Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol.5, No.14, 2015

Effect of Monosodium Glutamate Orally Administered to Male Wister Rats on Some Biochemical Parameters

Michael Okey Enemali[1], Ebenezer U. Danielson[2] and Titilayo O. Bamidele[1]
1, Department of Biochemistry and Molecular Biology, Faculty of Natural and Applied Sciences, Nasarawa State University, P. M. B 1022, Keffi, Nasarawa State Nigeria.
2, Department of Biochemistry, Faculty of Biological Sciences, University Of Nigeria, Nsukka

Abstract
Monosodium glutamate (MSG) of brand name "Ajinomoto" was purchased from Nsukka Market and was administered to wistar rat. Twenty four wistar rats were randomly divided into four groups housed in different cages. The rats were administered with varying doses (500, 1000 and 1500 mg/kg body weights) of MSG. The effect on some haematological parameters; WBC, PCV, Hb, sodium ion (Na^+), potassium ion (K^+) blood urea nitrogen (BUN) chloride ion (Cl^-) creatinine (Cr^{2+}), and bicarbonate (HCO_3^-) were investigated. There was an insignificant difference ($P > 0.05$) in PCV, Hb and WBC levels of the test groups, compared with the control group. The serum electrolyte; creatinine (Cr^{2+}), of the group administered 1500mg/kg body weight of MSG showed significant difference ($P<0.05$), when compared with control while other serum electrolytes sodium, potassium, urea, carbonate and chloride showed no difference ($P>0.05$).
Keywords: Monosodium glutamate (MSG), "Ajinomoto", Serum electrolytes, haematological parameters

1 Introduction

Monosodium glutamate (MSG) is the sodium salt of the amino acid, glutamic acid. It is sold as a fine white crystalline substance, similar in appearance to table salt (NaCl) and sugar. It does not have a distinct taste and how it adds flavour to other foods is not fully understood (FASEB and FDA 1995). It is used as a flavour enhancer in a variety of foods prepared at homes, in restaurants and by food processors (FASEB and FDA, 2005). The body uses glutamate as a neurotransmitter in the brain and there are glutamate responsive tissues in other parts of the body as well (Choi 1988). It has been reported that the injection of glutamate into laboratory animals have resulted in damage to the nerve cells in the brain (Kubo et al 2004).

The kidneys are a pair of fist-sized organ located outside the peritoneal cavity on each side of the spine. The human kidneys are two bean-shaped organs, one on each side of the backbone. It represents about 0.5% of the total weight of the body but receive 20-25% of the total arterial blood pumped by the heart; each contains from one to two million nephrons (Klahr and Miller, 1998).

The Kidneys are highly specialized organs that maintain the internal environment of the body by selectively excreting or retaining various substances according to specific body needs. The kidney is more than just an excretory organ. It does remove waste, but it also removes normal components of the blood that are present in greater-than-normal concentrations. When excess water, sodium ions, calcium ions, potassium ions and so on are present, the excess quickly passes out in the urine. On the other hand, the kidneys step up their reclamation of these substances when they are present in the blood in less than normal amounts (Stewart, 1998). Thus the kidney continuously regulates the chemical composition of the blood within narrow limits. The kidney is one of the major homeostatic devices of the body. The human kidney is also an endocrine gland secreting two hormones; Erythropoietin (EPO), and Calcitrol (1,25 dihydroxyl Vitamin D3), the active form of vitamin D. The kidney is also the organ where the enzyme rennin is produced (Meyer and Hostetter, 2007).

Kidneys are crucial organs for excretion of metabolic waste products and regulation of volume, pH, electrolyte composition as well as osmolarity of the extracellular body fluid including plasma (Meyer and Hostetter, 2007).

The kidney allows a person to eat and drink according to his/her habit without changing the composition of fluid compartments. This is achieved by the following processes:

- Retention of substances vital to the body such as protein and glucose.
- Maintenance of acid/base balance
- Excretion of waste products, water soluble toxic substances and drugs.
- Endocrine functions.

Monosodium glutamate (MSG) is used as a flavour enhancer in a variety of foods prepared both at homes, in restaurants and by food processors in most parts of the world including Nigeria.

For the past 30 years, the use of MSG has been controversial. Its safety has been doubted because of reports (FDA, 1996) of adverse reaction in people who have eaten food that contain MSG. Many researches (FDA, 1996, FASEB, 1996) on the role of glutamate in the nervous system have also raised questions on the chemical safety of MSG. A number of other works have also found no adverse effects occasioned by the

utilization of MSG foods (FASEB and FDA 1995, George, 2004).

