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On the Taste of the Salt of Glutamic Acid.

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A new primary taste quality.

There are four well defined taste qualities, viz. sweet, sour, bitter and briny. Besides these they are such qualities as metallic and alkaline, which are less well defined and over which views are divided whether they are to be regarded as simple taste sensations or not. Be it as it may, there is still another quality, which is quite distinct from all these, and which must be considered primary, because it can not be produced by any combination of other qualities. An attentive taster will find out something common in the complicated taste of asparagus, tomato, cheese and meat, which is quite peculiar and can not be classed under any of the above mentioned qualities. It is usually so faint and overshadowed by other stronger tastes, that it is often difficult to recognize it unless the attention is specially directed towards it. Had we nothing sweeter than carrots or milk, our idea of the quality "sweet" would be just as indistinct as it is the case with this peculiar quality. Just as honey and sugar gave us so clear a notion of what sweet is, the salts of glutamic acid are destined to give us an equally definite idea of

this peculiar taste quality. Any one who tastes a solution of sodium glutamate will at once recognize its taste to be different from all other well known qualities. He will at the same time identify it with that indistinctly perceived peculiar quality which ever recur in the complicated taste combinations of his daily food. For this taste quality the name "glutamic taste" is proposed.

The taste of an ion.

Glutamic acid has two replaceable hydrogen atoms and forms two series of salts. The salts of divalent glutamic acid, in which both hydrogen atoms are replaced, do not concern us here, because most of them are difficultly soluble, while salts of alkaline metals are strongly alkaline on account of hydrolysis. On the contrary, the salts of monovalent glutamic acid are mostly readily soluble in water and the alkaline salts are amphoteric in reaction. All these soluble salts present the same glutamic taste in so far as it is not affected by the taste of the metallic radicals.

The glutamic taste of these salts are so strong that a minute quantity dissolved in a large volume of water impart to it a perceptible taste. The threshold value for some of these salts has been determined in the following manner. In order to avoid any extraneous suggession the experimenter was blindfolded and a series of dozen or more test tubes with 20 cc. of the solution or of water were handed to him one after another to taste. The liquids were heated to 38° beforehand and about one half of the volume was taken at once to the mouth. He had then to decide whether the liquid contained a glutamate or not. Between each trial the mouth was rinsed abundantly with water warmed to the

deemed

same temperature. The water employed was not distilled, but ordinary tap-water. This was also used in the preparation of the solutions. The answers given by the experimenter were tabulated, and when a majority of them were correct both in positive and negative cases, the concentration of the solution was deemed to be above the threshold value. In order to avoid the effect of personal idiosyncrasy my assistant and I took up the rôle of the experimenter alternately. He did not smoke and I abstained from smoking for some weeks. Our health was excellent. At first there was some difference in our results, but after some exercise it disappeared. Glutamates of sodium, potassium, calcium, magnesium and baryum were examined. They gave all identical results. When the concentration was $\frac{1}{2500}$ normal a difference between the solution and water could be distinctly perceived, while at $\frac{1}{3000}$ normal it became uncertain. The threshold value for all these salts is therefore $\frac{1}{2500}$ normal. It must be remarked that the distinctive glutamic quality ceases to be perceived at somewhat greater concentration, perhaps at a few millinormal. Below this it was difficult to decide whether it was sweet or glutamic.

From the fact that all soluble salts of monovalent glutamic acid present even at great dilutions the same glutamic taste, we may safely conclude that this is the taste of the anion $C_5H_8NO_4$. This is further confirmed by the identity of the threshold value for different salts and the smallness of its absolute value in comparison to other salts. That the taste of neutral salts must, at least partly, be due to their ions has long been surmised; but in default of exact observations this could not be strictly demonstrated. The bitter taste of the sulphates may be cited as a good example

This taste is, however, common to so many inorganic salts, that it can not be asserted that the bitter taste is due to the anion SO_4''. In the case of the glutamates, there is no such complicacy, because the taste is of very peculiar quality. As there is no sensitive chemical test known for glutamic acid, the taste is very serviceable for the purpose of detection. Yet it must not be understood that there are no other substances which present similar taste, because this is quite probable and many compounds having this particular quality may be found among amino-acids.

A short remark on the taste of glutamic acid itself may be inserted ~~here~~ in this place. Fischer has observed that this acid present at first a sour and then a peculiar insipid taste (einen eigentümlichen faden Geschmack). By this last expression is doubtless meant the glutamic taste. My own observation confirms his completely, only the glutamic taste is much more pronounced than the acid. The explanation may be sought in the greater diffusibility of hydrogen ions and its subsequent neutralization in the tissue, because then the concentration of hydrogen ion, which causes the sensation of an acid taste in the first moment will naturally be much smaller than that of the glutamic ion which comes afterwards.

Occurrence of the salts of glutamic acid in nature.

