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Evaluation of Taste Properties of Commercially Available Salts

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This study examined commercially available salts' taste properties. The salts were used in preparation of four dishes: *asazuke* of cucumber, *asazuke* of Chinese cabbage, clear soup, and green soybean rice. The respective tastes of the salts in those prepared foods differed from those of the salts alone. We evaluated the salt taste in those dishes using sensory evaluations and a taste sensor. Sensory evaluations assessed four taste parameters: saltiness, mildness, unpleasantness, and palatability. Differences of the salt samples affected the perception of saltiness. Results of taste sensor analyses showed that monosodium glutamate (MSG) affected response patterns toward the salt solution.

Key Words : Salts, Inorganic components, Sensory evaluation, Taste sensor

1. Introduction

Various commercially available salts that compose bittern seem to emphasize a delicious taste and are superior, as food materials, to salts that have sodium chloride content greater than 99%. Such high-NaCl-content salt is frequently produced through an electrodialytic ion-exchanging membrane procedure in salt manufacturing. Nevertheless, commercial advertisements lack scientific evidence to support that assertion[1-3].

We studied taste properties of salt solutions and demonstrated effects of bittern components on the respective tastes of salts[4-6]. Sensory evaluations of salt solutions produced by different procedures at 1.2% solid contents revealed statistically significant differences in saltiness and bitterness only for salt samples produced by spraying seawater directly at room temperature[6]. Taste sensor analyses revealed different response patterns for salt samples produced using various procedures[6].

This study used a salt solution and popular foods using the salt — clear soup and others — as sensory test samples. We examined four salts' effects on the food taste. The salts were produced using different procedures. A professional panel group and one comprising non-professionals did sensory tests. Herein, we report results of different evaluations of the respective panels, along with results yielded by taste sensors.

2. Materials and Methods

2.1 Salt samples

We used four salt samples that were produced through different processes and that comprised different inorganic contents. Sample A was sodium chloride (highest quality; Wako Pure Chemical Industries Ltd.). Samples B — D were commercially available salts. Sample B was salt produced by boiling seawater. Sample C was reprocessed imported solar-dried salt. Sample D was salt that had been dried by direct spraying of seawater at room temperature. Table 1 shows inorganic components of the four samples. The values represent the solid contents. After all samples were dried at 105℃ for 4 h, these samples' respective inorganic contents were analyzed. The respective moisture contents of samples A, B, C and D, which were dried at 105℃ for 4 h, were 0%, 5.35%, 2.11% and 3.61%.

Table 1 Composition of inorganic ions in four salt samples. Values represent solid contents.

wt(%)

salt	Ca	K	Mg	Na	Cl	SO_4
Sample A	0	0	0	39.34	60.66	0
Sample B	0.56	0.18	1.1	36.7	58.57	3.3
Sample C	0.09	0.1	0.29	38.7	60.76	0.02
Sample D	0.61	1.18	3.72	28.9	53.03	6.0

2.2 Preparation of sensory evaluation samples

Asazuke of cucumber, asazuke of Chinese cabbage, clear soup, and green soybean rice were cooked respectively using the four salt samples shown in Table 1. The salts were added to adjust the solid contents because the salt samples had various water contents.

<Salt solutions>

Salts were dissolved in 1.5 l of deionized water (1% solid content) and the salt solutions were kept at 70℃. These solutions were used as samples for sensory evaluations.

<*Asazuke* of cucumber>

The salts were added to 430 g of the cucumbers cut irregularly

(2% solid content), the cucumbers were pickled, left at 4℃ overnight, and then used as samples for sensory evaluation.

<*Asazuke* of Chinese cabbage>

The salts were added to Chinese cabbage (2×3 cm, 797 g) to 2% solid content and Chinese cabbages were pickled, left at 4℃ for three nights and then used as samples for sensory evaluation.

<Clear soup>

In 1.5 l of deionized water at 70℃, 1.5 g of sodium L(+)-glutamate monohydrate, 1% solid content of salt, and 100 μl of soy sauce were dissolved. Two pieces of *tofu* (1 cm^3), a suitable amount of hornwort, and a piece of warmed carrot were added to the solutions. These clear soups were used as samples for sensory evaluations.