This work was therefore designed to evaluate the safety of MSG as a food enhancer by evaluating the effect of MSG on Haemoglobin (Hb) concentration, Parked cell volume (PCV), White blood cells (WBC) count and the kidney function, using some serum electrolytes (Sodium (Na^+), Potassium (K^+), Chloride (Cl^-), Bicarbonate (HCO_3^-), Blood urea Nitrogen (BUN) and Creatinine) as an indirect approach.

2 MATERIALS AND METHODS

2.1 Procurement and Management of Animals

The animals used for the study were 8 weeks old adult male Wistar rats weighing between 110 g and 230 g, obtained from the animal houses of the Faculty of Veterinary Medicine and Faculty of Pharmaceutical Sciences, University of Nigeria Nsukka (UNN). The feeds used for the study were normal rat diet chow bought from King Size feed and mill flour limited, Nsukka

2.1.1 Experimental Design/Treatment of Animals

Forty rats were acclimatized to the laboratory environment for seven days and then assigned to four groups of ten rats each. Administration of MSG was by oral intubation. The rats were maintained on normal rat chow bought from King-size and flour mill Ltd, Nsukka, Enugu State.

The animals were fed *ad libitum* on the chow and water throughout the duration of the experiment. The groups were as follows:

Group I was the control group and was administered distilled water only (2 ml/kg).

Group II was administered with 0.5 g/kg body weight of monosodium glutamate dissolved in distilled water (250 mg/ml).

Group III was administered with 1.0g/kg body weight of monosodium glutamate dissolved in distilled water (250 mg/ml).

Group IV was administered with 1.5g/kg body weight of monosodium dissolved in distilled water (250 mg/ml).

The rats in groups II, III and IV were given MSG 3 times a day, 7 days a week for 4 weeks.

2.1.2Animal Sacrifice and Sample Collection

All rats were sacrificed on day 28. The blood from the rats were collected through the ocular vein and allowed to clot, centrifuged and the serum separated from the cells. This was used for the analysis.

2.2 Estimation of Biochemical Parameters

Estimation of Haemoglobin (Hb) Concentration was done using the method of Drabkin and Austin (1935), Parked Cell Volume (PCV) was by Capillary tube method, (Microhaematocrit), as found in Baker et al., (2004) and the assay of White Blood Count (WBC) was done using Turks Solution (Baker and Silverton, 1985)

Assay of Blood Urea Nitrogen (BUN) was by DAM method, Serum Bicarbonate (HCO_3^-) by Forrester *et al*, 1976 method, Chloride by Skeggs and Hochestrasser 1964 method, Serum Potassium Ions by Terri and Sesin, 1958 method, Serum Sodium by Maruna, 1958 method, Serum Creatinine by the method based on the principle that creatinine in alkaline solution.

2.3 Statistics

The results were expressed as means ± SD and tests of statistical significance were carried out using one-way analysis of variance (ANOVA). The statistical package used was Genstat Release 4.23D lawes Agricultural Trust (Rothamsted Experimental Station). The acceptable level of significance was $P<0.05$ using a 2-tailed distribution.

3 RESULTS AND DISCUSSION

Table 1: In Vivo effect of varied concentration of MSG on Parked Cell Volume of Wistar Rats

Group	Dose (g/kg b.w)	%PCV	% change PCV
1	0.00	57.50 ± 1.71	0.0
2	0.50	55.00 ± 2.48	- 4.3
3	1.00	55.75 ± 1.11	- 3.0
4	1.50	53.25 ± 2.84	- 7.4

n = 10, Results are means ± S.D, Statistical significant difference ($p \leq 0.05$)

The results on table 1 shows that there was a reduction in the level of the packed cell volume of the test groups given the varying doses 500mg/kg, 1000mg/kg and 1500mg/kg body weight of MSG compared to the control. However, these reductions were not statistically significant ($P > 0.05$).

Table 2: In Vivo effect of varied concentration of MSG on Haemoglobin of Wistar Rats

Group	Dose (g/kg b.w)	Hb(g/dl)	% change in Hb
1	0.00	16.40 ± 0.55	0.0
2	0.50	17.53 ± 0.74	6.9
3	1.00	17.70 ± 0.46	7.9
4	1.50	16.89 ± 0.78	1.8

n = 10, Results are means ± S.D, Statistical significant difference ($p \leq 0.05$)

Table 2 shows insignificant difference in haemoglobin ($p > 0.05$) of groups administered varying doses 500mg/kg, 1000mg/kg and 1500mg/kg body weight of MSG compared to the control group.

