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# Effects of monosodium glutamate on the pollen grains of two cytotypes of *Urginea indica* Kunth

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**Abstract**

In the present investigation, the pollens of two cytotypes of *Urginea indica* Kunth were used to evaluate the genotoxic effects of a food additive, Monosodium Glutamate (MSG). At the higher concentration treatment of MSG, the pollen morphology of both the cytotypes was reported to show significant variations when compared to control. Moreover, the percentage pollen fertility decreased with the increase in concentrations. The result thus, revealed the genotoxic and mutagenic properties of Monosodium Glutamate on cytotypes of *Urginea indica* Kunth.

**Keywords:** *Urginea indica* Kunth, Monosodium Glutamate, pollen fertility, pollen sterility, genotoxic effects

## Introduction

Monosodium Glutamate (MSG), a food additive, is used widely to enhance the flavor of several food items. It is a sodium salt ($C_5H_8NNaO_4$) of the naturally occurring L-form of glutamic acid which provides a flavoring function similar to naturally occurring free glutamate in foods (Yamaguchi and Ninomiya, 2000). It is due to the special taste, that MSG holds, its consumption rate is very high in food industry. Human exposure to this chemical is thus, very frequent. Nevertheless, the safety of Monosodium Glutamate consumption is a controversial issue as there is a general belief that it has adverse effects on human health, but so far, there is no evident acceptance that it can have toxic effects on human health. Although there are considerable reports showing the adverse effects of MSG on human health, proper assessment of this controversial food additive is decisive.

Few researches are there which has been carried out to find out the cytotoxic and genotoxic effects of Monosodium Glutamate using the plant systems. Genotoxicity test are basically designed to determine the changes caused in the genetic material of the species involved, by the chemical used. These results are usually taken as indicators of mutagenic effects. Although, chemical mutagens have different effects on plant and animal assays, but, results of plant bioassays can reveal potential health hazards in humans.

In this research work, two cytotypes of *Urginea indica* Kunth were selected. This plant belongs to Liliaceae family, which is considered to be one of the richest families, constituting a variety of forms, basically having a very simple, easily distinct pattern

of growth. Moreover, the species of this family are much important for their medicinal value. *Urginea indica* Kunth is an important medicinal plant used widely to cure innumerable human ailments. Bulbs of this plant is used extensively as an expectorant, cardiac stimulant, in treating rheumatism, dropsy, gout, asthma, skin troubles and as anticancer agent. *Urginea indica* Kunth collected from different ecotypes shows great variations in morphological characters as well as karyotype.

This study involves the comparative assessment of the effects of Monosodium Glutamate on the pollen grains of two cytotypes of *Urginea indica* Kunth. The main objective of this research was to investigate the genotoxic effects of Monosodium Glutamate.

**Materials and methods**

Bulbs of two cytotypes of *Urginea indica* Kunth were collected from Birsa Agriculture University, Ranchi, Jharkhand. Two cytotypes of *Urginea indica* Kunth used in this research work were named as:

(i) *Urginea indica* Kunth Cytotype I
(ii) *Urginea indica* Kunth Cytotype II

A food additive, Monosodium Glutamate (MSG) was used to treat the two cytotypes of *Urginea indica* Kunth. MSG is widely used as a flavor enhancer of many foods and is commonly called 'Ajinomoto'. It's a white odorless crystalline powder that is soluble in water and alcohol.

Five concentrations of Monosodium Glutamate (MSG) viz., 0.1g/l, 0.2g/l, 0.3g/l, 0.4g/l and 0.5g/l were prepared under aseptic conditions. Fresh and healthy *Urginea indica* Kunth bulbs of uniform size of the two cytotypes of *Urginea indica* Kunth, Cytotype I and Cytotype II, were treated with different concentrations of Monosodium Glutamate (MSG) for six hours. The control and the treated bulbs were grown in the experimental plots in the randomized block design.