<Green soybean rice>

We mixed 459 ml of food broth and 400 g of rice and stored them for 30 min. Then, 30 ml cooking liquor and the salt sample (to 2% solid content) were added and steamed. After addition of 80 g soybeans, the steamed rice was used for sensory evaluations.

2.3 Sensory evaluation

2.3.1 Selection of panel for sensory evaluation

We tested five basic tastes (sweetness, saltiness, bitterness, sourness, and *umami*) for 26 panels by matching tests and different tastes of concentrations using paired tests of sensory evaluation[7]. We selected data of 8 expert panelists and 18 non-professional panelists.

2.3.2 Sensory evaluation

We evaluated saltiness, mildness, unpleasantness and palatability for four processed foods using sensory evaluation. According to Scheffe's paired comparison method (modified Haga's method)[8], we planned a design of experiments and analyses: sensory evaluation of salt solutions was performed using 21 panelists (expert panel, 6 panelists; non-professional panelists, 15 panelists); *asazuke* of cucumber evaluation was by 20 panelists (expert panel, 6 panelists; non-professional panelists, 14 panelists); *asazuke* of Chinese cabbage was evaluated by 21 panelists (expert panel, 6 panelists; non-professional panel, 15 panelists); clear soups were evaluated by 18 panelists (expert panel, 5 panelists; non-professional panel, 13 panelists); and green soybean rice was evaluated by 16 panelists (expert panel, 4 panelists; non-expert panel, 12 panelists).

2.4 Taste-sensor measurements

We used a taste-sensing system (SA402; Anritsu Corp.) equipped with lipid membranes (Sensor 1 − Sensor 8) that had been prepared manually with eight lipids, as shown in Table 2, using polyvinyl chloride and dioctyl phenylphosphonate as plasticizers (Table 2). The model seawater was prepared as follows: sodium chloride (10.68 g), magnesium chloride (1.31 g), magnesium sulfate (0.84 g), calcium sulfate (0.55 g), potassium chloride (0.29 g), and magnesium bromide (0.03 g) were dissolved in 1 kg deionized water. We used this solution as a standard solution[4-6]. As sample solutions for a taste sensor, we tested four kinds of clear soup without ingredient materials and four kinds of salt solution containing the same amounts of salts as those used in the clear soups. All solutions were used after cooling to room temperature.

Using the taste sensor, the membrane potential response in the standard solution ($V1$) and potential response of the sample solution ($V2$) were measured successively. The taste sensor response (mV) represents the difference between $V2$ and $V1$ ($V2-V1$). The response values were measured three times for each sample; their averages were used for data analyses.

Table 2 Lipid materials used in preparation of eight membranes.

Sensor No.	Lipid
1	Decyl alcohol
2	Oleic acid
3	Dioctyl hydrogen phosphate
4	DOP : TOMA = 9 : 1
5	DOP : TOMA = 5 : 5
6	DOP : TOMA = 3 : 7
7	Trioctyl methyl ammonium chloride
8	Oleyl amine

(DOP : Dioctyl hydrogen phosphate, TOMA : Trioctyl methyl ammonium chloride)

3. Result and Discussion

We studied sensory evaluations for salt solutions and some dishes using samples A − D. Figure 1 shows scores of sensory evaluations. Negative and positive scores respectively represent strong and weak evaluations. In sensory evaluations, salt solutions, *asazuke* of cucumber, *asazuke* of Chinese cabbage, clear soup, and green soybean rice all contained the same quantities of the same salts. Judgments by both non-professional and expert panels showed that the saltiness of sample A was strong and that of sample D was weak (Figure 1). Statistically significant differences by Scheffe's paired comparison method (modified Haga's method) in saltiness for the salt solution, clear soup and green soybean rice were marked, but no statistically significant differences were recognized for *asazuke* of cucumber and *asazuke* of Chinese cabbage (Table 3). Salt solutions and clear soups were prepared by dissolving salt into deionized water and solutions containing MSG and soy sauce. Spraying salt directly onto the vegetables produced *Asazuke*. Green soybean rice was cooked in a rice-cooker with rice and salts. Those different methods of adherence, adsorption, osmosis, and spread of salts in foods might have affected saltiness evaluations. We considered that all panelists readily recognized saltiness because both non-professional and expert panels obtained similar results for saltiness of the salt solution, clear soup, and green soybean rice. Comparison of data for the salt solution and prepared food samples showed significant differences in mildness and unpleasantness. In the salt solution, evaluations by the non-professional panel showed no differences in mildness. Among all salt samples for the salt solutions, evaluations by the expert panel showed that the mildness of sample A were weaker than those of other samples (Figure 1). For the clear soup and green soybean rice, evaluations by the non-professional panels showed that sample D was stronger than other samples; evaluations by expert panels showed no differences in mildness among all salt samples (Figure 1). The non-professional panel recognized significant mildness in the clear soup and in green soybeans with sample D. In the salt solution, the expert panel recognized significant mildness (Table 3). The panelists who felt weak saltiness or sweetness or *umami* evaluated the taste of samples as mildness. Regarding differences in evaluation criteria of panels, statistically significant differences were not found.