Table 3: In Vivo effect of varied concentration of MSG on White Blood Cell of Wistar Rats

Group	Dose (g/kg b.w)	WBC(cell/dm^3)	% change in WBC
1	0.00	5325.00 ± 1000.30	0.0
2	0.50	3269.00 ± 2919.91	- 38.6
3	1.00	7150.00 ± 1632.23	34.3
4	1.50	7175.00 ± 1687.87	34.7

n = 10, Results are means ± S.D, Statistical significant difference ($p \leq 0.05$)

The results on table 3 shows that there was a reduction in the level of WBC of the test group administered 500mg/kg body weight of MSG compared to the control. It also shows that there was an increase in the level of WBC of the groups given both 1000mg/kg and 1500mg/kg body weight of MSG relative to the control group. These differences were not statistically significant ($P > 0.05$).

Table 4: In Vivo effect of varied concentration of MSG on serum creatinine of Wistar Rats

Group	Dose (g/kg b.w)	creatinine (mg/dl.)	% change of creatinine
1	0.00	1.25 ± 0.18	0.0
2	0.50	1.23 ± 0.47	- 1.6
3	1.00	1.58 ± 0.17	26.4
4	1.50	2.10 ± 0.12	68.0

n = 10, Results are means ± S.D, Statistical significant difference ($p \leq 0.05$)

The results in table 4 shows an insignificant reduction ($P > 0.05$) in the level of serum creatinine of the test group administered 500mg/kg body weight of MSG and an insignificant increase ($P > 0.05$) in the creatinine level of the test group given 1000mg/kg body weight of MSG compared to the control group. However, the creatinine level of the group administered 1500mg/kg body weight of MSG increased significantly ($P < 0.05$) compared to control group.

Table 5: In Vivo effect of varied concentration of MSG on Potassium ion of Wistar Rats

Group	Dose (g/kg b.w)	K^+ (mkq/1)	% change of K^+
1	0.00	3.83 ± 0.10	0.0
2	0.50	3.55 ± 0.05	- 7.31
3	1.00	3.90 ± 0.01	1.8
4	1.50	3.75 ± 0.05	- 2.1

n = 10, Results are means ± S.D, Statistical significant difference ($p \leq 0.05$)

Table 5 shows that there was no significant reduction ($P > 0.05$) in the level of serum potassium of the test groups administered 500mg/kg and 1500mg/kg body weight of MSG compared to the control group. There was also no significant increase ($P > 0.05$) in the potassium level of the test group given 100mg/kg body weight compared with control group.

Table 6: In Vivo effect of varied concentration of MSG on serum Sodium ion of Wistar Rats

Group	Dose (g/kg b.w)	Na^+ (mmol/1)	% change of Na^+
1	0.00	133.50 ± 2.10	0.0
2	0.50	138.75 ± 2.43	3.8
3	1.00	135.25 ± 1.03	1.5
4	1.50	131.50 ± 0.87	- 1.5

n = 10, Results are means ± S.D, Statistical significant difference ($p \leq 0.05$)

The results on table 6 shows an increase in serum sodium level of the test groups administered both 500mg/kg and 1000mg/kg body weight of MSG compared to the control group. A reduction in the level of sodium ions of the test group administered 1500mg/kg body weight of MSG was observed. These differences were not statistically significant ($P > 0.05$)

Table 7: In Vivo effect of varied concentration of MSG on serum Trioxocarbonate of Wistar Rats

Group	Dose (g/kg b.w)	HCO_3 (mmol/l)	% change of HCO_3
1	0.00	25.0 ± 0.58	0.0
2	0.50	26.0 ± 0.00	4.0
3	1.00	26.0 ± 0.82	4.0
4	1.50	24.5 ± 1.00	- 2.0

n = 10, Results are means ± S.D, Statistical significant difference ($p \leq 0.05$)

The result expressed table 7 shows an increase in the level of serum hydrogen trioxocarbonate IV of the test groups administered both 500mg/kg and 1000mg/kg body weight of MSG and a decrease in the test group given 1500mg/kg body weight of MSG compared with control group respectively. These differences were not statistically significant ($P > 0.05$).

