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Exploring the Monosodium Glutamate (MSG) and Its Role to Consumption Behaviors Regarding Food Safety

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ABSTRACT

This article explores the role of monosodium glutamate (MSG) in food safety by examining recent research findings and regulatory perspectives. MSG, a commonly used flavor enhancer in processed foods, has been the subject of controversy regarding its safety for consumption. The research encompasses studies on MSG consumption and its potential health effects, metabolism in the body, safety for different population groups, and regulatory assessments by agencies like the U.S. Food and Drug Administration (FDA) and the European Food Safety Authority (EFSA). Despite conflicting findings and public perceptions, scientific evidence suggests that MSG is safe for consumption at current levels found in food products. This article emphasizes the importance of consumer education and regulatory measures in ensuring the safe use of MSG. Further research is needed to address lingering concerns and enhance understanding of MSG's role in food safety.

KEYWORDS

Consumption; Flavor enhancer; Food safety; Monosodium glutamate; Regulatory perspective

1. INTRODUCTION

MSG has been a subject of both fascination and controversy in the realm of food safety. As a widely used food additive, MSG is known for its ability to enhance the flavor of various dishes, particularly in Asian cuisine [1]. However, its reputation has been marred by claims of adverse health effects, leading to debates regarding its safety in food products. MSG is a flavor enhancer commonly used in many processed foods to improve taste and palatability. Despite its widespread use, MSG has been a subject of controversy regarding its safety for consumption [2]. This controversy stems from various studies and public perceptions linking MSG consumption to adverse health effects such as headaches, nausea, and allergic reactions. However, numerous scientific studies have attempted to elucidate the true nature of MSG's effects on health, leading to conflicting findings and ongoing debate.

In recent years, there has been a growing body of research aimed at understanding the relationship between MSG and food safety [3]. These studies have explored the potential health effects of MSG consumption, its metabolism in the body, and its safety for different population groups, including infants, pregnant women, and individuals with certain health conditions. Additionally, regulatory agencies such as the U.S. FDA and the EFSA have conducted comprehensive reviews of MSG safety based on available scientific evidence.

The role of MSG in food safety is a multifaceted issue that warrants in-depth exploration [4]. Despite its widespread use as a flavor enhancer, MSG has been the subject of controversy regarding its potential

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adverse health effects. Understanding the relationship between MSG consumption and food safety requires addressing several key research regarding the negative effect of the MSG substance on the human body.

This article aims to provide an overview of the current scientific understanding of MSG and its relationship to food safety. By examining recent research findings and regulatory perspectives, we will explore the complexities surrounding MSG consumption and its implications for public health. Furthermore, we will discuss the role of consumer education and regulatory measures in ensuring the safe use of MSG in food products.

2. MATERIALS AND METHODS

2.1. Materials

The study was conducted on respondents of 700 questionnaires, distributed electronically to university students in Palestine. The respondents were chosen randomly. Table 1 shows the distribution of respondents according to gender variables.

Table 1. Study sample gender.

Gender	Frequency	Percentage (%)
Male	268	38.3
Female	432	61.7
Total	700	100

2.2. Data Collection

Data collected by defining the research community and determining the number of the representative sample, as well as choosing the technique for collecting the required data by choosing the survey strategy where the questionnaire about some food contain MSG such as (milk, meat, poultry, fish and vegetables) was designed and distributed to the selected sample. The collected data were analyzed and interpreted using the SPSS programs. In the last phase of this process, study results were summarized, in addition to that, conclusions were made based on the results of the study along with the data analysis.

2.3. Reliability Analysis

In order to measure the stability of the questionnaire, the researcher used the equation Cronbach's Alpha by calculating the reliability statistics. The result shows the questionnaire is stable based on the Cronbach's Alpha value in Table 2.

Table 2. Cronbach's Alpha value.