Table 3 Result of sensory evaluations of prepared salt solutions and relative dishes.

Taste profine	pair	salt solution		sazuke of cucumber		asazuke of chinese cabbage		clear soup		green soybean rice	
		non professional panel	expert panel	non professional panel	expert panel	non professional panel	expert panel	non professional panel	expert panel	non professional panel	expert panel
saltiness	A B	**	**					**	*		
	A C										
	A D	**	**	**				**	**	**	**
	B C										
	B D	**	**					**	*	**	*
	C D	**	**	*				**	**	**	*
mildness	A B		**							*	
	A C									**	
	A D		*					**		**	
	B C										
	B D						**	*		*	
	C D						*				
unpleasantness	A B	*									
	A C										
	A D	**	**	**				*			
	B C										
	B D	**	**	**		**					*
	C D	**	**	**		**		**			
palatability	A B										
	A C										
	A D	**		**			**	*			
	B C										
	B D	**	**	*							
	C D	**	**				**	**			

** $P<0.01$, * $P<0.05$

Regarding judgments for the salt solution, both panels showed that the unpleasantness of sample D was very strong. The unpleasantness of sample D in other prepared foods seemed not to be strong for the green soybean rice (Figure 1). Both panels recognized significant unpleasantness in a salt solution with sample D, but did not recognize it in prepared foods (Table 3). Palatability showed an opposite tendency to unpleasantness (Figure 1). Differences in evaluation criteria of panels influenced their evaluation of mildness and unpleasantness. The salt solution composition is simple, implying that evaluation and judgment of saltiness and bitterness that are imparted by bittern components might be easy. However, the taste of salt in the prepared foods differed from that in the salt solution. For example, the clear soup containing MSG and soy sauce, which are components of *umami*, and other ingredients in addition to the salts, the taste of the clear soup is more complex than the salt solution. Synergic effects by MSG, soy sauce, ingredients and salts engendered differences in the analytical data of the clear soup and the salt solution.

We studied taste properties of salts solutions and demonstrated effects of bittern components on the respective tastes of salts[1-6]. However, the results showed that the tastes of salt solutions differed from those used in prepared foods.

These findings suggest that the salts' taste properties were characteristic for each dish and that uniformity of evaluation criteria for taste profiles, except for saltiness, is important for sensory evaluations.

Recently, taste sensors have been used to evaluate taste properties[9-12]; we have examined salt solutions using a taste sensor[4-6]. The lipid membranes used in our experiments were reported to be useful for analyzing the taste of salts[5,9] and of seawater[4]. In sensory evaluation, we recognized differences in evaluations of the salt solution and clear soup. Therefore, we compared the response patterns of four salt solutions and four clear soups using a taste sensor. Detected differences the contents between salt solutions and clear soups were for MSG and soy sauce. Figure 2 shows response patterns and standard deviations of individual salt samples in sensors 1－8; the response values represent the relative electric potential to that of standard solutions. It is plotted around 0 if the value is similar to that of the standard solution.

