Technological research article

Estimation of monosodium glutamate (MSG) added to some food products in Syrian markets

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SUMMARY

Introduction: Monosodium Glutamate (MSG) is one of the world's most extensively used food additives which is ingested as part of commercially processed foods. MSG is used as a flavor enhancer and it increases the sapidity of food. MSG produces a flavor that can't be provided by other foods. It elicits a taste described in Japanese as umami. The toxic effects of MSG have raised the increasing interest in MSG intake as flavor enhancer. It causes many toxic effects on the health. It causes neurotoxicity (it causes Chinese Restaurant Syndrome), obesity, renal toxicity, cardiovascular toxicity, metabolic effects and other health effects. **Objective:** This study aimed to determine concentration of MSG in some foods products sold in Syrian Markets. **Methodology:** 40 samples of widely consumed food products were randomly selected from local markets in Damascus and Deratiah as follows: 12 samples chicken luncheon, 5 samples of instant soup, 6 samples of potato chips, 6 samples of chicken broth stocks, 5 samples of instant noodles and 6 samples of meat broth powder (each powder sachet is equivalent to one stock). A simple HPLC-UV method, based on a derivatization procedure with o-phthaldialdehyde (OPA) was used for determination of MSG in the samples. And a cross-sectional study was performed by using SPSS program. **Results:** Results revealed that the levels of monosodium glutamate (g/100 g) were varied in the examined foodstuffs. Chicken broth stocks samples had the highest levels of MSG with an average of (13.98), followed by (10.60) in samples of meat broth powders, followed by (10.16) in samples of chicken luncheon, followed by (8.9722) in samples of instant noodles, followed by (8.96) in samples of instant soup, while potato chips samples had the lowest levels with an average of (8.53). **Conclusions:** There was a significant variation in concentrations of MSG between samples of chicken broth stocks and samples of the other categories of food products.

Keywords: Monosodium glutamate (MSG); food products; derivatization; o-phthaldialdehyde (OPA); HPLC-UV.

RESUMEN

Estimación del glutamato monosódico (GMS) añadido a algunos productos alimenticios en los mercados sirios

Introducción: El glutamato monosódico (GMS) es uno de los aditivos alimentarios más utilizados a nivel mundial y se ingiere en alimentos procesados comercialmente. Se utiliza como potenciador del sabor y aumenta la sapidez de los alimentos. El GMS produce un sabor que otros alimentos no pueden proporcionar, lo que se conoce en japonés como umami. Los efectos tóxicos del GMS han despertado un creciente interés en su consumo como potenciador del sabor. Provoca numerosos efectos tóxicos para la salud, como neurotoxicidad (causando el síndrome del restaurante chino), obesidad, toxicidad renal, toxicidad cardiovascular, efectos metabólicos y otros efectos sobre la salud. **Objetivo:** Este estudio tuvo como objetivo determinar la concentración de GMS en algunos productos alimenticios vendidos en los mercados sirios. **Metodología:** Se seleccionaron aleatoriamente 40 muestras de productos alimenticios de amplio consumo de los mercados locales de Damasco y Deratiah de la siguiente manera: 12 muestras de almuerzo de pollo, 5 muestras de sopa instantánea, 6 muestras de papas fritas, 6 muestras de caldos de pollo, 5 muestras de fideos instantáneos y 6 muestras de caldo de carne en polvo (cada sobre de polvo es equivalente a un caldo). Se utilizó un método simple de HPLC-UV, basado en un procedimiento de derivatización con o-ftaldialdehído (OPA) para la determinación de MSG en las muestras. Y se realizó un estudio transversal utilizando el programa SPSS. **Resultados:** Los resultados revelaron que los niveles de glutamato monosódico (g/100 g) variaron en los productos alimenticios examinados. Las muestras de caldo de pollo presentaron los niveles más altos de GMS, con un promedio de (13,98), seguido de (10,60) en las muestras de caldo de carne en polvo, seguido de (10,16) en las muestras de pollo enlatado, seguido de (8,9722) en las muestras de fideos instantáneos, seguido de (8,96) en las muestras de sopa instantánea, mientras que las muestras de papas fritas presentaron los niveles más bajos, con un promedio de (8,53). **Conclusiones:** Se observó una variación significativa en las concentraciones de GMS entre las muestras de caldo de pollo y las muestras de otras categorías de productos alimenticios.

Palabras clave: Glutamato monosódico (GMS); productos alimenticios; derivatización; o-ftaldialdehído (OPA); HPLC-UV.

RESUMO

Estimativa de glutamato monossódico (MSG) adicionado a alguns produtos alimentícios em mercados sírios