Reliability statistics	
Cronbach's Alpha	N of items
0.897	28

2.4. Analysis of Degree of Impact

The answers from the respondents were analyzed with degree of impact of food consumers habits (Table 3). The classification system categorizes the percentage of individuals engaging in MSG-related habits into five levels of impact to better understand their significance. A percentage below 50% is seen as very low impact, indicating the habit is not widespread. If 50–59.9% engage in the habit, it is considered low impact, while 60–69.9% shows a medium impact, reflecting a growing but not dominant trend. A high impact is assigned to 70–79.9%, suggesting a significant and possibly expanding behavior, and 80% or more is classified as very high impact, indicating a deeply ingrained and widespread habit. This system helps evaluate the prevalence of MSG-related behaviors in a population, guiding research and public health strategies.

Table 3. Degree of impact of food consumers habits associated with MSG.

Percentage (%)	Degree of impact
Less than 50	Very low
From 50–59.9	Low
From 60–69.9	Medium
From 70–79.9	High
80 and over	Very high

3. RESULTS AND DISCUSSION

3.1. Historical Perspective

The use of MSG as a flavor enhancer dates back to the early 20th century when it was first isolated from seaweed by a Japanese chemist, Kikunae Ikeda. MSG gained popularity as a food additive due to its ability to enhance the savory taste known as umami. However, concerns regarding its safety emerged in the mid-20th century, leading to a contentious debate that continues to this day. MSG is the sodium salt of the non-essential amino acid glutamic acid. Glutamic acid is one of the most abundant amino acids found in nature and exists as both free glutamate and bound with other amino acids into protein. Animal proteins may contain about 11 to 22% by weight of glutamic acid, with plant proteins containing as much as 40% glutamate [5]. Thus, glutamate is found in many foods, including tomatoes, mushrooms, peas, and cheeses, where it enhances flavor. As a result of its flavour enhancing effects, glutamate is often deliberately added to foods – either as the purified monosodium salt or as a component of a mix of amino acids and small peptides resulting from the acid or enzymatic hydrolysis of proteins (e.g. Hydrolysed vegetable protein or HVP). Other substances, such as sodium Caseinate and "Natural Flavourings" are also added to many savoury foods and these can contain considerable amounts of free glutamate [6].

3.2. Chemistry of MSG

MSG, or monosodium glutamate, is a sodium salt of glutamic acid, which is one of the most abundant naturally occurring non-essential amino acids [7]. MSG is chemically synthesized by fermenting sugars such as molasses, starch, sugar cane, or sugar beet. The process involves the bacterial fermentation of starches, sugars, or molasses to produce glutamic acid, which is then converted into MSG through neutralization with sodium hydroxide [7]. Chemically, MSG is the sodium salt of glutamic acid and has the chemical formula $C_5H_8NNaO_4$ (Figure 1).

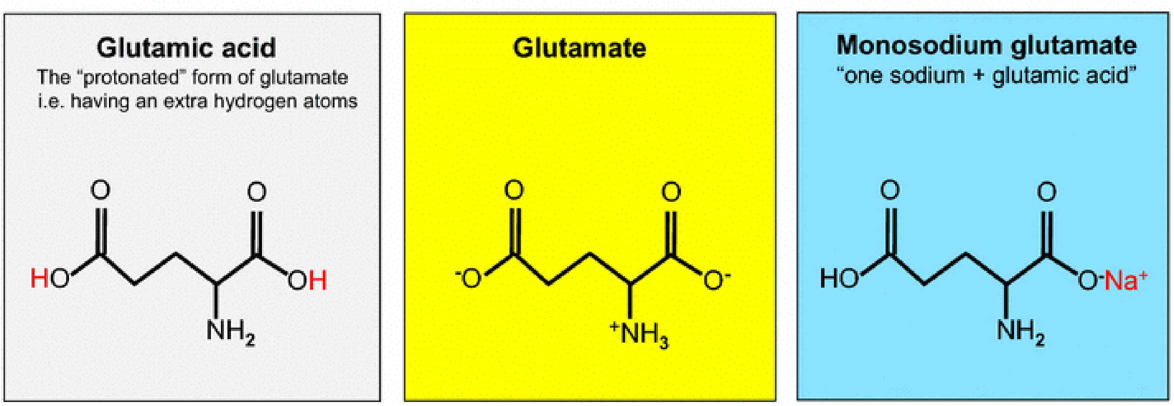

Figure 1. The chemical structures of glutamate, glutamic acid, and monosodium glutamate.

