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Effect of chronic monosodium glutamate on light-dark adaptation and tight rope suspension test in adult Swiss Albino Mice

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Abstract
Monosodium glutamate (MSG), a widely used flavor enhancer, has raised concerns about potential neurobehavioral impairments, especially with chronic exposure. This study examines the effects of chronic MSG administration on anxiety-like behaviors using the light-dark adaptation test and motor coordination with the tight rope suspension test in Swiss albino mice. Forty male mice were divided into four groups and received MSG (40, 60, or 80 mg/kg) intraperitoneally for 90 days. Results showed dose-dependent anxiety and motor impairments, suggesting that MSG may interfere with emotional and motor functions. These findings underline the importance of regulating long-term dietary MSG intake.

Keywords: Monosodium glutamate, anxiety, motor function, neurotoxicity, Swiss albino mice

Introduction
Monosodium glutamate (MSG) is a sodium salt derived from glutamic acid, widely used as a flavor enhancer since its discovery by Kikunae Ikeda in 1908 [1]. By activating glutamate receptors in the tongue and brain, MSG produces the umami taste, contributing to its popularity in processed foods. However, despite its culinary benefits, concerns about the safety of chronic MSG exposure remain due to potential neurotoxic effects, particularly when consumed at high levels.

Glutamate, as the primary excitatory neurotransmitter in the central nervous system (CNS), plays essential roles in learning, memory, and synaptic plasticity [2]. However, overstimulation of NMDA and AMPA receptors by glutamate can lead to excitotoxicity, a pathological process associated with neuronal damage, which has been implicated in neurodegenerative diseases such as Alzheimer's, Parkinson's, and Huntington's [3, 4]. Research indicates that chronic consumption of MSG can also impair emotional regulation, induce oxidative stress, and disrupt motor coordination by damaging cerebellar pathways [5, 6].

While earlier studies have shown that MSG exposure increases anxiety and affects motor coordination in animals, long-term studies assessing dose-dependent effects on multiple behavioral domains are limited [7, 8]. This study addresses these gaps by evaluating the impact of chronic MSG administration on anxiety-like behaviors and motor function using validated animal models: the light-dark adaptation test and the tight rope suspension test. These models assess emotional disturbances and motor deficits, respectively, providing insights into the neurobehavioral effects of MSG and the potential risks associated with chronic consumption [9, 10].

Methodology
This study involved 40 adult male Swiss albino mice (20–30 g), housed under standard laboratory conditions with a 12-hour light/dark cycle, controlled temperature, and access to food and water ad libitum. Ethical approval for the study was obtained from the Institutional Animal Ethics Committee. The mice were randomly assigned to four groups, and MSG was administered intraperitoneal as follows:

- **Group 1 (Control):** Received 0.5 ml distilled water i.p. daily for 90 days.
- **Group 2:** Received 40 mg/kg MSG i.p. daily for 90 days.

- **Group 3:** Received 60 mg/kg MSG i.p. daily for 90 days.
- **Group 4:** Received 80 mg/kg MSG i.p. daily for 90 days.

Behavioral Tests

Light-Dark Adaptation Test

The light-dark adaptation test evaluates anxiety-like behavior by measuring the animal's preference for dark or illuminated environments. Mice typically avoid bright areas, and an increased time spent in the dark compartment indicates heightened anxiety [9].

Procedure: Each mouse was placed in the illuminated compartment, facing away from the dark section, and allowed to explore for 10 minutes. The time spent in the dark compartment was recorded.

Tight Rope Suspension Test

The tight rope suspension test assesses motor coordination and grip strength. Impaired motor ability results in reduced suspension time [10].

Procedure: Mice were placed on a 50-cm horizontal rope suspended 30 cm above the ground. Each animal was given three trials, and the average suspension time was recorded.

Statistical Analysis

Data were analyzed using one-way analysis of variance (ANOVA), followed by Tukey's post-hoc test for multiple comparisons. A p-value < 0.05 was considered statistically significant.

Results

Light-Dark Adaptation Test

Table 1: Average time spent in the Dark compartment

Group	Average time spent in the dark compartment (in minutes)
Control group	4.1 ± 0.8
40 mg/Kg	5.9 ± 1.1
60 mg/Kg	7.5±1.4
80 mg/Kg	9.8 ±1.2

The results demonstrate a dose-dependent increase in anxiety-like behavior, with the 80 mg/kg group spending significantly more time in the dark compared to the control group ($p < 0.05$).

Tight Rope Suspension Test

Table 2: Average Suspension time in the tight rope suspension apparatus

Group	Average Suspension time (in seconds)
Control group	23.4 ±2.9
40 mg/Kg	19.7 ±2.5
60 mg/Kg	13.2 ±1.9
80 mg/Kg	9.5 ±1.6

Mice treated with higher MSG doses showed impaired motor coordination, with the 80 mg/kg group exhibiting the shortest suspension times ($p< 0.05$).

Discussion

This study demonstrates that chronic exposure to MSG induces dose-dependent anxiety-like behavior and motor impairments in Swiss albino mice. In the light-dark adaptation test, animals exposed to higher doses of MSG spent significantly more time in the dark compartment, indicating heightened anxiety. These findings align with previous studies suggesting that chronic glutamate exposure disrupts emotional regulation by overstimulating NMDA receptors in the hippocampus and amygdala [7]. The overstimulation may cause an imbalance between excitatory and inhibitory neurotransmission, contributing to anxiety-like behavior [8].

Motor impairments observed in the tight rope suspension test further support the neurotoxic effects of MSG. Mice in the 80 mg/kg group exhibited the shortest suspension times, reflecting severe motor coordination deficits. Similar studies have linked glutamate-induced neurotoxicity to disruptions in cerebellar circuits, which are essential for motor control and coordination [10, 11]. Chronic glutamate overexposure likely impairs synaptic transmission in motor pathways, resulting in compromised neuromuscular function [11].

Oxidative stress appears to play a significant role in MSG-induced neurotoxicity. Chronic MSG administration has been reported to increase reactive oxygen species (ROS) production, causing neuronal damage and impairing mitochondrial function [12]. The cumulative effect of oxidative stress and excitotoxicity exacerbates behavioral and motor impairments, as observed in the current study [13]. Furthermore, metabolic complications such as insulin resistance, often associated with prolonged MSG exposure, may contribute to cognitive decline and behavioral disturbances [6, 14].

Although regulatory bodies, including the FDA and WHO, classify MSG as safe, the results of this study highlight potential risks associated with chronic consumption. The dose-dependent nature of the observed impairments underscores the need for further research on the long-term effects of MSG on human behavior and motor function [15]. Future investigations should explore the molecular mechanisms underlying these effects and evaluate therapeutic interventions to mitigate MSG-induced neurotoxicity.

Summary

This study demonstrates that chronic MSG exposure induces anxiety-like behavior and motor impairments in Swiss albino mice. Results from the light-dark adaptation test indicate increased anxiety at higher MSG doses, while the tight rope suspension test shows significant deficits in motor coordination. These findings raise concerns about the neurobehavioral risks of prolonged MSG consumption.

Conclusion

Chronic exposure to MSG results in dose-dependent anxiety and motor impairments, highlighting potential neurobehavioral risks. Further research is needed to explore the mechanisms underlying these effects and assess whether similar outcomes occur in humans. Public health initiatives should consider these findings when establishing guidelines for MSG consumption.

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