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INFLUENCE OF MONOSODIUM GLUTAMATE ON TASTE PERCEPTION[a,b]

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The fact that monosodium glutamate (MSG) increases palatability of some foods, as demonstrated by consumer preference studies *(3)*, would place it among the seasonings and condiments. However, statements have been made *(1, 6, 7)* to the effect that MSG is a unique substance that does not impart a flavor of its own but serves only to enhance the natural flavors of foods by increasing the sensitivity of the taste receptors. This might be termed an "accentuation" or "sensitization" hypothesis.

Several investigators have tested this hypothesis. Lockhart and Gainer *(5)* used subliminal concentrations of MSG in supraliminal sugar and salt solutions along with control (no MSG) solutions in triangle tests. The MSG had no significant effect on the taste of sucrose or sodium chloride. In those cases where a change in taste was observed, the taste appeared to be that of glutamate rather than additional sweetness or saltiness. Mosel and Kantrowitz *(8)* determined the effect of exposure to a 5 times threshold concentration of MSG five minutes before measuring absolute thresholds for the four basic tastes. Compared to control thresholds, *sweet* and *salty* were unaffected, acuity to *sour* was increased somewhat and acuity to *bitter* was greatly increased. These authors also discuss other publications, pointing out that there has been confusion of palatability with intensity and that some results are inconsistent with the "sensitization" hypothesis. Another study *(10)* employing subliminal concentrations of MSG (0.75 times threshold) showed a lowering of thresholds for *sweet* and *salt* but not those for *bitter* and *sour*. The results of these three studies do not support the hypothesis that MSG is a general sensitizer for taste acuity. Others who have sponsored this hypothesis do not support it with data.

Our investigation was undertaken to obtain further evidence on the validity of this hypothesis. The experiments included three types of measurements to assess the effects of MSG on gustatory acuity and flavor perception: changes in the absolute threshold (RL); changes in the differential threshold (DL); and, changes in subjective intensity.

PROCEDURE

Materials. The sodium chloride, sucrose and hydrochloric acid were C.P. grade; the caffeine was U.S.P., and the MSG was commercial 99+% pure. Water for preparing

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[b] Based on a paper presented at the 62nd Annual Meeting of the American Psychological Association, New York, N. Y., September 6, 1954.

solutions and for rinsing was distilled and then filtered through charcoal to remove all taste and odor. In all experiments the solutions were presented in 1 oz. glasses; the amount was 6 ml. for the RL's and DL's and about 25 ml. for subjective intensity. The time interval between samples was 30 seconds in all cases.

Subjects. Subjects for the threshold studies all had had considerable experience in laboratory sensory testing of foods and were familiar with the specific methods used. The latter are standard psychophysical techniques *(4)*. For the subjective intensity experiments subjects were drawn from a large group of people normally available for food preference studies.

Subjective intensity. The effect of MSG on weak, but supraliminal, concentrations of the primary taste qualities was determined by the method of paired comparisons. Each pair consisted of identical concentrations of one of the basic taste substances, with one sample of the pair containing MSG in addition to the basic taste substance. The question asked of each subject was: "Which is saltier?" or "Which is sweeter?," etc. The substances and the concentrations employed are shown in Table 1. The results were tested for significance against the expected chance distribution of 50-50.

TABLE 1

Subjective intensity[1] of basic taste solutions with and without added monosodium glutamate (0.2%)

Taste quality	No. of subjects	Substance and conc.		Samples with MSG judged stronger	p[2]
			%	%	
Sweet	35	Sucrose	2.0	34	.09
Sour	48	Hydrochloric acid	0.021	62	.11
Salty	30	Sodium chloride	0.2	80	.002
Bitter	48	Quinine sulfate	.00015	81	.001

[1] Method of paired comparisons. One pair of samples per subject (untrained consumer-observers).
[2] Probability that difference from expected distribution of 50-50 could have occurred by chance.