Glutamate, the major excitatory neurotransmitter in the central and peripheral nervous systems, is made from glutamic acid, an amino acid. When glutamic acid loses a hydrogen from its side chain, it becomes glutamate. In the human body, glutamic acid almost always exists as glutamate, because conditions in the body favor the loss of the hydrogen atom from glutamic acid [2].

3.3. Functionality of MSG

MSG is primarily known for its ability to enhance the savory taste of food, a taste sensation known as umami. Umami is considered one of the five basic tastes alongside sweet, sour, bitter, and salty. MSG does not impart its own flavor but instead intensifies the existing flavors in a dish, making them more pronounced and satisfying [8]. It achieves this by stimulating certain taste receptors on the tongue, specifically those sensitive to glutamate, one of the naturally occurring amino acids found in various foods.

MSG is used in a wide range of culinary applications, including soups, sauces, snacks, canned foods, processed meats, and restaurant dishes. It is particularly effective in enhancing the flavor of savory dishes containing ingredients such as meats, poultry, fish, vegetables, and broths [1]. Despite its widespread use, MSG has been a subject of controversy, with some individuals reporting symptoms such as headaches, flushing, sweating, and nausea after consuming foods containing MSG [9]. However, numerous scientific studies have failed to establish a consistent link between MSG and these symptoms, leading many experts to conclude that MSG is safe for the majority of people when consumed in normal dietary amounts.MSG like other salts, undergoes dissociation in aqueous solution. The degree of dissociation, represented by the dissociation constant (Ka), can vary with pH because it depends on the ionization of the acidic or basic functional groups present in the molecule. Glutamic acid, the precursor to MSG, has two ionizable groups: the carboxyl group (-COOH) and the amino group ($-NH_2$). The dissociation of MSG primarily involves the carboxyl group. The dissociation reaction of MSG can be represented as:

$$\text{MSG} \rightleftharpoons \text{MSG}^{-} + \text{H}^{+}$$

MSG is the monosodium glutamate molecule, MSG^- is the conjugate base, and H^+ is a proton. At various pH values, the percentage of dissociation (α) of MSG can be calculated using the Henderson-Hasselbalch in the equation (1).

$$\alpha = \frac{[MSG]^-}{[MSG] + [MSG^-]} = \frac{1}{1 + 10^{(pKa - pH)}} \tag{1}$$

[MSG^-] is the concentration of the conjugate base, [MSG] is the concentration of the undissociated MSG molecule, pKa is the negative logarithm of the dissociation constant (Ka) of MSG, and pH is the acidity of the solution. For MSG, the pKa value is approximately 3.2. At pH values below the pKa, the solution is acidic, and the protonated form of MSG predominates. As pH increases above the pKa, the solution becomes more basic, and the percentage of dissociation of MSG increases [3]. Table 4 show the percentage of dissociation of MSG at various pH values.

Table 4. Percentages of dissociation of glutamic acid at various pH.

pH	% of dissociation
3.0	5.30
3.5	15.1
4.0	36.0
4.5	64.0
5.0	84.9
5.5	94.7
6.0	98.2
7.0	99.8
8.0	96.9

At pH values significantly below the pKa (e.g. pH 1–3), the percentage of dissociation is minimal because the solution is acidic, and most of the MSG molecules remain protonated. As the pH approaches the pKa (pH 3–4), the percentage of dissociation increases rapidly. At pH values above the pKa (pH 5–6), the solution is basic, and nearly all of the MSG molecules are in the deprotonated form.

3.4. Sources of MSG

MSG can be found in various natural and processed food sources. including meat, fish, poultry, breast milk and vegetables, with vegetables tending to contain proportionally higher levels of free glutamate [3]. Various processed and prepared foods, such as traditional seasonings, sauces and certain restaurant foods can also contain significant levels of free glutamate, both from natural sources and from added MSG. The typical glutamate content of various foods is given in Table 5.

Table 5. MSG content in foods.

