

V.A. Synenko, G.A. Yeroshenko, K.V. Shevchenko, O.V. Klepets, A.S. Grygorenko,
V.M. Sokolenko, N.M. Sharlay
Poltava State Medical University, Poltava

THE CURRENT ISSUES ON THE IMPACT OF MONOSODIUM GLUTAMATE FOOD ADDITIVE ON THE VISUAL ORGAN AND THE HUMAN BODY

e-mail: gala_umsa@ukr.net

To investigate the impact of monosodium glutamate on the visual organ, specifically on the posterior segment of the eye, and the body as a whole, as how regular consumption of such an additive can affect health over time. The analysis of scientific data on the impact of monosodium glutamate on the retina of the eye, aimed at better understanding the potential risks and mechanisms of action of this substance. Particular attention is given to studying the mechanisms of monosodium glutamate's neurotoxicity, its effects on photoreceptors and retinal ganglion cells, as well as the potential long-term consequences of excessive consumption of this food additive. Analytical research methods were used in the writing of the article. The literature data on the use of monosodium glutamate in food products and its effects on the retina of the eye and the body as a whole have been analyzed and summarized. Determining the degree of negative impact of the food additive on the retina will enable timely prevention and detection of retinal damage, which, in turn, will help prevent vision loss in the patient.

Key words: monosodium glutamate, retina, fast food, food additive, diabetes mellitus, age-related macular degeneration.

В.А. Синенко, Г.А. Єрошенко, К.В. Шевченко, О.В. Клепець, А.С. Григоренко,
В.М. Соколенко, Н.М. Шарлай

АКТУАЛЬНІ ПИТАННЯ ВПЛИВУ ХАРЧОВОЇ ДОБАВКИ ГЛУТАМАТУ НАТРІЮ НА ОРГАН ЗОРУ ТА ОРГАНІЗМ ЛЮДИНИ

Метою роботи було дослідити вплив глутамату натрію на орган зору, зокрема на задній сегмент ока, та організм у цілому, а також те, як регулярне споживання такої добавки може впливати на здоров'я з часом. Проведений аналіз наукових даних, щодо впливу глутамату натрію на сітківку ока, для кращого розуміння потенційних ризиків та механізмів дії цієї речовини. Особливу увагу приділено вивченню механізмів нейротоксичності глутамату натрію, його впливу на фоторецептори та гангліозні клітини сітківки, а також можливим довгостроковим наслідкам надмірного споживання цієї харчової добавки. У написанні статті використовувалися аналітичні методи дослідження. Проаналізовано та узагальнено дані літератури щодо використання глутамату натрію у харчових продуктах і його вплив на сітківку ока та організм у цілому. Визначення ступеня негативного впливу харчової добавки на сітківку дозволить своєчасно запобігти та виявити пошкодження сітківки, що, у свою чергу, допоможе уникнути втрати зору у пацієнта.

Ключові слова: глутамат натрію, сітківка, фастфуд, харчова добавка, цукровий діабет, вікова макулярна дегенерація.

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Food additives encompass a wide range of chemical substances or natural compounds that are added in limited quantities to food products during production, packaging, transportation or storage to impart certain desired properties. The use of food additives in products is permitted provided that, based on available scientific data, their use does not pose a threat to consumer health, is technologically justified, and does not mislead the consumer.

The use of dietary supplements has been a common practice throughout human history. Even in prehistoric times, people used a variety of herbs, vinegar, table salt, pepper, and other spices in cooking. However, in the second half of the 20th century, the introduction of food additives became a more systematic process in the food industry [2].

By 2019, the use of 300 food additives had been permitted in Ukraine. For example, 3,000 tons of monosodium glutamate appear on the Ukrainian market each year [2]. It is difficult to find semi-finished or ready-made products produced industrially that do not contain this additive. Data on the use of food additives indicate that E621 additive is used more frequently in Ukraine than in European countries [10].

Currently, diets have shifted from natural products to fast food, ready-made snacks, sweet carbonated drinks, and low-alcohol beverages. This change has occurred due to the convenience, accessibility, and pleasant taste of these products.

Recently, complex food additives have become widespread, as they enhance the flavor of products and are economically efficient during their production. At the same time, they consist of combinations of additives that serve the same or different technological purposes.

Monosodium glutamate (E 621) is a salt of glutamic acid, a natural amino acid found in many food products. It is one of the most commonly used food additives in the food industry to enhance flavor.

Monosodium glutamate, primarily used to enhance the natural flavor of food, works by increasing the sensitivity of taste receptors, making the taste more pronounced and appealing [4]. This not only improves the overall flavor profile of a dish but also allows manufacturers to mask any defects in raw materials and restore flavors that may have been lost during storage or processing [19]. Additionally, its stability during cooking and high solubility in water make it an invaluable ingredient in a wide range of products [8].

Discovered in 1908 by Japanese chemist Kikunae Ikeda, this flavor enhancer quickly gained popularity due to its ability to impart a distinctive umami taste to dishes, enhancing their appeal and flavor quality [6].