With respect to the analysis of sensors 1－4 equipped with negatively charged lipid membranes, the response values of the salt solutions and clear soups with samples B and D were lower than those of other samples. The response patterns of the salt solutions and clear soups with samples B and D were similar. In this study, we used model seawater as a standard solution. High contents of bittern components in samples B and D might explain the lower responses garnered by their salt solutions. This finding indicated that inorganic components played important roles in the response value given on a taste sensor. Our previous study demonstrated that the inorganic salt components affected the response value for the salt solutions. In this study, high correlations were detected in the response patterns of not only the salt solution, but also clear soups on sensor 1－4, and inorganic components in samples B and D particularly influence the response value. Response patterns of all samples differed markedly in analyses by sensors 5－8 with positively charged membranes.

Because sensory evaluations demonstrated differences in the tastes between the salt solution and clear soup, we plotted the response patterns of salt solutions and clear soups for all sensors. Data of clear soups and salt solutions were plotted respectively on the vertical axis and horizontal axis and the straight lines ($y=x$) were drawn in all figures as a control (Figure 3). Data were plotted on the lines of $y=x$ if the addition of MSG in the clear soups gave no influence on the response pattern of a taste sensor. The data were plotted as straight lines parallel to $y=x$ if the effects of MSG on the sample A－D were constant. Data of sensors 2 and 4 were plotted on straight lines parallel for $y=x$. This result suggests that MSG similarly affected the response patterns of all samples on these sensors. Straight lines from sensors 1, 3, and 7

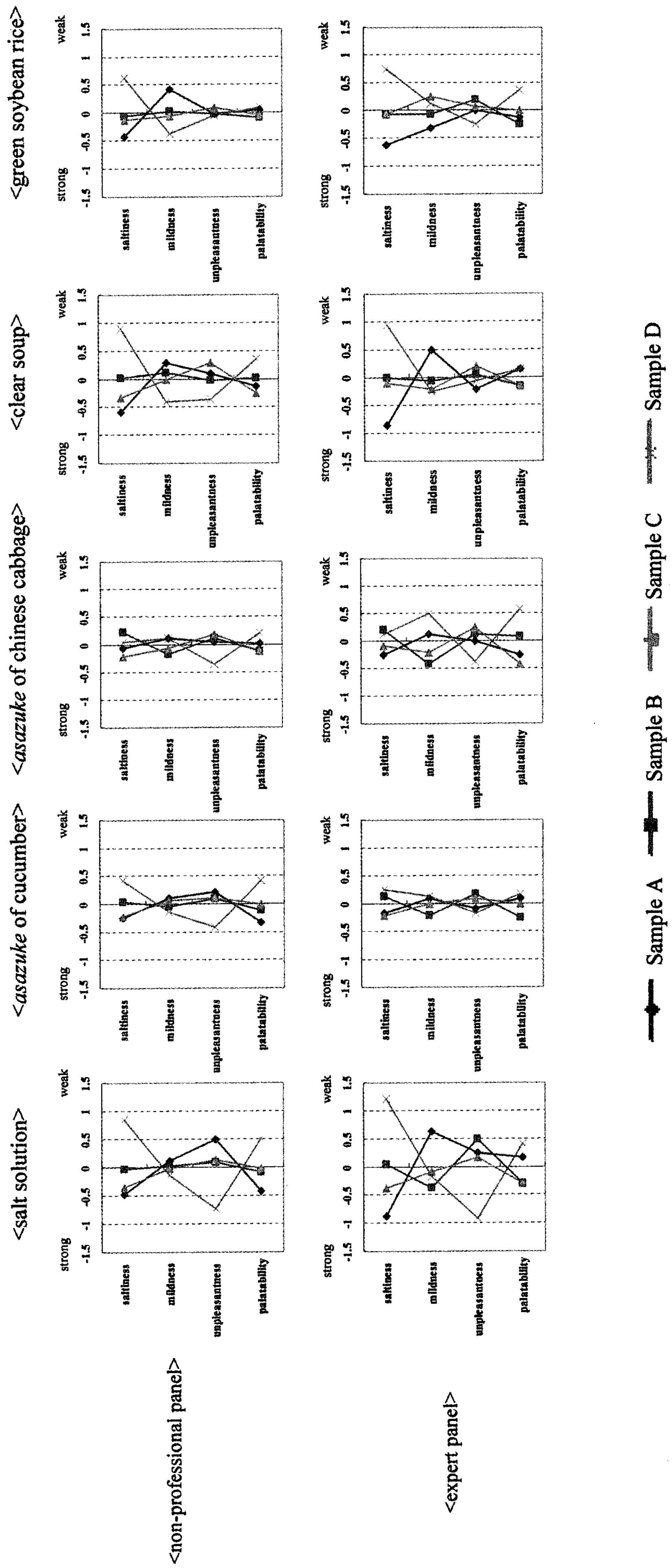

Figure 1 Sensory scores of prepared salt solutions and prepared dishes.