Introdução: O glutamato monossódico (MSG) é um dos aditivos alimentares mais utilizados no mundo, sendo ingerido como parte de alimentos processados comercialmente. O MSG é usado como intensificador de sabor e aumenta o sabor dos alimentos. O MSG produz um sabor que não pode ser fornecido por outros alimentos. Ele provoca um sabor descrito em japonês como umami. Os efeitos tóxicos do MSG têm aumentado o interesse na ingestão de MSG como intensificador de sabor. Ele causa muitos efeitos tóxicos à saúde. Causa neurotoxicidade (causando a Síndrome do Restaurante Chinês), obesidade, toxicidade renal, toxicidade cardiovascular, efeitos metabólicos e outros efeitos à saúde. **Objetivo:** Este estudo teve como objetivo determinar a concentração de MSG em alguns produtos alimentícios vendidos em mercados sírios. **Metodologia:** 40 amostras de produtos alimentícios amplamente consumidos foram selecionadas aleatoriamente de mercados locais em Damasco e Deratiah da seguinte forma: 12 amostras de frango para almoço, 5 amostras de sopa instantânea, 6 amostras de batata frita, 6 amostras de caldo de galinha, 5 amostras de macarrão instantâneo e 6 amostras de caldo de carne em pó (cada sachê de pó é equivalente a um caldo). Um método simples de HPLC-UV, baseado em um procedimento de derivatização com o-ftaldialdeído (OPA), foi usado para determinação de MSG nas amostras. E um estudo transversal foi realizado usando o programa SPSS. **Resultados:** Os resultados revelaram que os níveis de glutamato monossódico (g/100 g) foram variados nos alimentos examinados. Amostras de caldo de galinha apresentaram os maiores níveis de MSG, com uma média de (13,98), seguidas por (10,60) em amostras de caldo de carne em pó, (10,16) em amostras de frango para almoço, (8,9722) em amostras de macarrão instantâneo, (8,96) em amostras de sopa instantânea, enquanto amostras de batata frita apresentaram os menores níveis, com uma média de (8,53). **Conclusões:** Houve uma variação significativa nas concentrações de MSG entre amostras de caldo de galinha e amostras das demais categorias de produtos alimentícios.

Palavras-chave: Glutamato monossódico (MSG); produtos alimentícios; derivatização; o-ftaldialdeído (OPA); HPLC-UV.

1. INTRODUCTION

Monosodium glutamate (MSG) is the sodium salt of the non-essential amino acid, L-glutamic acid (Figure 1). It is widely used in food industry as a flavor enhancer (E621) due to its ability to modulate umami taste and improve overall food palatability. It is one of the world's most extensively used food additives which is ingested as part of commercially processed foods [1-6].

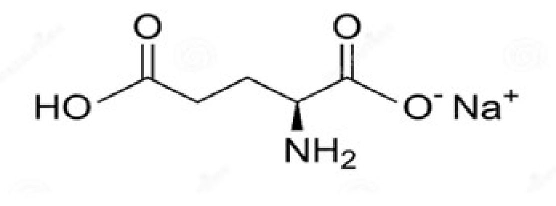


Figure 1. Structure of monosodium glutamate.

In 2017 the European Food Safety Authority set that the permissible amount of glutamic acid per day is (30 mg/kg) of body weight. European Food Safety Authority also clarified the quantities that, when used daily, can cause symptoms such as: headache (85.8 mg/kg), insulin increase (>143 mg/kg) and blood pressure increase (150 mg/kg) [7]. World Health Organization stated that the daily consumption of MSG per person should not exceed the safe limit of 120 mg/kg/day [8].

Consumption of 1.5-3 g of MSG is resulting in acute toxicity of MSG, which is also called "The Chinese restaurant syndrome" (CRS). CRS was described for the first time more than 40 years ago. The original description of symptoms having their onset about 20 minutes after starting the meal and included numbness or burning at the back of the neck, radiating into both arms and sometimes into the anterior thorax, which was associated with a feeling of general weakness and palpitations. In addition to other symptoms that may appear later such as flushing, dizziness, syncope and facial pressure [9-11].

Consumption of food products rich in MSG can result in chronic toxicity of MSG that include many health disorders such as obesity, diabetes, neurotoxicity, hepatotoxicity, nephrotoxicity, reproductive toxicity, oxidative stress and genotoxicity [12-34]. The major chronic toxic effects of MSG are summarized as shown in the following figures (Figure 2) and (Figure 3) [35-37].

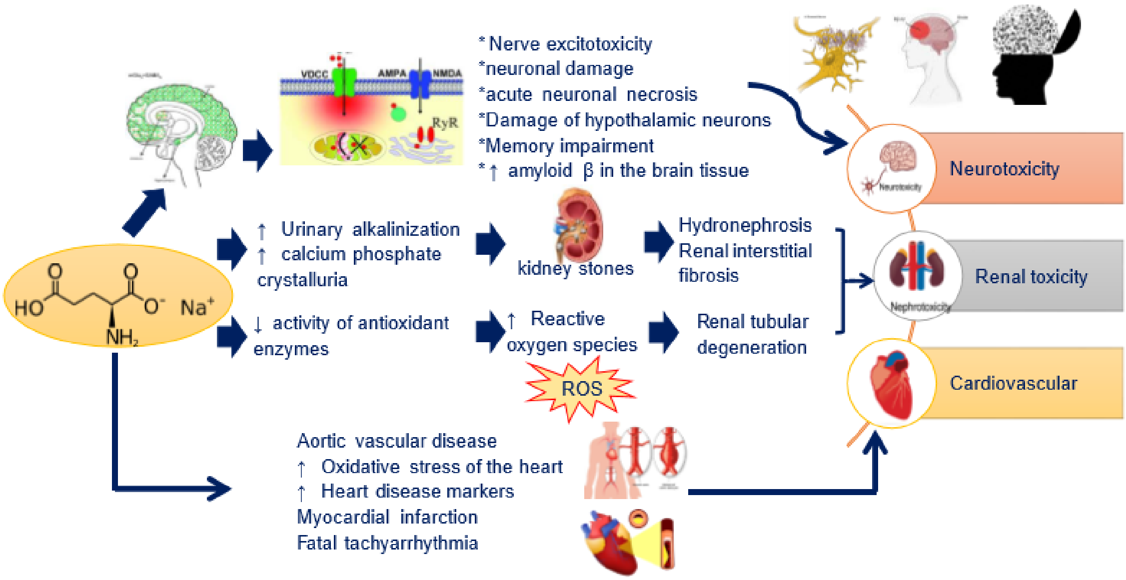


Figure 2. Major toxic effects of MSG on human functions.