Pollen studies were performed from flowers of both the cytotypes of *Urginea indica* Kunth raised from the bulbs treated with Monosodium Glutamate (MSG). Pollen fertility was determined from the acetocarmine stainability test (Kihara, 1958).Stained pollen grains were considered to be fertile and unstained one as sterile. The percentage pollen fertility and sterility was determined by the formulae:

$$\text{Percentage Pollen Fertility} = \frac{\text{Number of Fertile Pollens}}{\text{Total Number of Pollens studied}} \times 100$$

$$\text{Percentage Pollen Sterility} = \frac{\text{Number of Sterile Pollens}}{\text{Total Number of Pollens studied}} \times 100$$

Shape of the pollen grains of treated flowers were determined by using Erdtman, 1952table based on the relation between polar axis and equational axis (P/E) of the pollen grains of both the cytotypes of *Urginea indica* Kunth.

**Results**

In this research work, an attempt has been made to find out the cytotoxic and genotoxic effects of Monosodium Glutamate (MSG) on pollens of the two cytotypes of *Urginea indica* Kunth,as any such result give an indication of mutagenic properties.

The statistical data related to the cytotaxonomical effects of Monosodium Glutamate (MSG) on the two cytotypes of *Urginea indica* Kunth are depicted in the table1 to 4; fig.1 to 10.

The polar diameter and equatorial diameter of pollen grains were measured to determine the shape of pollen grains. In *Urginea indica* Kunth Cytotype I and Cytotype II, shape of pollen grains were reported sub-prolate and oblate spheroidal respectively in control which was reported to change with increase in the concentrations (table 1-2; fig.3-4, 7-8).

Similarly, percentage pollen fertility was reported to decrease while percentage pollen sterility increased in a dose dependent manner in both the cytotypes of *Urginea indica* Kunth after treatment. In *U. indica* Cytotype I and Cytotype II, percentage pollen fertility was reported 85.025% and 83.007% respectively in control which decreased with the increase in concentration (table 3, 4; fig.1-2, 5-6, 9-10). In contrast, the percentage pollen sterility increased in a dose dependent manner after treatment with different concentrations in both the cytotypes of *Urginea indica* Kunth.

When both the cytotypes of *Urginea indica* Kunth were compared after treatment, Cytotype II was reported to show comparatively higher percentage pollen sterility and lower percentage pollen fertility at the highest concentration (table 3-4; fig. 1-10).

**Table 1: Pollen morphology in *Urginea indica* Kunth Cytotype I after treatment with different concentrations of Monosodium Glutamate (MSG).**

| Concentration | Pollen Grains | | | |
|---|---|---|---|---|
| | Polar Diameter (P) µ | Equatorial Diameter (E) µ | P/E | Shape |
| Control | 33.5 ± 0.830 | 26.3 ± 1.219 | 1.3 ± 0.583 | Sub prolate |
| 0.1% | 27.7 ± 1.065 | 23.5 ± 0.769 | 1.2 ± 0.189 | Sub prolate |
| 0.2% | 34.0 ± 1.092 | 21.6 ± 0.250 | 1.6 ± 0.107 | Prolate |
| 0.3% | 34.3 ± 0.420 | 27.4 ± 0.643 | 1.3 ± 0.222 | Sub prolate |
| 0.4% | 36.1 ± 1.329 | 23.4 ± 0.628 | 1.5 ± 0.119 | Prolate |
| 0.5% | 36.9 ± 1.349 | 22.2 ± 0.365 | 1.7 ± 0.373 | Prolate |

**Table 2: Pollen morphology in *Urginea indica* Kunth Cytotype II after treatment with different concentrations of Monosodium Glutamate (MSG).**

| Concentration | Pollen Grains | | | |
|---|---|---|---|---|
| | Polar Diameter (P) µ | Equatorial Diameter (E) µ | P/E | Shape |
| Control | 37.5 ± 0.688 | 37.5 ± 0.831 | 1.0 ± 0.801 | Oblate spheroidal |
| 0.1% | 32.9 ± 0.983 | 28.1 ± 0.244 | 1.2 ± 1.076 | Sub prolate |
| 0.2% | 34.3 ± 0.895 | 27.2 ± 0.286 | 1.3 ± 0.543 | Sub prolate |
| 0.3% | 35.9 ± 1.222 | 35.1 ± 0.281 | 1.0 ± 0.878 | Oblate spheroidal |
| 0.4% | 39.7 ± 1.018 | 37.8 ± 0.286 | 1.1 ± 0.999 | Prolate spheroidal |
| 0.5% | 39.9 ± 1.261 | 35.7 ± 0.493 | 1.1 ± 0.123 | Prolate spheroidal |

