

## A Study of the Effect of Monosodium Glutamate on the Development of *Drosophila melanogaster*

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Monosodium Glutamate(MSG)가 초파리(*Drosophila melanogaster*)  
의 발생에 미치는 영향에 대하여

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### 적 요

Monosodium glutamate는 많이 쓰이고 있는 화학조미료이다. 인간을 비롯하여 생쥐, 원숭이(Rhesus monkey), 초파리등의 동물에 대한 MSG의 영향을 실험 검토하여 MSG가 해롭다 또는 그렇지 않다는 상반된 여러 보고가 있다. 초파리(*Drosophila melanogaster*)의 발생에 대한 MSG의 영향을 조사하여 이렇듯 엇갈린 보고를 검토 확인할 목적으로 여러 가지 농도의 MSG와 cane sugar media(대조구)에 두 계통의 초파리(Oregon-R와 Sinchon-I)를 사육해서 우화해 나온 F<sub>1</sub> 초파리의 수를 조사 검토한 결과는 다음과 같다.

1) MSG의 처리는 초파리의 어느 계통에서나 다 같이 그 농도가 증가함에 따라 발생에 억제적 효과를 나타내는 동시에 10% 이상의 농도에서는 성충의 생육조차 불가능하였다.

2) Cane sugar는 초파리 발생에 억제적이라기 보다 오히려 촉진적 효과를 보이는 것 같다.

3) MSG나 cane sugar 처리구에서 다 같이 Sinchon-I이 Oregon-R보다 F<sub>1</sub> 산출수가 많았는데 이것은 Sinchon-I이 Oregon-R 보다 생식 및 생존력이 강함을 암시하며 그 원인으로 사육하는 동안 근친교배되는 기간의 차이라고 생각된다.

4) Muller-5 test는 부정적 결과를 나타냈는데 이것은 MSG가 mutagenic effect가 없음을 시사하고 있다.

5) MSG의 초파리 발생에 대한 억제적 효과에 관한 생리학적 기구는 아직 미지의 문제인데 이것은 조만간 해결하여야 할 것이다.

### INTRODUCTION

Since the first indication of possible ill effects from consumption of monosodium glutamate (MSG, widely used food additive) was recorded in what has come to be known as the Chinese Restaurant Syndrome (Schaumburg, 1968) in man, many

investigations of the effects of MSG have been done on the various animals.

Schaumburg *et al* (1969) reported MSG as the cause of such syndrome, as it was determined that both intensity and duration of symptoms were related to the ingested amount of MSG. Administrating high doses of MSG subcutaneously, Olney (1969), Olney & Sharpe (1969) and Arees & Mayer (1970) induced brain lesions in the hypothalamus of mice and Rhesus monkeys.

Blood (1969), Bazzano *et al* (1970), and Morselli & Garattini (1970) found no clinical or pathological changes in adult humans when relatively high dose of MSG was administered orally. The recent study of Reynolds *et al* (1971) reported that no morphological differences were found in the hypothalamic region of treated and control monkeys.

The examinations of the ill effects of MSG were also done on drosophilid flies. Turner & Wright (1971) designed an experiment in which the effects of some human-consumed chemicals including MSG on the development of *Drosophila melanogaster* were analyzed and found that 1% and 3% solutions of MSG caused no change in the development. Forman & Majumdar (1971) reported that 0.7 M MSG had an inhibitory effect on the development of the flies and suggested that there might be a threshold point somewhere between 3% and 10% solutions at which chemical produced an effect on the flies. Recently De la Rosa *et al* (1972) performed an experiment to determine the action of MSG as a radioactive substance on *Drosophila melanogaster*, as well as its mutagenic effect. As the results, the MSG effect on non-disjunction was observed only at the highest concentration assayed (0.8%) and X chromosome loss appeared after feeding with 0.4% MSG concentration but none of them was found to be significant.

Because of the conflicting reports described above, the present investigation was undertaken to examine the effects of MSG on the development of *Drosophila melanogaster*.

## MATERIALS AND METHODS

The two strains of *Drosophila melanogaster* were used in the present experiment: Oregon-R and Sinchon-I, the former has been kept in the constant temperature room ( $25\pm 1^{\circ}\text{C}$ ) for several years and the latter was captured from Sinchon area in Seoul and has been raised in the constant temperature room for several months.

The present experiments were performed at  $25\pm 1^{\circ}\text{C}$ , and the MSG ("M" commercial additive and MSG manufactured by Kanto Chemical Co.) and the cane sugar (as the second control) media were prepared by adding them at a concentration of 20.0, 15.0, 12.0, 10.0, 7.0, 5.0, 3.0, 1.0, and 0.0% (as the first control) to the standard corn meal, yeast, agar media.