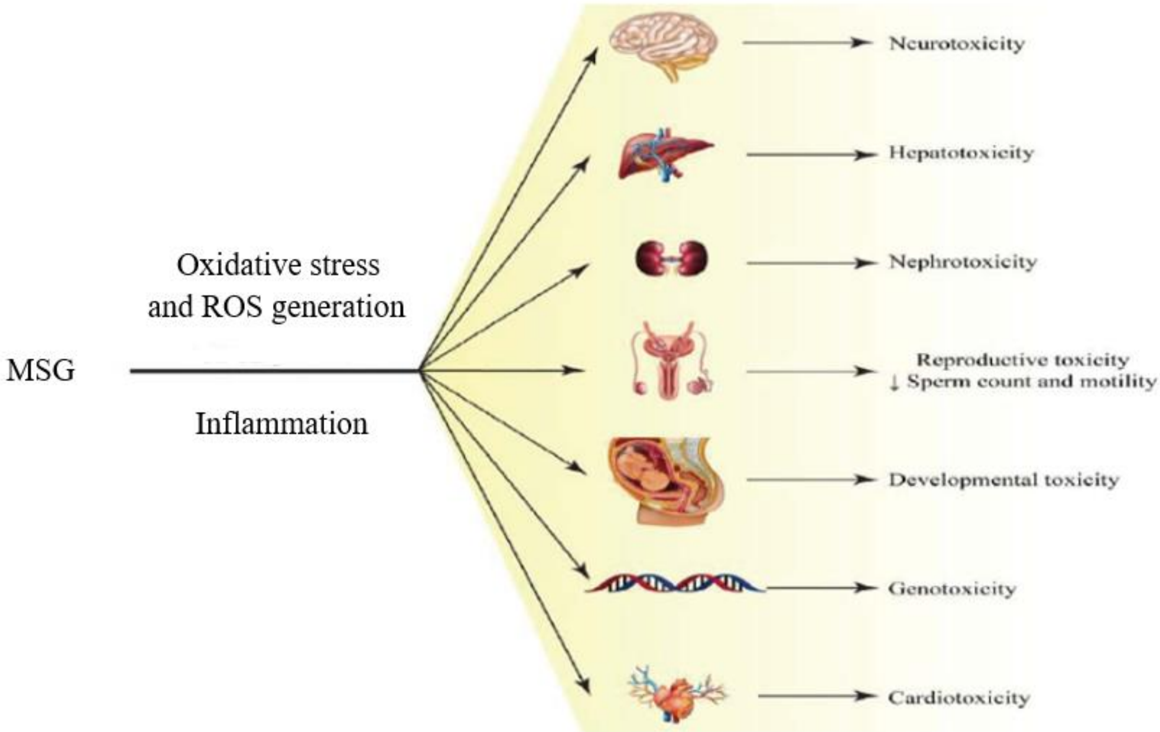


Figure 3. A schematic representation of MSG toxicity and the organs may be affected by MSG.

1.1. The specific contribution of the research:

Nowadays, MSG is added as a flavor to food and food products without taking into consideration the added concentration and there is increasing in consumption of food-containing MSG among all age groups especially university students.

MSG has many toxic effects on health especially after long-term of exposure. In addition, there is no local or international standardization for allowable concentration of MSG in food products. Also, the global studies on this subject are very limited. This is the first study in Syria which used HPLC-UV method based on a derivatization procedure with o-phthaldialdehyde

(OPA). Therefore, the aim of the study is to determine levels of MSG in 40 samples of randomly selected food products and to find out if there is a statistical variation between analyzed food categories or not by performing a cross-sectional study and analyzing data by using SPSS program. This study found a significant variation in concentrations of MSG between samples of chicken broth stocks and samples of the other categories of food products.

2. METHODOLOGY

A simple HPLC-UV method, based on a derivatization procedure with o-phthaldialdehyde (OPA), was used for determination of MSG in food products. This procedure is effective, simple and rapid analytical method. Also, it is simple to operate and is relatively inexpensive [38].

2.1. Food selection

The samples were randomly selected from local markets in Damascus and Deratiah. A total of 40 samples of widely consumed food products were randomly selected as follows: 12 samples of chicken luncheon, 5 samples of instant soup, 6 samples of potato chips, 6 samples of chicken broth stocks, 5 samples of instant noodles and 6 samples of meat broth powder (each powder sachet is equivalent to one stock).

2.2. Additional samples (spiked samples)

3 samples of chicken luncheon were prepared at the laboratory, and known concentrations of MSG standard solutions were added to them. The purpose is to ensure that the extraction procedure of MSG is effective.

2.2.1. Preparation of chicken luncheon samples (spiked samples)

The samples were prepared by taking 600 g of minced chicken (200 g for each sample), then salt was added to them. After that known concentrations of MSG (8 mg, 10 mg and 15 mg) were added to the samples respectively (where 40, 50 and 75 μg of MSG was added for each gram of Minced chicken respectively). Then each sample was wrapped by a sheet of cellophane and a sheet of foil and were placed in a water bath (K.F.T LAB Equipment) with 75 °C for 1 hour. Then the samples were left in the same conditions of the samples in the market. They were stored in room temperature and away from moisture.

