Taste and Structures II[1)]
On the Measurement of Saltiness

Koko SATSUMABAYASHI, Yoko NISHIDA, and Kiyoshi TANEMURA

The Nippon Dental University, School of Dentistry at Niigata, Hamaura-cho, Niigata 951-8580, JAPAN

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Summary : Eighteen sensitive tasters were selected out of 23 reseachers, and they examined the saltiness of 6 kinds of salts. The results of measurements of the saltiness of Disodium L-malate, Sodium chloride, Sodium bromide, Sodium fluoride, Lithium bromide, and Lithium chloride were recorded and using these results the degree of saltiness, S, was calculated by the statistical method. The relative saltiness was as follows : LiCl > NaCl > LiBr > NaBr > Disodium L-malate > NaF.

Key Words : Degree of saltiness, Taste threshold.

Introduction

In the previous paper[1)], the taste materials with nitro group and sulfur atom were synthesized, and it examined the correlation between taste and conformation.

So far, because the measurement of a degree of saltiness has not been made conventionally, we want to report the results of the measurement of saltiness.

The bitterness increases, as the molecular weight increases in inorganic salt, the bitterness surpasses the salty taste in Sodium iodide, Potassium iodide, and Caesium chloride, etc..

In this paper, using Sodium chloride which is a representative of salty taste to be a standard, it obtained equivalent concentration, the degree of saltiness, and the threshold on five kinds of salty materials which do not show the bitterness.

Disodium L-malate, Sodium bromide, Sodium fluoride, Lithium bromide and Lithium chloride were used as the materials that resemble Sodium chloride.

Experimental

Materials : Disodium L-malate was obtained from commercial suppliers and purified by repeated recrystallization. Sodium chloride, Sodium bromide, Sodium fluoride, Lithium bromide, and Lithium chloride were all extra pure materials commercially obtained.

Selection of Tasters : We have used eighteen sensitive tasters selected out of 17 males and 6 females. The procedure of selection was as follows.

The experimental subject was given, out of order, a series of four Sodium chloride solutions of a definite concentration difference, namely, 0.20, 0.15, 0.10, and 0.050 mol dm^{-3} (i = 0.05 mol dm^{-3}). Each solution, 10 to 15 cm^3 in volume, was contained in a numbered small cup, the number being scrambled so that tasters were ignorant of what they were tasting. The tasters, by rinsing their mouths and wiping their tongues with a dry cloth everytime before tasting in order to increase the sensitivity. They compared the four solutions, by tasting this and that, and were asked to state the series in order of saltiness. The persons who passed this examination successfully were 12 males (aged 21 to 67) and 6 females (aged 21 to 31).

Results of Measurements

Method of Measurement : We measured the saltiness of Sodium chloride, applying the method of complete series as described by Pauli[2)] and Paul[3)].

As the standard salty solution, NaCl 0.2 mol dm^{-3} was used. The tasters observed how the relative saltiness of Disodium L-malate changes with concentration.

To begin with, 8 kinds of aqueous solutions of Disodium L-malate from the highest 0.35 to the lowest 0.11 mol dm^{-3} with 0.03 mol dm^{-3} with the regularly-interval concentration were prepared.

The method of tasting was the same as described in the selection of tasters. Each solution was put in the little glass 10-15 cm^3 each. The tasters were told neither the

Table 1. Saltiness of Disodium L-malate (N=NaCl 0.2 mol dm^{-3})

Solution No.	Conc. (mol dm^{-3})	Number of Judgments		
		stronger (gr)	equal (gl)	weaker (kl)
1	0.35	18	0	0
2	0.32	9	5	4
3	0.29	6	6	6
4	0.23	2	2	14
5	0.20	3	0	15
6	0.17	1	2	15
7	0.14	0	1	17
8	0.11	0	0	18
	Total	39	16	89

Table 2. Saltiness of Sodium Bromide (N=NaCl 0.2 mol dm^{-3})

Solution No.	Conc. (mol dm^{-3})	Number of Judgments		
		stronger (gr)	equal (gl)	weaker (kl)
1	0.32	18	0	0
2	0.29	13	3	2
3	0.26	10	5	3
4	0.23	0	15	3
5	0.20	1	4	13
6	0.17	0	4	14
7	0.14	0	1	17
8	0.11	0	0	18
	Total	42	32	70

Table 3. Saltiness of Sodium Fluoride (N=NaCl 0.2 mol dm^{-3})