Absolute threshold. RL's for *sweet* and *sour* were determined by the method of constant stimuli, using 7 concentrations for each subject. The 7 concentrations were chosen from a larger series to encompass the range of each subject's RL. The 7 samples were presented in a different random order to each subject at a session and in a different order for a given subject at successive sessions. Control and experimental sessions were alternated for a total of 10 sessions. For the control sessions the subject rinsed his mouth with water for 5 seconds before each sample; for experimental sessions he rinsed for 5 seconds with 0.068% (0.004M) MSG. He rinsed with water after each sample in both experimental and control sessions. To each sample, the subject responded with a "Yes" or "No" indicating presence or absence of the taste. Another study on the sweet threshold, employing the method of limits, was made to assess the effect of method on the results. Only the ascending order was used, as is common practice in gustatory studies in order to avoid adaptation to the stimulus. In this study each subject rinsed with an MSG solution that was twice the concentration of his own threshold concentration.

Differential threshold. The DL for salt was measured by the method of a single stimuli using concentrations of 0.8, 0.9, 1.0 and 1.1% sodium chloride solutions. At each session each of 18 subjects received the 4 concentrations in ascending order, with knowledge, as a practice set, and then received the series twice in random order to be judged as to strength. The judgments were scored on the basis of proportion of times a sample was judged stronger than the hypothetical mid-point of 0.95% salt. For the control session he rinsed before and after each sample with water; for the experimental session he rinsed before with a 0.17% (.01M) solution of MSG and after with water. For the bitter DL the method of constant stimulus differences was used with .0020M (.039%) caffeine as the standard to be compared to concentrations of .0014, .0016, .0018, .0022, .0024, and .0026M solutions. The order of the pairs, and the position of the standard in the pairs, was randomized. The subject judged which sample in each pair was stronger. Seventeen subjects made a total of 72 judgments per point under both the experimental and control conditions. The rinsing procedures were the same as for salt.

Raw data were converted to proportion judged "Yes" in the case of RL's, and proportion judged stronger than the mid-point in the case of the DL's. Then these proportions were transformed to normal deviates, or sigma values, to convert the psychometric curves to straight lines *(4)*. Lines were fitted to the points by the least squares technique and the resulting equations were then solved for the required 50% and 75% points to obtain the RL's, DL's and PSE's (point of subjective equality).

RESULTS

That MSG has some effect on subjective intensity is evident from Table 1. *Salt* and *bitter* were intensified, but *sour* and *sweet* were not significantly affected. General flavor intensification was not apparent. It is questionable whether even the result for *salt* should be called intensification since a pure MSG solution will be called salty by many people. Hence, the increased saltiness may be only the result of increasing the concentration of salty-tasting solutes. The increase in bitterness cannot be explained as readily in the same way.

If MSG sensitizes the end organs of taste, then thresholds should be lower immediately after the mouth has been exposed to it. Table 2 shows the changes in thresholds for *sweet* and *sour*. Acuity to *sweet* and *sour* is actually decreased. This result for *sour* is the opposite of that obtained by Mosel and Kantrowitz *(8)*. This may be due to methodological differences.

The effect of an MSG rinse on the DL's for salty and bitter qualities is illustrated by data in Table 3. Neither result reaches the usually accepted levels of statistical significance.

DISCUSSION

No consistent pattern of the effect of MSG has emerged from these experiments. General intensification of taste is not evident. Intensity and acuity are reduced in some cases, increased in others, and sometimes there is no effect. These results substantiate those of other investigators. Selective intensification, such as was found in the experiments on subjective intensity, shown in Table 1, is congruent with traditional principles of flavor mixture and requires no special hypothesis.

Other studies from this laboratory *(2)* on preferences have shown that MSG improves hamburger that had developed rancidity due to exposure to ultra-violet light. According to the intensification hypothesis, these off-flavors should have been accentuated with a consequent loss in preference. Furthermore, preference studies have not shown MSG to be consistent in its effects on any one class of foods. For example, it improves some green vegetables and not others, using the criterion of consumer preference.

TABLE 2

Effect of a prior rinse with a monosodium glutamate solution on the RL's for two basic tastes

Taste quality	No. of subjects	Substance and conc.		Conc. of MSG solution	RL[1]	p[2]
			%	%	%	
Sweet[3]	5	Sucrose	0.05-0.7	0	.27	.05
				2 × thresh.	.32	
Sweet[4]	10	Sucrose	.25-.70	0	.34	.01
				.068	.43	
Sour[4]	8	Hydrochloric acid	0.0002-.002	0	.00128	.001
				.068	.00171	

[1] RL = absolute threshold.
[2] Probability that difference could have occurred by chance.
[3] Method of limits.
[4] Method of constant stimuli.