2.3. Apparatus

1) Smartline HPLC device (Knauer, Germany) with C18 (internal diameter 4.6 mm, particles dimensions 5 μm and length 250 mm) which is connected to a Smartline UV – Detector 2500. 2) Centrifugator (Hettich, EBA 20). 3) Water bath (K.F.T LAB Equipment). 4) Ultrasonic bath (Lab Tech).

2.4. Reagents and chemicals

The following reagents and chemicals: HPLC grade water, analytical grade monosodium glutamate (MSG) reference standard (Fluka) with 95% purity, 0.10 N Hydrochloride acid (HCl), o-phthaldialdehyde powder (OPA) (Agilent) and methanol gradient grade for HPLC (Merck) were used [38].

2.5. Extraction of MSG from samples

2.5.1. Samples preparation and derivatization

Each sample was ground and well homogenized. 5 g of each sample was homogenized with 50 ml of 0.10 N HCl solution and then placed in an ultrasonic bath for 60 minutes. Then it was filtered (0.45 μm filter). The resulted filtration was placed in a centrifuge 5000 rpm for 15 minutes. The resulted suspension was extracted with 20 ml of hexane 99% in order to remove the fatty substances. Then 1800 μL was mixed with 200 μL of OPA and filtered through a syringe filter (0.22 μm). The spiked samples were prepared and spiked as samples from local markets [39, 40].

2.5.2. Chromatographic conditions

Smartline HPLC device (Knauer, Germany) connected to a Smartline UV – Detector 2500 was used. Chromatographic conditions (Table 1) were carried out on a C18 column (internal diameter 4.6 mm, particles dimensions 5 μm and length 250 mm) with a mobile phase consisting of A= Phosphate Buffer Solution (pH = 5.35) and B= Methanol (75:25 v/v) at a flow rate of 0.7 mL/min. The injection volume was 20 μL, the needle was washed with Water-Methanol (70:30 v/v), and the detection was performed at 254 nm. The column's temperature was stable at 30 °C.

Table 1. Chromatographic conditions.

Time (minutes)	A= Phosphate Buffer	B= Methanol	Flow rate (mL/min)
0.0	92.0	8.0	0.7
11.0	75.0	25.0	0.7
14.0	75.0	25.0	0.7
14.1	92.0	8.0	0.7
15.0	92.0	8.0	0.7

2.6. Validation of the method

Validation of the method was based on ICH standards. Method validation was performed as recommended by Center for Drug Evaluation and Research (CDER). The validation characteristics considered in this study were: linearity, range, and limit of detection (LOQ), limit of quantification (LOD), repeatability and recovery.

Five different standards of MSG solutions of 40-60-80-100-120-ppm were taken to evaluate the plot of signal as a function of analyte concentration. For precision, the intraday and interday repeatability was performed by taking 10 ppm standard solution for 6 determinations. LOQ and LOD were determined by observing the signal-to-noise ratio and comparing the measured signals from samples with known concentrations. A signal to noise ratio between 2:1 and 10:1 was considered for LOD and LOQ. Recovery was tested by adding blank samples with different MSG standard concentrations and analyzing their content.

2.6.1. Linearity

Five different concentrations of standard MSG solution were analyzed, which would represent the sample well. The calibration curve was generated using 20 μL injection loop and the curve was established according to the response (peak area) and the concentration of MSG in standard solutions. The results obtained showed a linear relationship. Each standard concentration response was the average of three determinations. The calibration curve showed a strong positive correlation between the instrumental signal and the concentration of the MSG standards. The linearity studies showed that MSG content was found to be linear in the following concentration range (40-60-80-100-120-ppm) where R^2 value was 0.9993 as shown in the following figures (Figure 4) and (Figure 5).