Food source	MSG content (mg/100g)	Description	Reference
Soy sauce	1090–1780	Soy sauce, a condiment used in many Asian cuisines, contains naturally occurring glutamate.	[10]
Parmesan cheese	1200–1680	Parmesan cheese, particularly aged varieties, contains high levels of glutamate.	[11]
Tomato paste	150–340	Tomatoes are naturally rich in glutamic acid, the precursor to MSG.	[12]
Miso soup	200–300	Miso Soup, a traditional Japanese seasoning, is made from fermented soybeans and contains glutamate.	[13]
Seaweed (Kombu)	130–230	Kombu, a type of seaweed commonly used in Japanese cooking, is a natural source of glutamate.	[14]
Meats	100–200	Various meats contain glutamic acid, contributing to the umami flavor of cooked meat dishes.	[15]
Mushrooms	60–140	Certain types of mushrooms, such as shiitake mushrooms, are naturally rich in glutamate.	[16]

3.5. Metabolism and Absorption of MSG

Upon ingestion, MSG is rapidly metabolized in the body, primarily by the liver and kidneys. Glutamate, the primary component of MSG, is a non-essential amino acid that plays a crucial role in various physiological processes, including neurotransmission and protein synthesis [1]. Studies have shown that ingested MSG is quickly broken down into its constituent amino acids, including glutamate, which is then absorbed into the bloodstream, as shown in Table 6.

Table 6. Metabolism and absorption of MSG.

Process	Description	Reference
Ingestion	MSG is consumed orally as a food additive or naturally present in certain foods.	[17]
Digestion	In the stomach, ingested MSG is subjected to acid hydrolysis, resulting in the release of glutamate ions (from MSG) and sodium ions.	[18]
Absorption	Glutamate ions are absorbed primarily in the small intestine via sodium-dependent transporters (SGLT1 and EAAT3). These transporters facilitate the absorption of glutamate along with sodium ions. A small portion of ingested MSG may be absorbed in the stomach.	[7]
Distribution	Absorbed glutamate is distributed throughout the body via the bloodstream.	[19]

Table 6. (continued)

Process	Description	Reference
Metabolism	Glutamate is involved in various metabolic pathways in the body. It can be utilized as a neurotransmitter in the central nervous system, participate in protein synthesis, or be converted to other amino acids via transamination reactions.	[20]
Excretion	Excess glutamate and its metabolites are excreted primarily by the kidneys in the form of urea and other nitrogenous waste products.	[21]

3.6. Health Effects of MSG Consumption

The safety of MSG has been a topic of debate, with anecdotal reports linking its consumption to adverse health effects such as headaches, nausea, and allergic reactions. However, numerous scientific studies have attempted to elucidate the true nature of MSG's effects on health, leading to conflicting findings. While some studies have reported adverse reactions to high doses of MSG in sensitive individuals, the majority of research suggests that MSG is safe for consumption at typical dietary levels (Table 7).

Table 7. Regulatory perspective on MSG safety.

Aspect	Description	Reference
Neurological effects	Controversy regarding MSG's potential role in triggering symptoms like headaches and nausea, though research is inconclusive.	[2]
Blood pressure	Some studies suggest a potential association between MSG intake and blood pressure regulation.	[22]
Safety assessment	Regulatory bodies like the FDA and EFSA consider MSG safe for consumption at recommended levels.	[23]

3.7. Regulatory Perspective on MSG Safety

Regulatory agencies such as the U.S. FDA and EFSA have conducted comprehensive reviews of MSG safety based on available scientific evidence. Both agencies have concluded that MSG is safe for consumption at current levels found in food products. However, they recommend that individuals with certain health conditions, such as asthma, exercise caution when consuming foods containing MSG [24].

3.8. Safety for Special Population Groups

Several studies have examined the safety of MSG consumption for special population groups, including infants, pregnant women, and individuals with certain health conditions. While some studies have raised concerns about the potential effects of MSG on neurodevelopment in infants and fetuses, the overall evidence remains inconclusive as shown in Table 8. Similarly, research on the effects of MSG consumption on individuals with conditions such as asthma and migraine headaches has yielded conflicting results.

Table 8. Safety for special population groups of MSG.