Table 8: In Vivo effect of varied concentration of MSG on serum Chloride ions of Wistar Rats

Group	Dose (g/kg b.w)	Cl^-(ml/l)	% change of Cl^-
1	0.00	76.00 ± 1.00	0.0
2	0.50	81.75 ± 5.65	7.6
3	1.00	78.25 ± 2.75	3.0
4	1.50	69.50 ± 2.18	- 8.6

n = 10, Results are means ± S.D, Statistical significant difference ($p \leq 0.05$)

Table 8 shows that there were no significant changes ($P > 0.05$) between the levels of serum chloride of the control group and that of the test groups given MSG.

Table 9: In Vivo effect of varied concentration of MSG on serum Blood Urea of Wistar Rats

Group	Dose (g/kg b.w)	Blood Urea(ml/dl)	% change of Blood Urea
1	0.00	6.35 ± 0.46	0.0
2	0.50	6.98 ± 0.34	9.9
3	1.00	6.40 ± 0.33	0.8
4	1.50	9.05 ± 1.01	42.5

n = 10, Results are means ± S.D, Statistical significant difference ($p \leq 0.05$)

The results on table 9 showed that only the group given 1500mg/kg body weight of MSG had a statistically significant ($P < 0.05$) increase in the level of serum urea. The group administered both 500mg/kg and 1000mg/kg body weight of MSG had no statistically significant increase ($P > 0.05$) in the level of serum Urea.

4. DISCUSSION

Monosodium glutamate is widely used as a food additive and flavour enhancer in a variety of foods prepared at homes, in restaurants and by food processors in today's world (FASEB 1996; FDA 1996), although its effect on the body chemistry remains controversial (George, 2004).

The haemoglobin, WBC and PCV were evaluated. There was an insignificant difference ($P > 0.05$) in PCV, Hb and WBC levels of the test groups administered MSG compared with the control group. These insignificant difference ($P > 0.05$) in level of PCV, Hb and WBC of the test groups compared with the control is consistent with the finding of Laura *et al,* (2004) and Baker *et al,* (2005) which showed that MSG does not alter the PCV, Hb and WBC level.

The result of this study show an insignificant difference ($P > 0.05$) in the creatinine level of the test groups administered 500mg/kg and 1000mg/kg body weight of MSG compared with that of the control. This result is in agreement with the work of Voits *et al,* (2003) who reported that MSG does not alter the creatinine level. However, they show a significant difference ($P < 0.05$) in creatinine level of the test group administered 1500mg/kg body weight of MSG compared to the control. This result is at variance with the works of Meldrum, (1993) and Voits *et al,* (2003) which showed that MSG does not alter creatinine level. This variance might be due to the species of animal used in this study; adult rats as against postnatal female mice used by Voits *et al* (2003). It might also be due to the dosage of MSG used in this study 1500mg/kg body weight of MSG as against 4mg/g used by Meldrum, (1993).

There was an insignificant difference ($P > 0.05$) in serum potassium and sodium levels of the test groups compared with the control. This is consistent with the work of Meldrum, (1993) and Choi *et al,* (2004) which showed that MSG does not alter the serum potassium and sodium level.

The results also show an insignificant difference ($P > 0.05$) in serum hydrogen trioxocarbonate (HCO_3) levels of the test groups compared with the control group. These results are in agreement with the works of Zhang *et al,* (1996) and Mozes *et al,* (2004) which showed that MSG does not alter HCO_3 level.

There was an insignificant difference ($P > 0.05$) in serum chloride and blood urea nitrogen (BUN) of

the test groups administered 500mg/kg and 1000mg/kg body weight of MSG compared with the control. This result is in agreement with the findings of Zhang *et al,* (1996) and Mozes *et al,* (2004) which reported that MSG does not alter chloride and blood urea nitrogen levels in MSG treated mice. A significant decrease ($P < 0.05$) in serum blood urea nitrogen of the test group administered 1500mg/kg body weight of MSG was observed in this work relative to the control group. These results is at variance with the findings of Zhang *et al,* (1996), Voits *et al,* (2003) and Mozes *et al,* (2004) which reported that MSG does not alter blood urea nitrogen level. This discrepancy might be due to the dosage, species or sex of animals used in this work: Adult male rats as against female mice.