TABLE 3

Effect of a prior rinse with a monosodium glutamate solution on the differential sensitivity for two basic tastes

Taste quality	No. of subjects	Substance and conc. of mid-point		Conc. of MSG	k[1]	p[2]
			%	%		
Salty	18	Sodium chloride[3]	0.95	0	.119	0.35
				0.17	.123	
Bitter	17	Caffeine[4]	0.039	0	.378	0.12
				0.17	.588	

[1] $k = \frac{DL}{PSE}$ (Weber fraction).

[2] Probability that difference could have occurred by chance.

[3] Method of single stimuli, four points.

[4] Method of constant stimulus differences, six points.

Another line of evidence that has yielded information on the "sensitization" hypothesis can be found in electrophysiological experiments *(9)*. In these experiments the responses of the taste nerves of rats were measured while the tongue was being stimulated with solutions of various salts. It was found that MSG in NaCl solutions did not have an enhancement or persistence effect on the salt response; rather, the effects were merely additive. By itself MSG gave a characteristic salt response at 0.1M.

MSG is a useful seasoning since it does increase preference for a number of foods. In one series of experiments *(3)* about half of a selected group of foods were benefited; improvement was found among foods representing all of the common flavor types other than sweet foods. But since no evidence to date has shown that MSG has any unusual effect on sensory acuity, it may be assumed that the mechanism through which it alters flavors is similar to that of other seasonings.

SUMMARY

Three types of experiments were designed to test the hypothesis that monosodium glutamate (MSG) affects flavor perception by altering gustatory acuity. Absolute and differential thresholds were measured with and without a prior mouth rinse with MSG. The effect of the presence of MSG in solutions of the basic tastes on subjective intensity was determined.

MSG raised the absolute thresholds for *sweet* and *sour;* it did not significantly alter the differential thresholds for *salt* and *bitter.* It increased the subjective intensities of *salt* and *bitter,* but had no effect on sour and sweet tastes.

No consistent pattern of the effect of MSG emerged. The results do not support the hypothesis that MSG acts as a general intensifier of flavor and suggest no other hypothesis, except the general one that MSG is simply another seasoning that may contribute a flavor of its own to a complex food flavor.

LITERATURE CITED

1. BUCHANAN, B. F. Monosodium glutamate in food processing. *Food Packer,* 29, 10 (1948).
2. GIRARDOT, N. F. (Personal communication.)
3. GIRARDOT, N. F., AND PERYAM, D. R. MSG's power to perk up foods. *Food Eng.,* 26, (12) 71 (1954).

4. GUILFORD, J. P. *Psychometric Methods.* 2nd ed., 1954, McGraw-Hill, New York, N. Y.
5. LOCKHART, E. E., AND GAINER, J. M. Effect of monosodium glutamate on taste of pure sucrose and sodium chloride. *Food Research,* 15, 459-464 (1950).
6. LOGAN, P. Test of monosodium glutamate. *National Restaurant News Bulletin,* June 1949.
7. MELNICK, D. Monosodium glutamate: improver of natural food flavors. *Sci. Monthly,* 70, 199-204 (1950).
8. MOSEL, J. N., AND KANTROWITZ, G. The effect of monosodium glutamate on acuity to the primary tastes. *Am. J. Psychol.,* 65, 573-579 (1952).
9. QUARTERMASTER FOOD AND CONTAINER INSTITUTE PROGRESS REPORT, Project 7-84-15-007. Report No. 1: Nerve Responses to Organic Salts Applied to the Tongue (Florida State University), 1952.
10. VAN COTT, H., HAMILTON, C. E., AND LITTELL, A. The effects of sub-threshold concentrations of monosodium glutamate on absolute taste thresholds. (A paper presented at the 75th Annual Meeting of the Eastern Psychological Association at New York, April 9-10, 1954.)