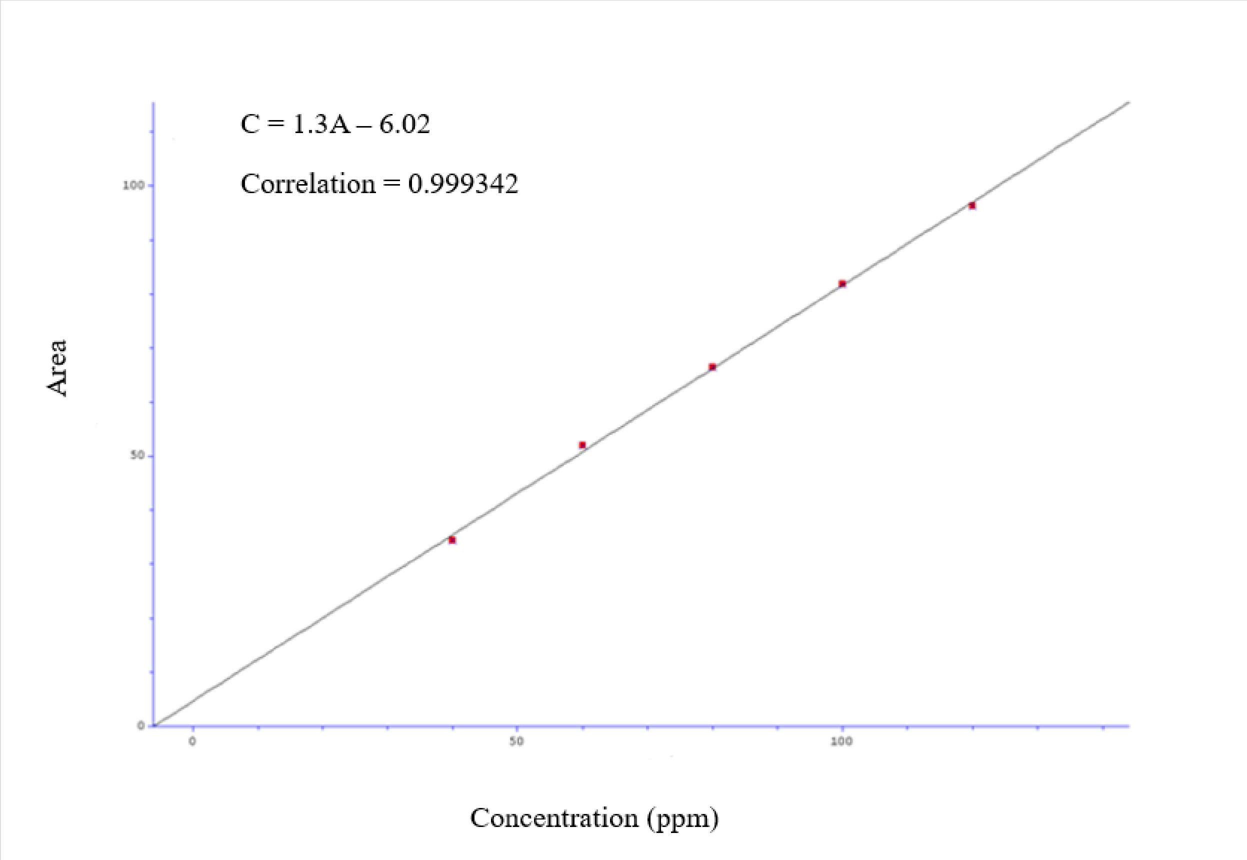


Figure 4. Standard curve of MSG standard solutions (40-60-80-100-120 ppm).

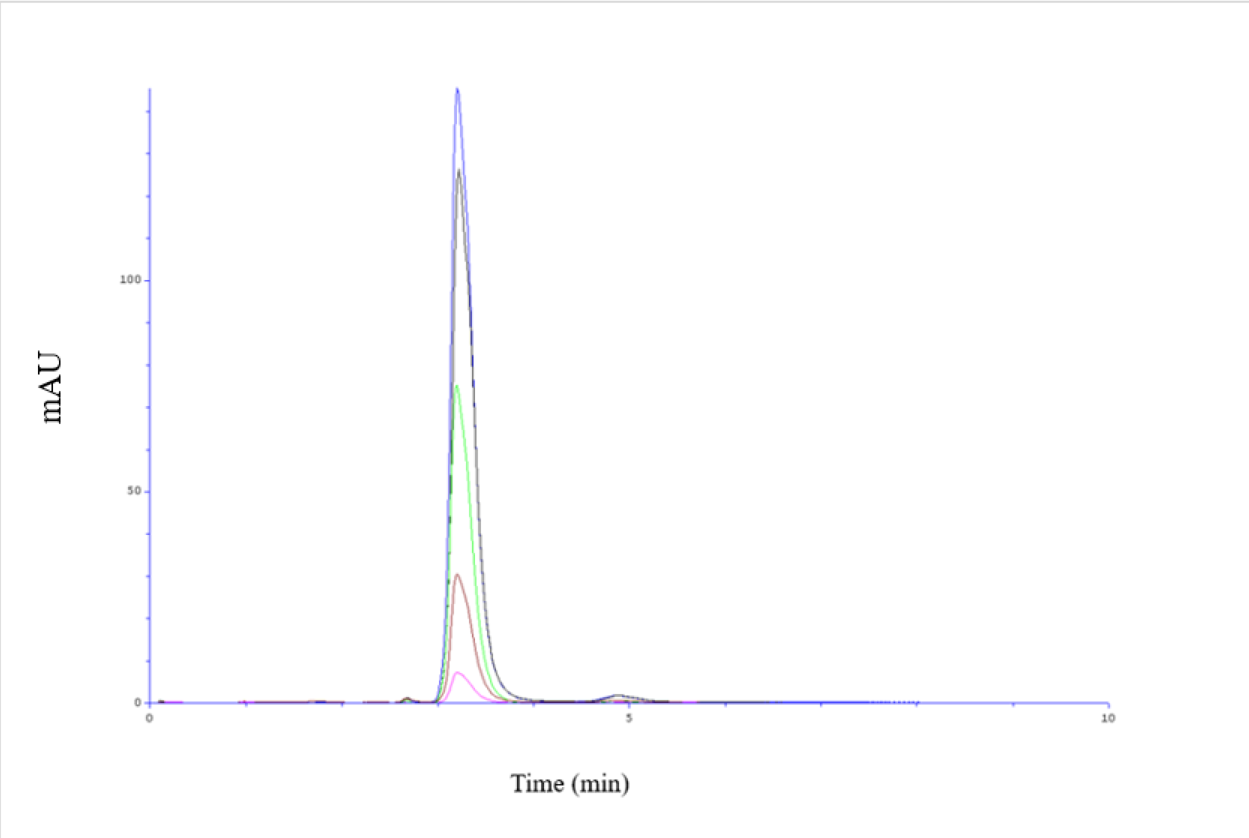


Figure 5. Corresponding of retention times of standard solutions.