Solution No.	Conc. (mol dm^{-3})	Number of Judgments		
		stronger (gr)	equal (gl)	weaker (kl)
1	0.800	18	0	0
2	0.725	14	3	1
3	0.650	12	4	2
4	0.575	10	4	4
5	0.500	9	3	6
6	0.425	6	1	11
7	0.350	3	2	13
8	0.275	0	0	18
	Total	72	17	55

concentration nor the order. The tasters were requested to report whether each solution of sodium malate was

Table 4. Saltiness of Lithium Bromide (N=NaCl 0.2 mol dm^{-3})

Solution No.	Conc. (mol dm^{-3})	Number of Judgments		
		stronger (gr)	equal (gl)	weaker (kl)
1	0.4000	18	0	0
2	0.3625	17	1	0
3	0.3250	15	2	1
4	0.2875	9	9	0
5	0.2500	8	7	3
6	0.2125	4	6	8
7	0.1750	0	7	11
8	0.1375	0	0	18
	Total	71	32	41

Table 5. Saltiness of Lithium Chloride (N=NaCl 0.2 mol dm^{-3})

Solution No.	Conc. (mol dm^{-3})	Number of Judgments		
		stronger (gr)	equal (gl)	weaker (kl)
1	0.2400	18	0	0
2	0.2175	14	4	0
3	0.1950	11	6	1
4	0.1725	7	4	7
5	0.1500	3	8	7
6	0.1275	1	2	15
7	0.1050	0	1	17
8	0.0825	0	0	18
	Total	54	25	65

stronger in saltiness, equal or weaker than the standard NaCl solution (N). The way of this distinction is called "the three discrimination method". The discriminant results are shown in Table 1.

The results of the measurements of the saltiness of Sodium bromide, Sodium fluoride, Lithium bromide, and Lithium chloride were concisely in Tables 2 to 6.

Discussions

The calculation of the results was carried out by means of the following formulae,

$$E_0=\left(D_0+\frac{i}{2}\right)-\frac{\Sigma gr\cdot i}{n};$$

$$E_u=\left(D_0-\frac{i}{2}\right)+\frac{\Sigma kl\cdot i}{n}$$

Σgr shows the number of judgments of "stronger", Σkl shows the number of judgments of "weaker". D_0 shows

Table 6. The Degree of Saltiness and the Lowest Thresholds

Salt	MW	Equal Saltiness (E_m) mol/dm^3	Equal Saltiness (E_m) g/100 cm^3	S value $0.2/E_m$	Lowest Threshold mol/dm^3
Malate*	178	0.2717	4.84	0.736	1/10
NaCl	**58.45**	**0.2000**	**1.17**	**1.000**	**1/35**
NaBr	102.9	0.2383	2.45	0.839	1/45
NaF	42.00	0.5021	2.11	0.398	1/15
LiBr	86.86	0.2375	2.06	0.842	1/15
LiCl	42.40	0.1681	0.713	1.190	1/11

*Disodium L-malate

the highest concentration, D_u shows the lowest concentration, i shows the concentration interval of the solution, and n shows the number of judgments for each solution.

The concentration, E_m, which has equal saltiness with the standard, being $(E_0+E_u)/2$. The degree of saltiness (S), taking NaCl as 1, is expressed as follows:

$$S=\frac{N\times 1}{E_m}=\frac{N\times 2}{E_0+E_u}$$

where N is the concentration, in the molarity (mol dm^{-3}), of Sodium chloride used as the standard. The results of S values by calculations are shown in Table 6, together with their molecular weights.

Disodium L-malate was once used for diet therapy such as liver disease instead of the salt-free soy sauce. From Table 6, it is proven to be the degree of saltiness of about 2/3 of the table salt.

As may be seen from Table 6, it can be said that the degrees of saltiness of the chlorides are big. It considers that an ionic radius and mobility seem to be related on this fact. When it is considered in view of the weight, it is proven that LiCl and NaCl are "salty materials". The relative saltiness of six kinds of salty taste including Sodium chloride was as follows : LiCl>NaCl>LiBr>NaBr>Disodium L-malate>NaF.

Generally, around 20-year-old women are most taste sensitive. To the reference the result of the lowest thresholds tasted by authors (aged over 40) who had passed the taste selection tests were shown in the last column of Table 6. It is understood that the lowest threshold is not proportional to the degree of saltiness from this value.

References

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