**Table 3: Percentage Pollen Fertility and Percentage Pollen Sterility in *Urginea indica* Kunth Cytotype I after treatment with different concentrations of Monosodium Glutamate (MSG).**

| Concentration | Total No. of Pollen grains studied | No. of fertile pollen grains | Percentage Fertility (%) | No. of sterile pollen grains | Percentage Sterility (%) |
|---|---|---|---|---|---|
| Control | 808 | 687 | 85.025 | 121 | 14.975 |
| 0.1% | 894 | 683 | 76.398 | 211 | 23.602 |
| 0.2% | 878 | 632 | 71.982 | 246 | 28.018 |
| 0.3% | 846 | 584 | 69.031 | 262 | 30.969 |
| 0.4% | 871 | 557 | 63.949 | 314 | 36.051 |
| 0.5% | 806 | 484 | 60.050 | 322 | 39.950 |

**Table 4: Percentage Pollen Fertility and Percentage Pollen Sterility in *Urginea indica* Kunth Cytotype II after treatment with different concentrations of Monosodium Glutamate (MSG).**

| Concentration | Total No. of Pollen grains studied | No. of fertile pollen grains | Percentage Fertility (%) | No. of sterile pollen grains | Percentage Sterility (%) |
|---|---|---|---|---|---|
| Control | 818 | 679 | 83.007 | 139 | 16.993 |
| 0.1% | 897 | 664 | 74.025 | 233 | 25.975 |
| 0.2% | 846 | 567 | 67.021 | 279 | 32.979 |
| 0.3% | 879 | 580 | 65.984 | 299 | 34.016 |
| 0.4% | 852 | 503 | 59.038 | 349 | 40.962 |
| 0.5% | 819 | 467 | 57.021 | 352 | 42.979 |

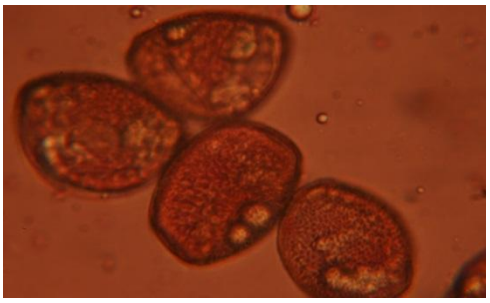

**Fig. 1: Fertile Pollen grains**

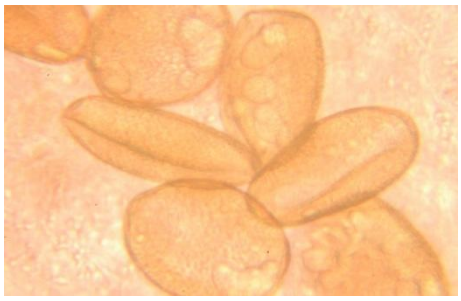

**Fig. 2: Sterile Pollen grains**

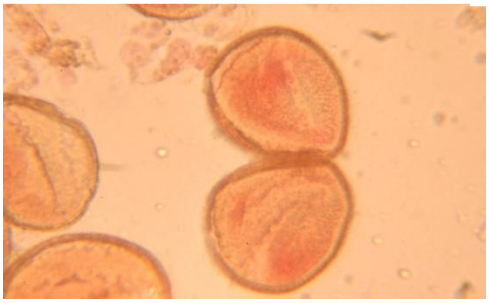

**Fig. 3: Distorted pollen grains**

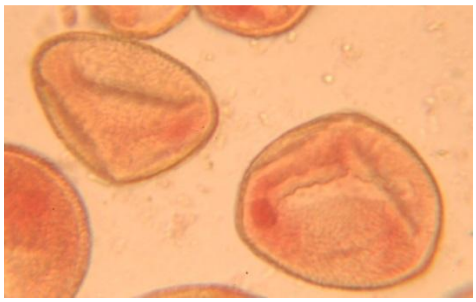

**Fig. 4: Triangular shaped pollen grains**

**Figures 1-4: Photomicrographs showing abnormalities in the pollen grains of the *Urginea indica* Kunth Cytotype I after treatment with different concentrations of Monosodium Glutamate (MSG).**