Five male and five female 3-day-old flies were placed in vials of each concentration of MSG or cane sugar for each strain of flies and those vials were kept in the constant temperature room. The numbers of emerging adults ( $F_1$ ) were counted and averaged for each concentration of MSG or cane sugar in each strain of flies.

After initial work, ten Oregon-R males were sampled from the media of 10.0% MSG and the Muller-5 test was carried out in order to examine the possibility of a recessive lethal sex-linked mutation.

## RESULTS AND DISCUSSION

The present investigation is divided into two parts: the preliminary and the main experiment.

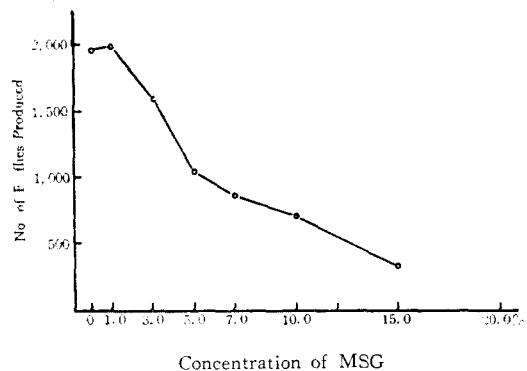
**A. Preliminary experiment:** Seven kinds of the media, 15.0 10.0, 7.0, 5.0, 3.0, 1.0 and 0.0% of MSG("M" commercial additive) were prepared for one strain of the flies, Oregon-R in the preliminary experiment and the results were presented

**Table 1.** Effects of monosodium glutamate ("M" commercial additive) on the development of Oregon-R of *D. melanogaster*

Conc. of MSG(%)	No. of vials	Total no. of $F_1$ flies produced			Average no. of $F_1$ flies per vial
		Male	Female	Total	
0.0	10	847	1110	1957	195.7
1.0	10	1001	995	1996	199.6
3.0	10	792	786	1578	157.8
5.0	10	520	522	1042	104.2
7.0	10	456	471	927	92.7
10.0	10	414	417	831	83.1
15.0	10	154	185	339	33.9

in Table 1 and Figure 1.

As illustrated in Table 1, the average number of  $F_1$  flies produced shows no difference between 1.0% and 0.0% (control) MSG but decreases significantly from a concentration of 3.0% and drops down to 1/2 and 1/6 of the control at a concentration of 5.0% and of 15.0% MSG, respectively. In other words, the number of  $F_1$  flies decreases as the concentration of MSG increases and the appears



**Fig. 1.** Numbers of  $F_1$  flies of Oregon-R produced from the MSG media listed in Table 1.

remarkably from a concentration of 5.0% MSG and much more conspicuously at a concentration of 15.0% MSG. This tendency is well manifested in Figure 1.

**B. Main experiment:** Nine kinds of the media, 20.0, 15.0, 12.0, 10.0, 7.0, 5.0, 3.0, 1.0 and 0.0% of MSG(Kanto Chemical Co.) and cane sugar (the second control) were prepared for the two strains of flies, Oregon-R and Sinchon-I in the main experiment and the results were presented in Table 2-6 and Figure 2-6.

**Table 2.** Effects of MSG on the development of Oregon-R of *D. melanogaster*

Conc. of MSG (%)	No. of vials	Total no. of F <sub>1</sub> flies produced			Average no. of F <sub>1</sub> flies per vial
		Male	Female	Total	
0.0	10	939	936	1875	187.5
1.0	10	680	709	1389	138.9
3.0	10	454	426	880	88.0
5.0	10	343	349	692	69.2
7.0	10	94	116	210	21.0
10.0	10	0	0	0	0.0
12.0	10	0	0	0	0.0
15.0	10	0	0	0	0.0
20.0	10	0	0	0	0.0

As seen in Table 2 and Figure 2, the average number of F<sub>1</sub> adults produced from Oregon-R decreases as the concentration of MSG increases: it begins to decrease from a concentration of 1.0% and drops down to 1/2 and 1/8 of the control at a concentration of 3.0% and 7.0%, respectively. Even no F<sub>1</sub> flies are emerged from a concentration of 10.0% to of 20.0% MSG.

Comparing the result of the present experiment with that of the preliminary one, the inhibitory effect of MSG in the former experiment appears much more conspicuously than in the latter, that is, the F<sub>1</sub> flies are produced from the medium 10.0%, even 15.0% MSG in the preliminary experiment but no flies are emerged from the medium of 1.0% or more MSG in the present experiment. This difference may be due to the quality of MSG since "M" commercial additive used in the preliminary experiment is not pure MSG.