2.6.2. System suitability test

System suitability test is necessary to be sure about quality of HPLC apparatus. Center for Drug Evaluation and Research (CDER) recommended to determine Capacity Factor (Retention Factor). Capacity Factor was determined by injection of standard solution of MSG with concentration 20 ppm and the resulted Capacity Factor k factor = 2.83 (according to the recommendations of CDER) is good.

2.6.3. Determination of HPLC accuracy and precision

The process of preparing and derivatization of samples was highly effective and its frequency was studied by repeating the derivatization of the same sample three times and the Relative Standard Deviation (RSD%) was less than 2%. Repeatability of injection (precision) was determined by repeating injection of the same standard solution of MSG (20 ppm) five times and RSD% was 0.4805% (Table 2). Therefore, the system is accurate according to the recommendations of CDER.

Table 2. Determination of HPLC injection accuracy and precision.

Concentration (ppm)	**Area**
Concentration 1 (20 ppm)	17.188
Concentration 2 (20 ppm)	17.192
Concentration 3 (20 ppm)	17.094
Concentration 4 (20 ppm)	17.242
Concentration 5 (20 ppm)	17.320
$\bar{x}$	17.207
RSD	0.4805

2.6.4. Results of relevance of HPLC system for MSG analysis

The following table (Table 3) shows results of relevance of HPLC system for MSG analysis. Theoretical plate numbers: when the standard solution of MSG was 20 ppm then the theoretical plate numbers were N=3670. Therefore, the ability of the column for analysis was good according to the recommendations of CDER.

Table 3. Results of relevance of HPLC system for MSG analysis.

Parameters	**Obtained value**	**Recommended value**
Retention time	4.8	-----------
Tailing factor	1.28T	T <2.00
Resolution (Rs)	5.10	Rs >2.00
Capacity factor	2.83	K > 2.00
Selectivity (α)	1.90	α > 1.00
Theoretical plate number	N 3670	N >2000
Repeatability of peak	(RSD %) < 0.4805	(RSD %) < 1.50

Tailing factor: peak's tailing factor of a standard solution of MSG (20 ppm) was 1.28. Therefore, symmetry of the peak was good. Then it can be integrated and gives a good quantity.

Retention time of a standard solution of MSG was 4.8 minutes. Also, using of the mobile phase (PBS and Methanol) showed a good efficacy in analysis of MSG as a symmetrical peak. On the other hand, trying to increase flow rate to decrease retention time was not successful due to the increase of tailing factor and a significant increase in baseline noise.

Quantitation limit (Table 4) is the quantity or the lowest concentration of the studied substance which can be measured by a good accuracy and precision. To determine the quantitation limit, standard solutions of decreasing concentrations was prepared and the measurement of concentration which gives the lowest action was repeated 6 times and then RSD% was measured. RSD% (Relative Standard Deviation) must not exceed 20% and the limit = SD (standard deviation) × 10.

Table 4. Limit of quantification is 0.5 mg/L and limit of detection is 0.2 mg/L.

Concentration (ppm)	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	SD	$\bar{x}$	RSD %
1	3.31	3.14	2.98	3.29	3.32	2.34	0.202	3.26	6.194
0.8	2.42	2.46	2.48	2.47	2.49	2.51	0.0314	2.47	1.271
0.6	1.84	2.11	1.99	2.12	1.89	1.86	0.119	1.96	6.09
0.4	1.22	1.24	1.26	1.19	1.25	1.23	0.0248	1.231	0.0432
0.2	0.62	0.54	0.61	0.55	0.52	0.61	0.0432	0.575	7.520
0.05	-	-	-	-	-	-	-	-	-

3. RESULTS

3.1. Results for the spiked samples

The following table (Table 5) showed concentrations of MSG added to the spiked samples and yield concentrations after analysis (recovery). In all cases, the value of recovery was 95.4±1.4 % as shown in the following table.

Table 5. Recovery of MSG and its concentrations in the spiked samples.

Concentration	Number of the spiked samples		
	Spiked sample 1	Spiked sample 2	Spiked sample 3
Original concentration of MSG in the sample (µg/g or ppm)	0	0	0
Quantity of standard MSG (µg) added to 1 g of the sample	40	50	75
Total concentration of MSG expected to found in 1 g of the spiked sample (µg/g or ppm)	40	50	75
Concentration of MSG found in 1g of the spiked sample µg/g (ppm) ±SD	38.48 ± 0.2	46.80 ± 0.2	72.3 ± 0.3
Recovery ± SD	96.2 ± 1.6	93.6 ± 1.0	96.4 ± 1.4

3.2. Results for samples of food products

As shown in (Table 6), results revealed that the levels of monosodium glutamate (g/100 g) were varied in the examined foodstuffs. Chicken broth stocks samples had the highest levels of MSG with an average of (13.98) in a range of (11.30) to (16.70) followed by (10.60) in a range of (8.50) to (12.30) in samples of meat broth powders, followed by (10.16) in a range of (6.60) to (13.60) in samples of chicken luncheon, followed by (8.9722) in a range of (6.20) to (10.70) in samples of instant noodles, followed by (8.96) in a range of (6.30) to (11.30) in samples of instant soup and followed by (8.53) in a range of (6.60) to (10.80) in samples of potato chips.