In the food industry, monosodium glutamate is used to enhance the flavor of products. It is particularly popular in items that require flavor enhancement, such as snacks, meat products, ready-made soups, sauces, and frozen meals. Monosodium glutamate helps increase the appeal of low-calorie and low-fat products, making them tastier without adding large amounts of salt or sugar.

Additionally, it is used in the production of spices and seasonings added to various dishes to enhance flavor. Its use allows manufacturers to reduce production costs, as fewer expensive ingredients are needed to achieve the desired taste. Monosodium glutamate is also widely used in fast food and processed products, where maintaining a consistent taste and quality over extended periods is essential.

However, despite its widespread use, monosodium glutamate raises significant concerns regarding potential health impacts. One of the main areas of concern is its possible effect on the central nervous system and the visual organs, particularly the retina of the eye [12].

Monosodium glutamate is often used in combination with other food additives that also enhance flavor and preserve products. However, the synergistic effects of different food additives can have unpredictable health consequences.

Some studies suggest a potential increased risk of developing metabolic disorders, such as obesity, diabetes mellitus and cardiovascular diseases, especially when monosodium glutamate is consumed in large amounts along with other flavor enhancers and preservatives [11, 15].

For example, the combination of monosodium glutamate with high-calorie foods can increase appetite and contribute to overeating, which raises the risk of obesity. It is known that the synergistic effect of glutamate with other additives can amplify their impact on the body, necessitating further research to understand all potential risks [23]. Some studies also suggest that glutamate may affect glucose and lipid metabolism, which could have negative health consequences in the long term.

Despite its widespread use as a flavor enhancer in food products, concerns have arisen about the potential negative effects of excessive monosodium glutamate consumption, particularly regarding retinal health. Research has shown a connection between high glutamate intake and an increased incidence of glaucoma. For example, studies indicate that a significant portion of the Asian population, which traditionally consumes a diet high in monosodium glutamate, exhibits a higher prevalence of glaucoma compared to populations with lower glutamate consumption [11]. This correlation suggests that while monosodium glutamate enhances the flavor of food, it may also pose a risk to retinal cells, either directly affecting the cells or indirectly impacting overall eye health.

Research has investigated the impact of monosodium glutamate on pregnant women who include fast food and sweet carbonated drinks in their daily diet at various stages of pregnancy. It has been demonstrated that if a pregnant woman consumes products containing monosodium glutamate, this substance can cross the blood-brain barrier, potentially affecting the fetal nervous system and negatively influencing the development of the visual organs [23].

The research [13, 14] report that with age, individuals become more sensitive to the effects of monosodium glutamate, which increases the risk of developing glaucoma. Studies [7, 14] show that regular consumption of sweets, baked goods, and sauces containing monosodium glutamate increases the risk of developing and progressing age-related macular degeneration, as well as contributing to obesity and type 2 diabetes mellitus. Further research [7, 16] reveals that consuming fast food, frozen pizza, packaged cookies, and energy bars containing monosodium glutamate increases the risk of vascular damage to the eye, leading to reduced vision. Additionally, other studies [16, 22] indicate that monosodium glutamate has a negative impact on the visual organs by causing irreversible changes in the optic nerve, leading to vision loss and increasing the likelihood of developing glaucoma, a condition that threatens blindness.

Some studies have noted [9, 20] that systematic consumption of products containing monosodium glutamate can disrupt hormonal balance and lead to digestive issues [9], including gastritis and stomach

ulcers. Additionally, research [20, 21] suggests that continuous intake of monosodium glutamate may result in disturbances in cerebral circulation and could potentially contribute to conditions such as Alzheimer's and Parkinson's diseases.

In addition to clinical studies, experimental research has also been conducted on the effects of monosodium glutamate on animal organisms.

The neurotoxic effects of monosodium glutamate (MSG) on the retina have been the subject of significant scientific research, particularly in animal studies. Research in rats has demonstrated notable results; for example, rats administered with MSG solution exhibited significant retinal thinning and those fed a diet containing 20 % MSG experienced vision loss along with further retinal thinning [17]. This indicates a profound impact of MSG on retinal health, possibly due to its interaction with glutamate receptors on retinal cells. These glutamate-bound receptors reduce the ability of cells to conduct electrical signals, which may explain the observed vision disturbances [1]. Moreover, high levels of MSG in the intraocular fluid are implicated in retinal cell damage, leading to secondary reactions that further compromise retinal integrity [1]. These findings highlight the potential neurotoxic effects of MSG on the retina, underscoring the need for caution in its dietary consumption.

High doses of monosodium glutamate can cause retinal cell damage through mechanisms related to oxidative stress and apoptosis. For instance, studies in mice have shown that injections of monosodium glutamate lead to a significant reduction in the thickness of the inner nuclear layer (INL) and the inner plexiform layer (IPL) of the retina. These changes suggest that glutamate may induce neurodegenerative processes in the retina, potentially leading to vision disturbances [3, 18].

