abnormally low find the intensity of sweetness of sucrose solutions less than do normal subjects.

- Individual characteristics. As with preference, the intensity of sweetness evoked by given concentrations of a sweetener is not the same for all individuals.

Apart from the blunting of sweetness perception among clinically hypoglycaemic subjects (see 3.5 above), other metabolic variations are claimed to be without effect. The acuity of perception of the sweetness of sucrose is said to be affected by chronic alcoholism, heavy smoking, infected gums, marked tooth decay, mild head colds, hay fever or allergy.

4. THE QUALITY OF SWEETNESS.

Sweetness is not, as is sometimes implied, a simple primary sensation common to all sweet substances. No two such substances taste exactly alike in quality in all circumstances, even when concentrations are adjusted so that the intensities of sweetness are the same. (This is equally true of other so-called primary taste sensations: saltiness, bitterness, sourness).

There may be a time-related difference. Many intense sweeteners, e.g. TGS (trichlorogalactosucrose) and thaumatin, do not taste sweet until they have been in contact with the tongue for a perceptible time, and they also leave a sweet after-taste. In contrast, the sweetness of sucrose is perceived almost immediately and does not linger.

Some sweeteners have characteristic "side-tastes" in addition to their sweetness, e.g. bitter-metallic with saccharin, liquorice-like with glycyrrhizin. Others differ from each other in less easily definable ways.

There are sweeteners whose sweetness is fairly close (though not identical) to that of sucrose when tasted in solution but differs markedly when tasted in solid form. Sorbitol and xylitol, for example, have a pronounced mouth-cooling when tasted this way.

Other sweeteners, whose quality of sweetness is fairly close when tasted alone, taste differently when blended with other food ingredients. For example glucose (dextrose) and sucrose, whose qualities of sweetness are otherwise quite close, taste differently when blended with fat. The difference is one of quality, distinct from the difference in intensity.

These differences in the taste quality of sweeteners do not disqualify them for all use, but they do limit the application of some of them.

5. THE INTENSITY OF SWEETNESS.

It is common knowledge that not all sweeteners taste equally sweet. The measurement of relative sweetness is not easy and divergent values are often quoted. Some typical values are given below.

Sweetener	**Sweetness, relative to sucrose on weight basis**
Fructose	1,40
Isomalt	0,5
Hydrogenated glucose syrup ('Lycasin')	0,75
Lactitol	0,5
Lactose	0,2
'Malbit'	0,9
Mannitol	0,6
Sorbitol	0,5
Xylitol	1,0
Maltose	1,0
Glucose (dextrose)	0,6
Acesulfame K	180-200
Aspartame	200
Saccharin	500
Thaumatin	2 500
TGS	500-600

These values are of use only as a very rough guide. Not everyone perceives relative intensities in the same way. Also, relative intensities vary with temperature, with concentration, and according to the medium in which they are tasted. Furthermore, intensities are not always additive. For example, blends of saccharin and cyclamate are sweeter than either alone, and less bitter.

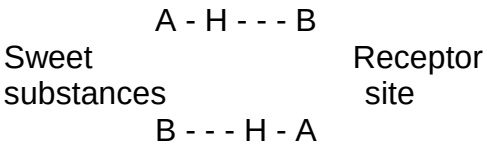
6. THE MECHANISMS OF SWEETNESS PERCEPTION.

About 2500 years ago, Democritus proposed that sweet substances were composed of "small molecules".

This was a remarkable anticipation of current thought. The molecules of simple sugars could be said to be round, in that in their predominant form they are rounded rather than linear.

The molecules of other sweet substances are not all round and not all small, but at least their shape is believed to be critically significant.

When it became known that sugars and sugar alcohols all contained adjacent hydroxyl (-OH) groups it was concluded that their sweetness depended on this. This simple concept was refined by Shallenberger and Acree (1967) into the so-called "AH-B" hypothesis. In this, A and B represent electronegative atoms, typically oxygen and nitrogen, and H represents hydrogen. It was proposed that a sweet sensation was elicited when substances containing A or B, appropriately spaced, made contact with receptor sites on the taste buds and formed temporary hydrogen bonds with them thus:



The dotted line represents the hydrogen bond.

This hypothesis explained the sweetness of sugars and some amino acid but only in a roughly qualitative fashion. It was extended by requiring a third, lipophilic ("fat-loving") group, appropriately spaced. In sugars this was represented by $-CH^2$.

This refinement was an improvement but did not account for the sweetness, absolute or relative, of all sweet substances. Further modifications have been proposed from time to time but as yet there is no theory which is satisfactory in all cases.

The sweetness of some of the intense sweeteners now in use or proposed for use was discovered accidentally and could not have been predicted from any single theory now current.

7. IOCCC POSITION.

Sweetness provides product palatability and pleasure. It is a fundamental property of most or all of the products made by members of the IOCCC.

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