Table 6. Concentration of MSG (g/100g) in the examined food products.

Descriptive (Statistic)	Chicken Luncheon	Potato Chips	Instant Soup	Instant Noodles	Chicken Broth Stocks	Meat Broth Powders
Mean	10.16	8.53	8.96	8.9722	13.98	10.60
Std. Deviation	2.32	1.45	2.10	1.79360	2.26	1.41
Minimum	6.60	6.60	6.30	6.20	11.30	8.50
Maximum	13.60	10.80	11.30	10.70	16.70	12.30

3.3. Statistical analysis

A cross-sectional study was performed by using SPSS program. (Table 6) showed concentrations of MSG (g/100 g) in the examined food products. Tests of Normality (Kolmogorov-Smirnov and Shapiro-Wilk Tests) were performed as shown in (Table 7) which revealed that the results were normal.

Table 7. Tests of Normality.

Type of sample		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Concentration of MSG (g/100g)	Chicken Luncheon	0.160	12	.200*	0.947	12	0.588
	Potato Chips	0.180	6	.200*	0.983	6	0.964
	Instant Soup	0.187	5	.200*	0.943	5	0.690
	Instant Noodles	0.184	5	.200*	0.938	5	0.649
	Chicken Broth Stocks	0.215	6	.200*	0.893	6	0.333
	Meat Broth Powders	0.228	6	.200*	0.929	6	0.571
*. This is a lower bound of the true significance.							
a. Lilliefors Significance Correction							

Test of homogeneity of variances (Levene Statistic) was shown in (Table 8) and revealed that the results were homogenized.

Table 8. Test of Homogeneity of Variances.

Concentration of MSG (g/100 g)			
Levene Statistic	**df1**	**df2**	**Sig.**
0.972	5	34	0.449

The results of the study were homogenized; therefore, ANOVA test was performed as shown in (Table 9). ANOVA test showed that the significance value was 0.000 which is less than 0.05.

Table 9. ANOVA Test.

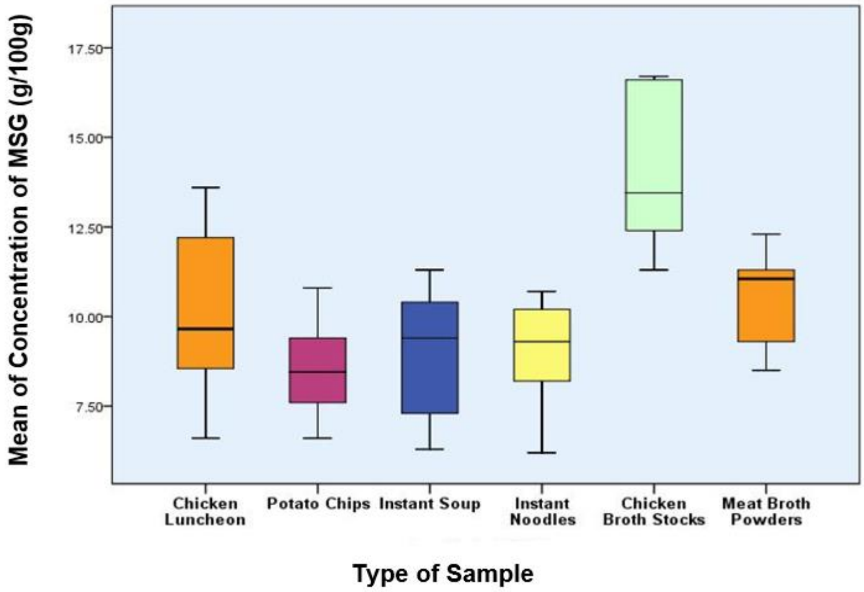
Concentration of MSG (g/100 g)					
	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Between Groups	119.177	5	23.835	5.960	0.000
Within Groups	135.982	34	3.999		
Total	255.159	39			

As a result, there was a significant variation between samples of the categories. According to the obtained results in (Table 10) and (Figure 6), there was a significant variation between samples of chicken broth stocks and the samples of the other categories.

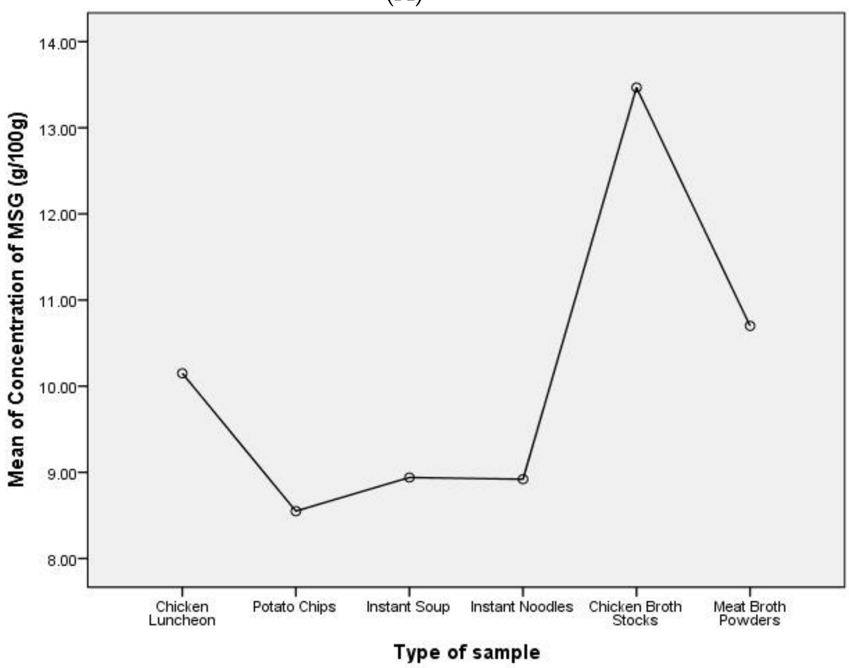
Table 10. Statistical comparisons between samples categories.