**Table 3.** Effects of MSG on the development of Sinchon-I of *D. melanogaster*

Conc. of MSG (%)	No. of vials	Total no. of F <sub>1</sub> flies produced			Average no. of F <sub>1</sub> flies per vial
		Male	Female	Total	
0.0	10	1688	1483	3171	317.1
1.0	10	1180	1082	2262	226.2
3.0	10	1153	1215	2368	236.8
5.0	10	692	659	1351	135.1
7.0	10	211	218	429	42.9
10.0	10	0	0	0	0.0
12.0	10	0	0	0	0.0
15.0	10	0	0	0	0.0
20.0	10	0	0	0	0.0

The results of the experiment performed on the Sinchon-I strain by the same procedure as on the Oregon-R strain is presented in Table 3 and Figure 2. The trend of the inhibitory effect of MSG on the development of Sinchon-I is similar to that of Oregon-R except that the  $F_1$  flies of Sinchon-I are produced much more than of Oregon-R. This may be interpreted such that the Oregon-R strain has been inbred in the laboratory for a quite long period of time, resulting in lower productivity and viability as compared with the Sinchon-I strain which was captured recently and has been raised in the laboratory for a not so long period of time.

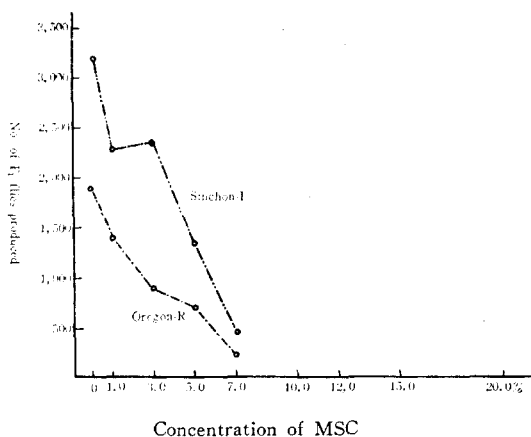


Fig. 2. Numbers of  $F_1$  flies of Oregon-R and sinchon-I produced from the MSG media listed in Table 2 and Table 3.

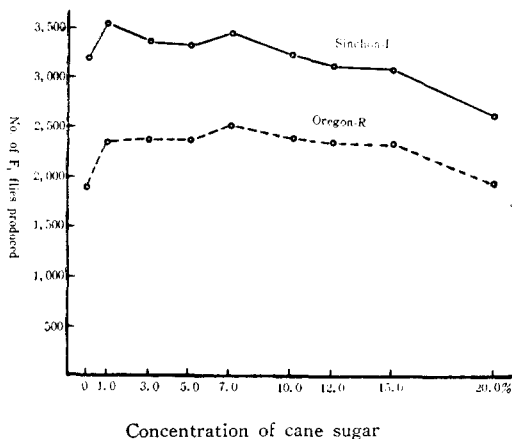
Table 4. Effects of cane sugar on the development of Oregon-R of *D. melanogaster*

Conc. of sugar (%)	No. of vials	Total no. of $F_1$ flies produced			Average no. of $F_1$ flies per vial
		Male	Female	Total	
0.0	10	939	936	1875	187.5
1.0	10	1198	1139	2337	233.7
3.0	10	1157	1218	2375	237.5
5.0	10	1180	1161	2341	234.1
7.0	10	1301	1215	2516	251.6
10.0	10	1157	1224	2381	238.1
12.0	10	1316	1046	2362	236.2
15.0	10	1090	1246	2336	233.6
20.0	10	932	1005	1937	193.7

In order to see if MSG affected only quantitatively on the development of the flies, the second control was set up and the effect of cane sugar was examined by the same procedure as used in the experiment of MSG effect. The results are shown in Table 4, 5, and Figure 3. The numbers of  $F_1$  adult flies produced from the cane sugar media show no considerable decrease but rather constant values as the concentrations of cane sugar increase and the average number of  $F_1$  adults in the second control is a little greater than in the first control (0.0%). This tendency appears in both strains, Sinchon-I and Oregon-R but the numbers of  $F_1$  adult flies in the former strain are greater than in the latter which may be due