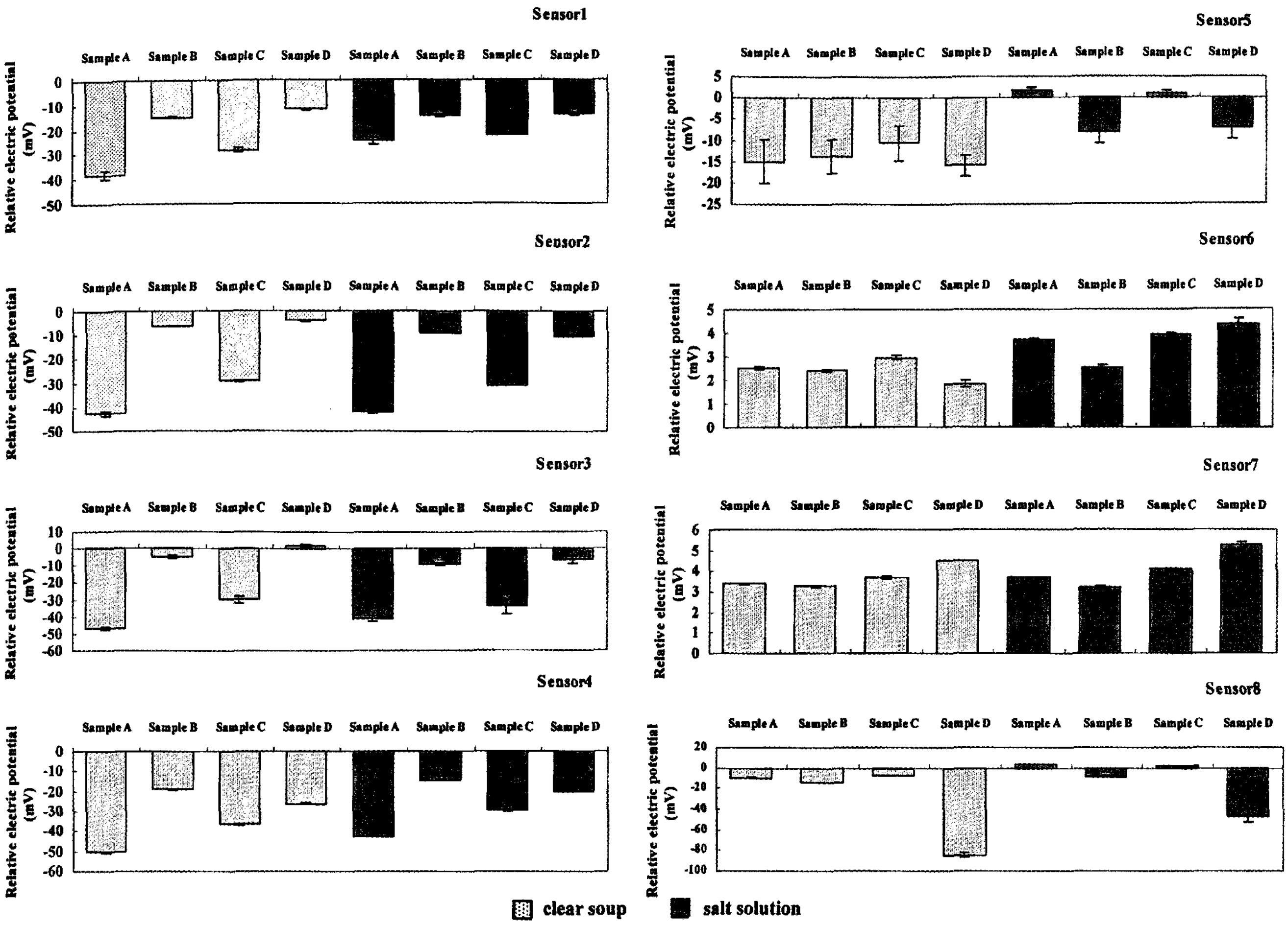

Figure 2 Taste sensor response patterns for four clear soup and four salt solutions.