Multiple Comparisons						
Dependent Variable: LSD						
(I) Type of sample		**Mean Difference (I-J)**	**Std. Error**	**Sig.**	**95% Confidence Interval**	
					Lower Bound	**Upper Bound**
Chicken Luncheon	Potato Chips	1.60000	0.99993	0.119	-0.4321	3.6321
	Instant Soup	1.21000	1.06451	0.264	-0.9533	3.3733
	Instant Noodles	1.23000	1.06451	0.256	-0.9333	3.3933
	Chicken Broth Stocks	-3.83333-*	0.99993	0.001	-5.8654	-1.8012
	Meat Broth Powders	-0.43333	0.99993	0.667	-2.4654	1.5988
Potato Chips	Chicken Luncheon	-1.60000	0.99993	0.119	-3.6321	0.4321
	Instant Soup	-0.39000	1.21098	0.749	-2.8510	2.0710
	Instant Noodles	-0.37000	1.21098	0.762	-2.8310	2.0910
	Chicken Broth Stocks	-5.43333-*	1.15462	0.000	-7.7798	-3.0869
	Meat Broth Powders	-2.03333	1.15462	0.087	-4.3798	0.3131
Instant Soup	Chicken Luncheon	-1.21000	1.06451	0.264	-3.3733	0.9533
	Potato Chips	0.39000	1.21098	0.749	-2.0710	2.8510
	Instant Noodles	0.02000	1.26483	0.987	-2.5504	2.5904
	Chicken Broth Stocks	-5.04333-*	1.21098	0.000	-7.5043	-2.5823
	Meat Broth Powders	-1.64333	1.21098	0.184	-4.1043	0.8177
Instant Noodles	Chicken Luncheon	-1.23000	1.06451	0.256	-3.3933	0.9333
	Potato Chips	0.37000	1.21098	0.762	-2.0910	2.8310
	Instant Soup	-0.02000	1.26483	0.987	-2.5904	2.5504
	Chicken Broth Stocks	-5.06333-*	1.21098	0.000	-7.5243	-2.6023
	Meat Broth Powders	-1.66333	1.21098	0.179	-4.1243	0.7977
Chicken Broth Stocks	Chicken Luncheon	3.83333*	0.99993	0.001	1.8012	5.8654
	Potato Chips	5.43333*	1.15462	0.000	3.0869	7.7798
	Instant Soup	5.04333*	1.21098	0.000	2.5823	7.5043
	Instant Noodles	5.06333*	1.21098	0.000	2.6023	7.5243
	Meat Broth Powders	3.40000*	1.15462	0.006	1.0535	5.7465
	Chicken Luncheon	0.43333	0.99993	0.667	-1.5988	2.4654

Meat Broth Powders	Potato Chips	2.03333	1.15462	0.087	-0.3131	4.3798
	Instant Soup	1.64333	1.21098	0.184	-0.8177	4.1043
	Instant Noodles	1.66333	1.21098	0.179	-0.7977	4.1243
	Chicken Broth Stocks	-3.40000-*	1.15462	0.006	-5.7465	-1.0535
*. The mean difference is significant at the 0.05 level.						



(A)



(B)

Figure 6. Statistical variation between samples of chicken broth stocks and the samples of the other categories.

4. DISCUSSION

The validated HPLC- UV method was successfully applied for the analysis of MSG in all of the analyzed food samples.

According to the statistical study as shown in Table 10, there was a significant variation in MSG concentration between samples of chicken broth stocks and samples of the other categories (chicken luncheon, potato chips, instant soup, instant noodles and meat broth powders) where P-values (significance values) were less than 0.05 (0.001, 0.000, 0.000, 0.000 and 0.006, respectively). Concentration of MSG in samples of chicken broth stocks was the highest because it is widely used to make taste of food more palatable and more delicious. Also, there are no local or international standardizations for the allowable concentration of MSG added to food and food products. In addition, there were no limits to the amount of MSG (Chinese Salt) that can be purchased from local markets.

Therefore, local and international standardizations must be regulated to determine the allowable concentration of MSG added to food and food products.

5. CONCLUSIONS

The highest level of MSG was in chicken broth stocks samples and the lowest one was in potato chips samples. MSG has many health risks if food-containing MSG is consumed in large quantities. Upon acute exposure it causes symptoms of CRS and upon chronic exposure it causes many toxic effects such as: neurotoxicity, obesity, renal toxicity, cardiovascular toxicity, metabolic effects and other health effects [41]. Local and international regulations and recommendations about allowed levels of MSG are required. Also, more attention is required to reduce the risk of health hazards of this additive with accumulative exposure. It is recommended that students should adopt healthy life style and use food-containing MSG in moderation. It is also recommended that awareness programs on the side-effects and symptoms of MSG must be carried out.

CONFLICTS OF INTEREST

All authors declare that there are no conflicts of interest.

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