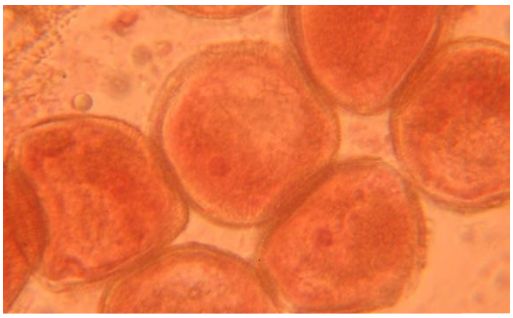

**Fig. 5: Fertile Pollen grains**

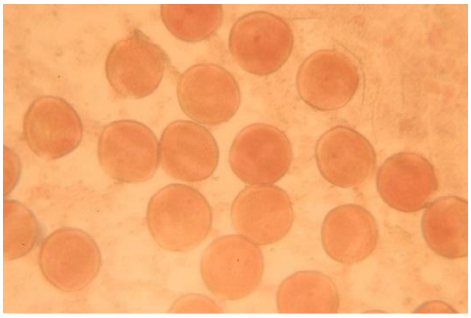

**Fig. 6: Sterile Pollen grains**

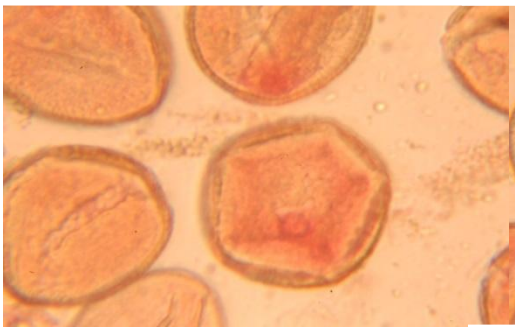

**Fig. 7: Hexagonal Pollen Grain**

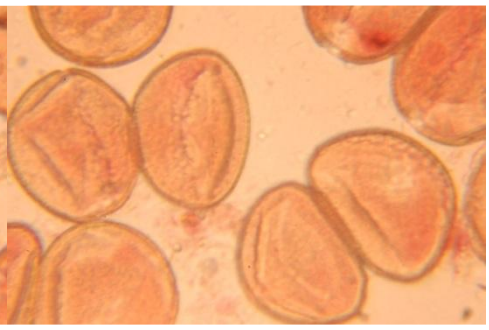

**Fig. 8: Distorted Pollen grains**

**Figures 5-8: Photomicrographs showing abnormalities in the pollen grains of *Urginea indica Kunth* Cytotype II after treatment with different concentrations of Monosodium Glutamate (MSG).**

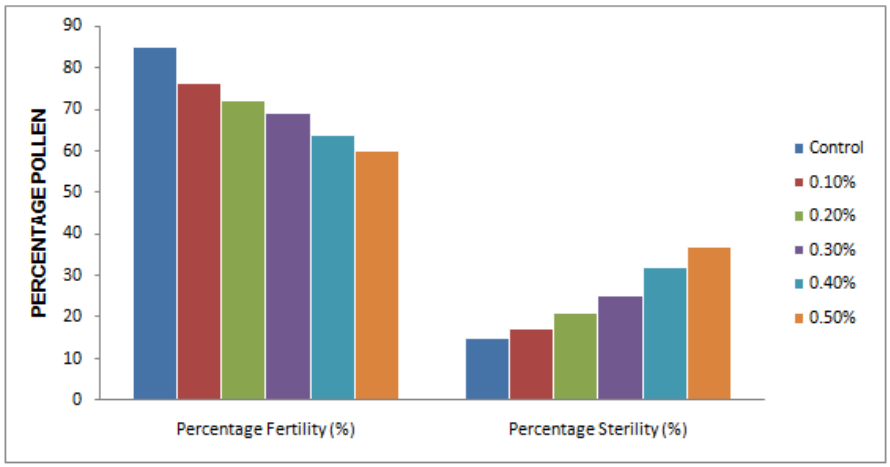


**Figure 9: Column graph showing Percentage Pollen Fertility and Percentage Pollen Sterility in *Urginea indica* Kunth Cytotype I after treatment with different concentrations of Monosodium Glutamate (MSG).**