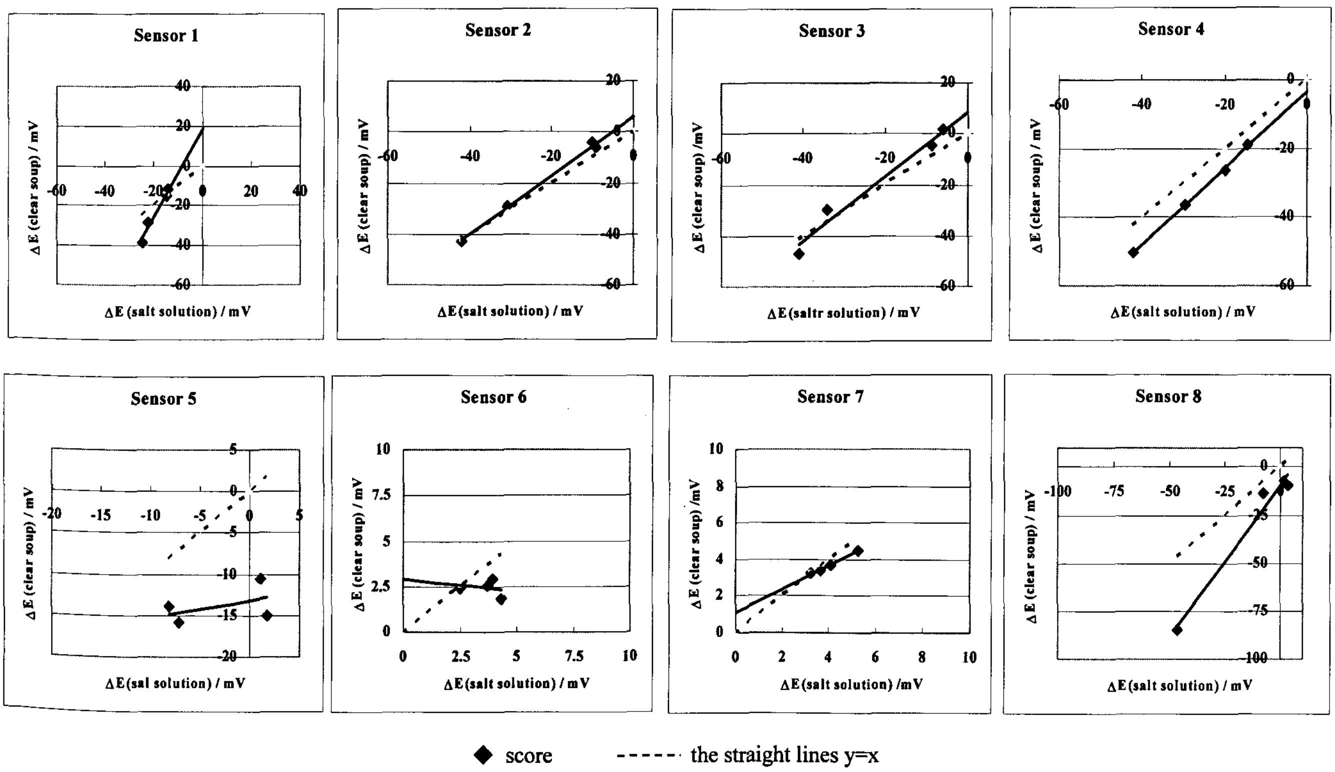

Figure 3 Score plots of taste sensor response values for clear soup and salt solutions. Response values of salt solutions and clear soup are plotted for every sensor; a straight line inclined 45° was drawn as a control.

were not parallel for $y=x$. This result suggested that MSG imparted different effects on response patterns against four salts in Sensors 1, 3, and 7.

Regarding sensory evaluation, in the salt solutions and clear soups, panels were able to distinguish the types of salts; a taste sensor detected those differences. However, the evaluation criteria are not equal for panels in the case of sensory evaluation of mildness in the salts. Further studies are necessary to clarify the relationships between sensory evaluations and the response patterns on a taste sensor.

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