Excessive consumption of monosodium glutamate can lead to the degeneration of photoreceptors and ganglion cells in the retina. This is associated with increased intracellular calcium levels in retinal cells, which triggers oxidative stress and initiates the apoptosis process.

Oxidative stress occurs in the imbalance between the production of free radicals and the body's ability to neutralize them. Monosodium glutamate can induce oxidative stress, leading to retinal cell damage. Elevated calcium levels in cells, caused by glutamate, activate a cascade of events leading to apoptosis, or programmed cell death. This is particularly dangerous for photoreceptors and ganglion cells in the retina, which are crucial for the visual process [11, 15].

Studies have shown that glutamate can induce degenerative changes in these cells. For example, animal experiments revealed that excessive consumption of monosodium glutamate leads to a reduction in the expression of key receptors such as NMDAR2A and GluR2, which critically affects retinal function [3, 23].

A reduction in receptor expression and retinal cell damage can lead to serious vision impairments. For example, research has shown that glutamate can affect photoreception processes and nerve impulse transmission. This may result in visual dysfunctions, including decreased visual acuity and other visual anomalies [13, 18].

Retinal cell damage caused by monosodium glutamate can increase the risk of developing degenerative diseases such as age-related macular degeneration and glaucoma. Research indicates that chronic consumption of high doses of glutamate may contribute to the progression of these conditions due to ongoing oxidative stress and inflammatory processes in the retina.

To fully understand the risks associated with monosodium glutamate consumption, additional research is needed, focusing on: Long-term clinical studies in humans. Long-term clinical studies are essential to determine the chronic effects of glutamate on the retina. These studies will help establish the relationship between glutamate consumption and the development of degenerative eye diseases. It is crucial that these studies include diverse population groups, such as children, the elderly, and individuals with heightened sensitivity to this additive.

It is important to evaluate the effects of different doses of monosodium glutamate on various population groups. This will help determine safe consumption levels for different categories of people. Studies should consider individual metabolic variations and potential genetic factors that affect sensitivity to glutamate.

Interactive studies with other food additives are necessary to investigate the synergistic effects of monosodium glutamate. Such research will help understand how the combination of different additives can impact retinal health. For example, studies might reveal that combining glutamate with other additives enhances their harmful effects on the retina [5, 18].

Developing new diagnostic and monitoring methods is essential for detecting early signs of retinal damage caused by monosodium glutamate. This will enable timely intervention to prevent the progression of serious diseases. For instance, new biomarkers could be developed to detect the neurotoxic effects of glutamate on the retina at an early stage.

To reduce the risks associated with monosodium glutamate consumption, the following measures are recommended:

Moderate Consumption: Consume monosodium glutamate in moderation. Avoid products with high levels of this additive, especially those consumed regularly.

Balanced Diet: Maintain a balanced diet that includes fresh fruits, vegetables, proteins, and whole grains. This helps reduce the need for flavor enhancers and provides essential nutrients.

Choose Natural Products: Prefer natural products without added monosodium glutamate. Check product labels and choose those that do not contain this additive.

Further Research: Conduct long-term clinical studies on humans to more accurately determine the impact of monosodium glutamate on retinal health. This will help develop specific recommendations for safe levels of consumption.

Educational Programs: Implement educational programs to inform the public about the potential risks associated with excessive consumption of monosodium glutamate and ways to mitigate these risks. Given the existing scientific evidence, it is reasonable to be cautious with monosodium glutamate consumption and adhere to healthy eating recommendations to mitigate potential health risks, particularly concerning retinal health.

Conclusion

The use of certain food additives can be a source of controversy due to differing views among researchers on their potential effects. To fully understand the impact of these additives, thorough experimental and clinical studies are needed, taking into account individual variations in human physiology. Research conducted on both animals and humans has revealed side effects affecting the cardiovascular, gastrointestinal and muscular systems, as well as leading to neurological disorders and the development of glaucoma and age-related macular degeneration, particularly in individuals sensitive to food additives.

According to scientific research, monosodium glutamate (MSG) may have neurotoxic effects on the retina. High doses of this substance can cause damage to retinal cells through mechanisms related to oxidative stress and apoptosis. Moreover, excessive consumption of MSG may lead to the degeneration of photoreceptors and ganglion cells in the retina, potentially contributing to the development of degenerative diseases such as age-related macular degeneration and glaucoma.

To fully understand the risks associated with the consumption of monosodium glutamate, additional research is needed that should take into account the following aspects: long-term clinical studies on humans, assessment of the impact of different doses of glutamate on various population groups, interactive studies with other food additives, as well as the development of new methods for diagnosing and monitoring the condition of the retina to detect early signs of damage caused by monosodium glutamate (Frontiers).

A thorough review of all available scientific sources in leading global databases (Scopus, Web of Science, PubMed) allows us to state that research on the effects of complex food additives on the posterior segment of the eye is quite limited and requires further investigation.

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