**Table 5.** Effects of cane sugar on the development of Sinchon-I of *D. melanogaster*

Conc. of sugar (%)	No. of vials	Total no. of F <sub>1</sub> flies produced			Average no. of F <sub>1</sub> flies per vial
		Male	Female	Total	
0.0	10	1688	1483	3171	317.1
1.0	10	1895	1608	3503	350.3
3.0	10	1776	1569	3345	334.5
5.0	10	1778	1553	3331	333.1
7.0	10	1744	1698	3442	344.2
10.0	10	1722	1504	3226	322.6
12.0	10	1505	1610	3115	311.5
15.0	10	1470	1627	3097	309.7
20.0	10	1277	1383	2660	266.0

**Fig. 3.** Numbers of F<sub>1</sub> flies or Oregon-R and Sinchon-I produced from the cane sugar media listed in Table 4 and Table 5.

to the difference in the length of inbreed period, as interpreted above. The result of the experiment with the second control implies that cane sugar enhances rather than inhibits the development of *D. melanogaster*. This is well manifested in Figure 4 and 5. Thus it is possible to say that MSG inhibits qualitatively the development of the flies.

average numbers of F<sub>1</sub> flies produced are significantly different among the concentrations of MSG, also confirmed by the analysis of variance ( $F=10.74$ ,  $n_1=4$ ,  $n_2=4$ ,  $p<0.05$ ). On the other hand, the numbers of F<sub>1</sub> flies produced from the cane sugar media are almost constant as the concentrations of it decrease as confirmed by the statistical analysis ( $F=5.05$ ,  $n_1=8$ ,  $n_2=8$ ,  $p<0.05$ ) and evidently cane sugar has an enhancing effect rather than an inhibitory one on the development of the flies. And the numbers of F<sub>1</sub> flies are significantly different between the two strains, Oregon-R and Sinchon-I. Analysis of variance also indicates significant difference in not only the MSG medium ( $F=15.95$ ,  $n_1=1$ ,  $n_2=4$ ,  $p<0.05$ ) but also the cane sugar medium ( $F=224.35$ ,  $n_1=1$ ,  $n_2=8$ ,  $p<0.01$ ) This difference was interpreted above.

Many investigations of the effects of the various chemicals on the development

To sum up the results of the present experiments, as presented in Table 6 and Figure 6, MSG has an inhibitory effect on the development of the flies and the

of drosophilid flies were carried out by many workers (Miyoshi 1961, Miyoshi & Nakamura 1968, Kang *et al*, 1970, Chung & Kang 1971 a,b, 1972, Kang 1971, 1972, Chung 1972—on NaCl; Miyoshi 1961, Kang 1972—on KCl; Chung 1973—on GA<sub>3</sub> and IAA; Turner & Wright 1971, Forman & Majumdar 1971, De la Rosa *et al* 1972—on MSG; Forman & Majumdar 1971—on sucrose). Most of the investigations listed above resulted such that the chemicals (NaCl, KCl, GA<sub>3</sub>, IAA, and MSG) exhibited the inhibitory effects on the development of *Drosophila melanogaster* as the concentrations of the chemicals increased. This is agreed with the result of the present experiment on the MSG media but it is noticeable that only the cane sugar promotes rather than inhibits the development of the flies as appeared in the result of the present experiment. The results of the above investigations indicated no significant difference among the strains of the flies. This seems to be contrary to the findings in the present experiment that the numbers of F<sub>1</sub> flies of the Sichon-I strain are greater than of the Oregon-R strain and this difference was interpreted above.

Turner & Wright(1971) reported that 1% and 3% solutions of MSG caused no change in the development and Forman & Majumdar(1971) indicated that 0.7M (about 10.0%) solution of MSG showed an inhibitory effect on the development of

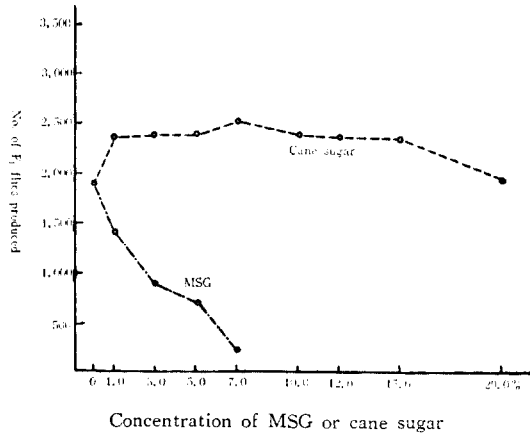


Fig. 4. Numbers of F<sub>1</sub> flies of Oregon-R produced from the MSG and the cane sugar media listed in Table 2 and Table 4.