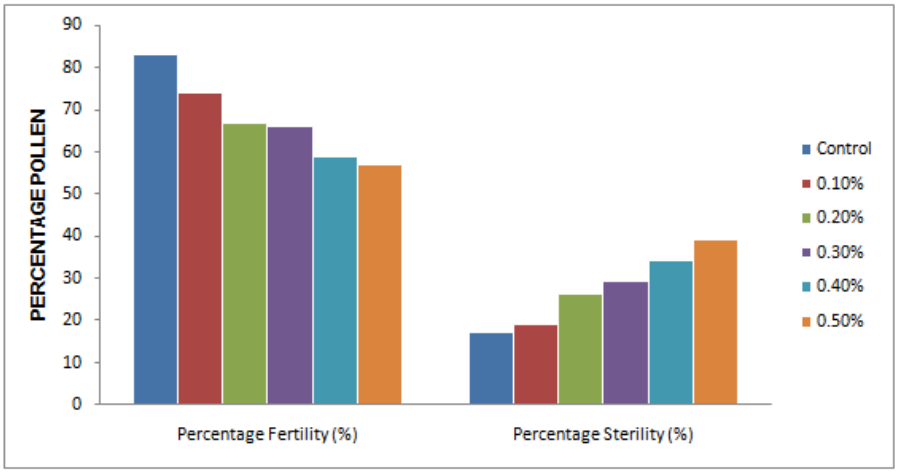


**Figure 10: Column graph showing Percentage Pollen Fertility and Percentage Pollen Sterility in *Urginea indica* Kunth Cytotype II after treatment with different concentrations of Monosodium Glutamate (MSG).**

## Discussion

Treatment with the different concentrations of Monosodium Glutamate on the two cytotypes of *Urginea indica* Kunth revealed that with the increasing concentrations, size as well as shape of the pollen grains changed. Moreover, percentage pollen fertility also reduced in a dose dependent manner. The changes induced by mutagensin the shape, size and other properties of pollen grains are caused by the irregular or abnormal meiosis, as the structure and physiology of pollen grains is under genetic control (Abel, 1970; Vanhof and Harder, 1995).It was also noticed that the increase or decrease in size of pollen grains was not in linear fashion. But the pollen grains were reported to show variations in their shape.

Significant decrease in the percentage pollen fertility was observed in both the cytotypes. Decreased pollen fertility with increased mutagenic concentrations might be the result of increase in chromosomal aberrations as well as physiological damages (Bashir et al. 2013). Since the pollen fertility decreased, the percentage pollen sterility increased with the increase in concentrations. This increase in pollen sterility may be due to physiological and genetic damages that are induced by the breakage of chromosomes through the formation of antimetabolic agents in the cell(Bashir et al. 2013). Pollen sterility induced by mutagens is reported as an indicator of an immediate consequence of various aberrations in pollen mother cells due to mutagens used. It is considered as a dependable parameter to find out the mutagenic effects in plants (Azad et al. 2012). The result thus, showed the sensitivity of *Urginea indica* Kunth Cytotype I and II to Monosodium Glutamate.

## Conclusion

Treatment with different concentrations of Monosodium Glutamate showed the variations in the pollen morphology and percentage pollen fertility of *Urginea indica* Kunth Cytotype I and II revealing the potential genotoxic and mutagenic effects of MSG which may lead to similar cytogenic effects in higher organisms.

This research thus showed the mutagenic effects of Monosodium Glutamate (MSG) on the cytotypes of *Urginea indica* Kunth.

**Acknowledgement**

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