In Japan and China a large quantity of Laminaria japonica, a sort of a brown sea-weed, is consumed as food. Its decoction is much employed to impart an agreeable taste to soup and other articles of food. The taste of this decoction is a rather complicated one. It is brine on account of much common salt contained in it, it is sweet as a large quantity of mannite is present, but what makes it valuable is its strong glutamic taste. In 1907 I undertook to find out

the substance to which this taste is due. For this purpose several kilograms of the dried sea-weed was extracted with water. The greater part of mannite and sodium chloride was removed by crystallization. The taste imparting substance was retained in the mother liquor. By a few preliminary testing it was soon found out that the substance must be a salt of an organic acid. On adding lead nitrate to the mother liquor a resinous precipitate was obtained, which contained much chloride, some phosphate and sulphate together with the lead salt of the unknown acid. (It is a peculiarity of soluble glutamate to form with a lead salt a readily fusible resinous precipitate in the presence of much chloride). The powdered precipitate was treated with hydrogen sulphide in the presence of water and barium carbonate. The barium salt of the unknown acid mixed with the chloride was thus obtained in solution. By adding silver sulphate dissolved in a large volume of hot water barium chloride was completely removed. The unknown acid was liberated by precipitating barium with sulphuric acid. The solution was then concentrated and left to crystallize; crystals of sphenoidal habit then made their appearance and grew very slowly. By repeating these operations several times about 30 grams of the acid was obtained from about 12 kilograms of the dried sea-weed. The melting point was about 195°. The equival. weight determined by titration with standard alkali, the molecular weight determined by the ebullioscopic method and the elementar analysis led to the molecular formula $C_5H_9NO_4$. It was then recognized to be glutamic acid. This was confirmed by preparing and analysing the characteristic copper and barium salts. Various soluble salts were then prepared from the acid obtained from the laminaria and from the acid obtained by the hydrolysis of gluten. These were all found to have intense glutamic taste.

By employing an analytical method, which was devised some time ago, the amount of glutamic acid in one of the best sort of the Laminaria has been determined and found to amount to about 1% of the dried sea-weed. But its distribution is not uniform throughout the whole leaf, which reaches several meters in length. The acid exists in greater concentration near the base and towards the top of the leaf it is far less. Now it is at the base that the growth of the leaf takes place and the synthesis or decomposition of proteins must be here most vigorous. It is therefore not to be wondered, that glutamic acid, one of the most important proximate components of proteins, should be found here in a larger quantity than in the other parts of the leaf.

Such a large accumulation of glutamic acid as in Laminaria japonica will be rare, but that it should be found in minute quantities in almost every part of plants and animals, where active metabolism is going on, is but natural. As the taste imparting power of a glutamate is so great, it is to be expected that the glutamic taste will be found in great many articles of food, even where analytical chemistry can not demonstrate its existence.

A new flavoring substance.

Of the existence of the specific taste quality, which we have been considering, I was long convinced, and I was of the opinion that a pure flavoring substance should be provided for satisfying the natural demand for it. The investigation on the essential constituents of Laminaria japonica was undertaken expressly for this purpose. As the substance sought turned out to be so easily accessible, my object was attained without much further trouble. Of all the glutamates of non-poisonous metallic radicals the sodium salt alone was found to combine, in itself, all the properties

essential or desirable in an article of daily consumption. This is a white salt with one molecule of water of crystallization, readily soluble in water, yet perfectly non-deliquescent. As its solubility varies greatly with temperature, it can be easily purified by recrystallization. When pure it is perfectly inodorous. It is not hygroscopic and can be kept indefinitely. It has certainly some nutritive value, but as glutamic acid is largely supplied to the system by the digestive product of vegetable proteins, its value in this respect should not be overrated. Its flavoring power is so great that two or three grams dissolved in one liter of water impart to it a very agreeable taste. It is especially palatable in combination with common salt. Thus we see that sodium glutamate is an almost ideal flavoring substance for the glutamic taste.

Impure flavoring substances for the glutamic taste were known of old. In this country, besides Laminaria japonica dried and prepared fishes were used for this purpose from ancient times. In Europe and America Liebig's meat-extract and allied preparations are essentially flavorings of the same category. The Japanese soy, which is now much consumed in the occident also, owes its value partly to the glutamate contained in it.

How it is that certain taste qualities cause pleasant sensations while others are disagreeable to us, is an exceedingly interesting problem, to which we can at present give only proximate teleological answers. Taste sensation must have been developed as a guide in choice of food. Hence, agreeable taste must be such as accompany nutritious substances of natural ~~origin~~ occurrence, while disagreeable taste must go hand in hand with harmful substances. The latter is exemplified in the repugnance felt towards the bitter taste, which warn us

against poisonous plants. Why bring taste in moderate intensity is agreeable can be explained by the natural demand for sodium chloride, continual loss of which from the blood must be promptly compensated. Sweet taste is agreeable because sugars are not only in themselves nutritious, but usually accompany nourishments of vegetable origin. The reason why we find glutamic taste so pleasant must be sought in the fact that glutamates are often present in minute quantities in nutritious matter of albuminous natur, and mostly of animal origin. Hence, the appetite for these three taste qualities are quite normal. Since many generations pure salt and pure sugar are the flavoring substances for the first two qualities, and in the future a pure glutamate must form the principal flavoring substance for the third.

Chemical industry of the decomposition products of albuminous matters.*

From the foregoing it is probable that the manufacture of the glutamate will develope to a great industry in the future. Synthetical processes of making are of course conceivable, but industrially it must be obtained from the hydrolytic products of proteins. Since three years Mr. Suzuki, a chemical manufacturer in Tokyo, is producing Sodium glutamate under the trade name of Aji-no-moto ~~subject~~ or quintessence of flavor. At present yearly output is about 25 tons, but it is steadily increasing.

The manufacture of the glutamate will doubtless inaugurate a new branch of chemical industry, that of the decomposition products of albuminous matters. The scientific foundation lies

* A process of making flavoring matters consisting essentially of glutamates, and processes of working up hydrolytic products of proteins, invented by me, have been patented in several countries.

been laid by a series of eminent German and American chemists, but there are still much to be done both by scientists and manufacturers. The utilisation of the components other than the glutamate is a very interesting problem and full of possibilities. The recent researches on nutrition by the physiological chemists are specially suggestive in this respect. It is, however, not my object to work out the programme in this place, but to call the attention of my colleagues to a promising new branch of chemical industry.