Population group	Safety assessment	Reference
Pregnant women	Generally considered safe when consumed in moderation as part of a balanced diet.	[23]
Infants and children	No evidence of adverse effects at typical dietary levels; however, moderation is recommended.	[25]
Individuals with asthma	Some individuals may experience adverse reactions; however, controlled studies have not shown a consistent link.	[26]
Individuals with diabetes	No specific safety concerns; consumption should be consistent with dietary guidelines.	[9]
Individuals with hypertension	Limited evidence suggests a potential association with blood pressure regulation; further research is needed.	[22]

3.9. Consumer Perception and Education

Despite scientific evidence supporting the safety of MSG, public perception remains divided, with many consumers expressing concerns about its potential health effects. Consumer education plays a crucial role in addressing misconceptions surrounding MSG and providing accurate information about its safety as shown in Table 9. Efforts to educate consumers about the role of MSG in food and its safety profile can help alleviate concerns and promote informed dietary choices.

Table 9. Consumer perception for MSG.

Aspect	Description	Reference
Perception of safety	Perception of safety varies among consumers, influenced by media reports, cultural beliefs, and personal experiences.	[27]
Labeling and ingredient awareness	Lack of awareness and understanding of MSG as an ingredient, leading to misconceptions about its safety and effects.	[7]
Health education initiatives	Efforts by health authorities and food industry to educate consumers about MSG safety and dispel myths and misconceptions.	[23]
Impact of labeling regulations	Mandatory labeling of MSG in some countries has led to increased consumer awareness and scrutiny of food labels.	[28]
Role of media	Media plays a significant role in shaping consumer perceptions through news reports, articles, and social media discourse.	[29]

3.10. Advantages and Disadvantages of MSG in Food

Overall, while MSG offers many advantages in enhancing flavor and reducing sodium content in food products, it is important that consumers be aware of potential allergens and that manufacturers use it responsibly and within recommended guidelines. Table 10 summarizes some of the advantages and disadvantages of using MSG in food.

In recent years, efforts have been made to increase transparency in food labeling to help consumers make informed choices about their food intake, including the presence of MSG in products. Additionally, alternative flavor enhancers and natural substitutes are being explored by the food industry to provide options for consumers who prefer to avoid MSG. The safety of MSG is still contested, although current evidence suggests that most people can safely consume it. However, individuals who experience adverse reactions should avoid foods containing MSG and consult with healthcare professionals if necessary. Moreover, ongoing research and advancements in food science aim to provide consumers with a wider range of choices regarding flavor enhancers while maintaining food safety standards.

Table 10. Some of the advantages and disadvantages of using MSG in food.

Aspect	Description	Reference
Advantages	Enhances flavor: MSG enhances umami taste, making food more savory and palatable.	[30]
	Cost-effective: MSG is an inexpensive way to improve the taste of processed and convenience foods.	[9]
	Reduces sodium: By enhancing flavor, MSG can reduce the need for added salt in recipes.	[7]
Disadvantages	Allergic reactions: Some individuals may experience adverse reactions such as headaches or nausea.	[2]
	Perception of safety: Consumer concerns and misconceptions about MSG safety may affect acceptance.	[31]
	Health effects controversy: Debates about potential health effects like obesity and metabolic syndrome.	[22]

3.11. Food Habits Associated with MSG

Table 11 shows that the total score is (medium). This indicated that the majority of respondents agree on the responses of the paragraphs of the questionnaire. The percentage reached 66.6%, while the largest percentage of the paragraphs was 89.1%, (2.750) and the meat monthly is compared to the general arithmetic mean (1.998).

Table 11. Mean, standard deviation, and percentages of food habits associated with MSG.