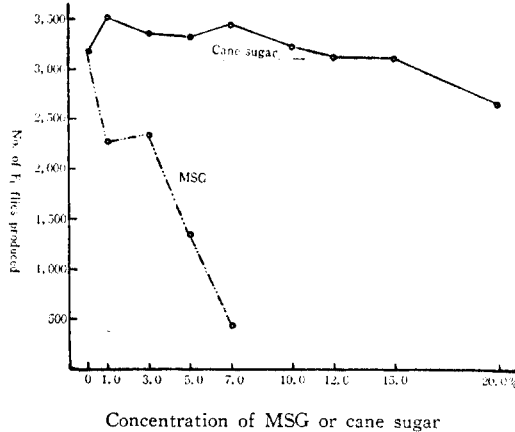
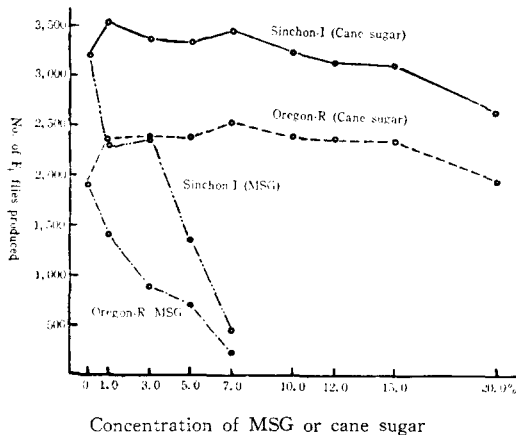


Fig. 5. Numbers of F<sub>1</sub> flies of Sinchon-I produced from the MSG and the cane sugar media listed in Table 3 and Table 5.

**Table 6.** Effects of MSG and cane sugar on the development of Oregon-R and Sinchon-I of *D. melanogaster*

Conc. (%)	Total no. of F <sub>1</sub> flies produced			
	MSG		Cane sugar	
	Oregon-R	Sinchon-I	Oregon-R	Sinchon-I
0.0	1875	3171	1875	3171
1.0	1389	2262	2337	3503
3.0	870	2368	2375	3345
5.0	692	1351	2341	3331
7.0	210	429	2516	3442
10.0	0	0	2381	3226
12.0	0	0	2362	3115
15.0	0	0	2336	3097
20.0	0	0	1937	2660

**Fig. 6.** Numbers of F<sub>1</sub> flies of Oregon-R and Sinchon-I produced from the MSG and the cane sugar media listed in Table 6.

the flies and they pointed out that it was possible to be a threshold point somewhere between 3% and 10% solutions (approximately 0.7 M) at which the chemicals produced an effect on the flies. The result of the present experiment shows that no F<sub>1</sub> flies are produced from the media of 7.0% or more concentrations of MSG. Thus the threshold point may be 7.0% MSG

The Muller-5 test was undertaken to determine the mutagenic activity of MSG. Ten Oregon-R males were sampled from the media of 10.0% MSG and the flies were tested for sex-linked recessive lethal mutations, giving the neg-

ative results. De la Rosa *et al* (1972) performed an experiment to determine the action of MSG as a radioactive substance on *Drosophila melanogaster*, as well as its mutagenic effect. As the results, the MSG effect on nondisjunction was observed only at the highest concentration assayed (0.8%) and X chromosome loss was observed after feeding with 0.4% MSG concentration but none of them was found to be significant. The Muller-5 test made in the present experiment also shows a negative result. Thus the evidence of the mutagenic activity of MSG in the drosophilid flies has not been manifested yet.

How MSG affects physiologically on the development of the flies is not known. This must be investigated somehow in future.



### SUMMARY

Monosodium glutamate(MSG) is a widely used food additive. Some reports described its positive effect and the others, negative effect on mouse, monkey, human or drosophilid flies. Because of the conflicting reports the present investigation was undertaken to study the effects of MSG on the development of *Drosophila melanogaster*. The two strains of *D. melanogaster*, Oregon-R and Sinchon-I were used and MSG as well as cane sugar (as the second control) media were prepared by adding MSG or cane sugar at various concentrations to the standard food media for the present study. Ten flies (Male 5, Female 5) were placed in each vial and the numbers of F<sub>1</sub> flies emerged from it were counted.

The results are presented below:

1. The numbers of F<sub>1</sub> flies decrease as the concentrations of MSG increase, implying that MSG has an inhibitory effect on the development of *D. melanogaster*.
2. The effects of cane sugar show an enhancing effect rather than an inhibitory one
3. The numbers of F<sub>1</sub> flies produced in the Sinchon-I strain are greater than in the Oregon-R. This may be due to the difference in the length of inbred period.
4. The Muller-5 test shows a negative result, suggesting that MSG may be not mutagenic.

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