Rank	No	Question	Mean	Standard deviations	Percentage (%)	Degree of impact
12	1	Milk/daily	1.625	0.586	54.1	Low
9	2	Milk/weekly	1.700	0.564	56.6	Low
7	3	Milk/monthly	1.775	0.660	59.1	Low
6	4	Poultry products/daily	2.250	0.670	75	High
5	5	Poultry products/weekly	2.300	0.648	76.6	High
4	6	Poultry products/monthly	2.325	0.656	77.5	High
3	7	Meat/daily	2.575	0.675	85.3	Very high
2	8	Meat/weekly	2.600	0.591	86.6	Very high
1	9	Meat/monthly	2.675	0.526	89.1	Very high
9	10	Fish/daily	1.700	0.853	56.6	Low
8	11	Fish/weekly	1.725	0.847	57.5	Low
8	12	Fish/monthly	1.725	0.877	57.5	Low
10	13	Vegetables/daily	1.675	0.730	55.8	Low
11	14	Vegetables/weekly	1.650	0.736	55	Low
10	15	Vegetables/monthly	1.675	0.730	55.8	Low
Total score			1.998	0.411	66.6	Medium

Table 12 shows that the total score is very high. This indicates that the majority of the respondents agreed on the responses of the question paragraphs. The percentage was 84.9 % while the highest percentage was 70% with an average of 1.4%and the effect of monosodium glutamate on the human body compared with the general arithmetic mean (1.699).

Table 12. Mean, standard deviation, and percentages of MSG and its relationship to food safety.

Rank	No	Question	Mean	Standard deviations	Percentage (%)	Degree of impact
2	1	Food habits associated with monosodium glutamate	1.998	0.411	66.6	Medium
1	2	Effect of monosodium glutamate on the human body	1.400	0.391	70	High
Total score			1.699	0.411	84.9	Very high

Table 13 shows that the total score is (high), indicates that the majority of respondents agree on the responses of the question paragraphs where the percentage reached 70% while the largest percentage of the paragraphs 82.5% with an average of (1.650) For paragraph I feel nausea after eating mono-sodium glutamate. Compared to the general accounting average 1.400%.

The results of the questionnaire analysis show that the consumption of mono sodium glands is higher than that of meat. After asking several questions about the effect of monosodium glutamate on human performance, it was found that its consumption often leads to nausea and sometimes stomach pain, headaches and allergies. While studies suggest that mono-sodium glutamate increases weight, the findings in the current study suggest that eating products containing mono-sodium glutamate does not affect the weight of their bodies. The study also noted that eating products containing monosodium glutamate moderately does not affect the health of pregnant women.

Table 13. Mean, standard deviation, and percentages of effect of MSG on the human body.

Rank	No	Question	Mean	Standard deviations	Percentage (%)	Degree of impact
3	1	I feel pain in my head when I eat monounsaturated sodium glutamate	1.4750	0.506	73.7	High
1	2	I feel nausea after eating mono-sodium glutamate	1.650	0.483	82.5	Very high
5	3	I feel pain in the stomach after eating monounsaturated sodium glutamate	1.400	0.496	70	High
4	4	I have an allergy to food containing mono sodium glutamate	1.450	0.504	72.5	High
8	5	Eating monosodium glutathione increases body weight	1.150	0.362	57.5	Low
6	6	You feel addicted to foods that contain monosodium glutamate?	1.275	0.452	63.7	Medium
7	7	Does MSG ingested in the diet affect the nervous system?	1.225	0.423	61.2	Medium
2	8	Can MSG help to reduce salt intake?	1.575	0.501	78.7	High
Total score			1.400	0.391	70	High

4. CONCLUSION

The role of MSG in food safety is a topic of ongoing debate and research. While MSG has been used as a flavor enhancer for decades and is considered safe for consumption by regulatory agencies such as the U.S. FDA, concerns regarding its potential health effects have persisted. Numerous scientific studies have been conducted to assess the safety of MSG, and the consensus among experts is that it is generally safe for the majority of people when consumed in typical amounts found in food. However, some individuals may experience adverse reactions such as headaches or nausea after consuming foods containing MSG, a condition commonly referred to as "Chinese Restaurant Syndrome." Despite these reported reactions, extensive research has failed to conclusively link MSG to any serious health issues. After asking several questions about the effect of monosodium glutamate on human performance, it was found that its consumption often leads to nausea and sometimes stomach pain, headaches and allergies.

AUTHOR CONTRIBUTION

All author contributed equally to the main contributor to this paper. All authors read and approved the final paper. **Ali Jebreen**: Writing (review & editing), writing (original draft), formal analysis. **Amalya Nurul Khairi**: Writing (review & editing), supervision, conceptualization.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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