There was an insignificant difference ($P > 0.05$) in PCV, Hb and WBC levels of the test groups administered MSG compared with the control group. These insignificant difference ($P > 0.05$) in level of PCV, Hb and WBC of the test groups compared with the control is consistent with the finding of Laura *et al,* (2004) and Baker *et al,* (2005) which showed that MSG does not alter the PCV, Hb and WBC level.

Enemali and Danielson (2013), suggested that MSG may have been hazardous to the health of the test animals used in the work. They observed that varying doses 500mg/kg, 1000mg/kg and 1500mg/kg body weight of MSG significantly reduced the brain lipid levels of the test animals; hence this might lead to a state of depression of the brain.

We also reported earlier that although the use of monosodium glutamate may lead to the alteration of the activities of the liver enzymes in the serum, the changes were not significant enough to suggest the disruption of the architecture of the liver and/or other tissues bearing the enzymes (Enemali and Danielson, 2014).

In this present study, it has been found that, although there were changes (noticed in the concentrations of the serum electrolytes with the exception of creatinine and blood urea of the animals administered with 1500mg/kg body weight), non was found to be significant to suggest the disruption of the metabolic activities of the kidney.

5. Conclusion

From the foregoing, it can be concluded that apart from the brain lipid which was significantly altered (Enemali and Danielson, 2013), the in vitro serum enzyme (AST, ALT and ALP) activities, were unaltered (Enemali and Danielson, 2014) and also the kidney metabolic functions and other haematological parameters assayed here, were undisrupted. Our studies therefore, concludes that if the MSG can be barred from crossing the blood brain barrier and used in concentrations less than 1500mg/kg bw (which significantly increased the creatinine and BUN), it could be certified safe for consumption based on the parameters assessed in these studies.

6. References

Choi, D., Duff, D.A., Snell, K. and Hing, S.A. (2004). Late effect of postnatal monosodium glutamate on insulin action in adult rats physiol Res 49: 79 – 86.

Enemali, M. O. and Danielson, E. U. (2012). Effect of Monosodium Glutamate Orally Administered to Male Wister Rat on the Brain Lipid. *NSUK Journal of Science and Technology* 2 (1 & 2): 118 – 121

Enemali, M. O. and Danielson, E. U. (2014). The Effect of Monosodium Glutamate Orallyadministered to Male Wister Rats on the Serum AST, ALT and ALP. *Transnational Journal of Science and Technology* **4** (1) 7 – 15.

Federation of American Society for Experimental Biology (FASEB) (1996), Safety of amino acid used as dietary supplements/enhancement. Life science 19: 223-288.

Federation of American Society for Experimental Biology (FASEB) and Food and Drug Administration (FDA) (1995). Analyis of Adverse Reactions to monosodium glutamate (MSG). Life science vol. 9, 32.

Food and Drug Administration (FDA) (1996). Monosodium Glutamate. FDA backgrounder, BG – 91-97.

George, J.G. (2004). The toxicity and safety of processed free glutamic acid. J. Neuroscience, 21 8941-8952.

Klahr, S. and Miller, S. (1998). "Acute Oliguria" N. Engl. J. Med. 338 (10): 671-675.

Kubo, T., Kohiva, R., Okano, T., and Ishikawa, K. (2004). Neonatal glutamate can destroy the hippocampal CAI Structure and impair discrimination learning in rat. Brain Research 616: 311-314.

Meldrum, B. (1993). Amino acids as dietary excitotoxins: a contribution to understanding neurodengerative disorder. Brian Research Reviews. 18: 293-314.

Meyer, T.W. and Hostetter, T.H. (2007) "Uremia" N. Engl. J. med. 357(13): 1316.

Mozes S., Sefeikova I, Lenhardt L. (2004). Obesity and changes of alkaline phosphatase activity in small intestine of 40 – and 80 – day old rats subjected to early postnatal overfeeding or monosodium glutamate physiol REs 53: 177-186.

Stewart, P. (1998). Physiology of Kidney. J. Physi 9: 1-3.

Voits, M. Fosters, K.J, Rodels, P.U., Goight JP, Plagemann A., Flink H. (2003) obesity induced by unspecific early postnatal overfeeding in female rats: hypophagic effect of MSG. Namyn schmiedebergs Arch pharmacol 354: 374-378.

Zhang, Y. Shao J-s, Thie a-m, Alpers D.H. (1996) Effect of postnatal overfeeding on intestinal alkaline phosphatase activity in tissue and serum of rat treated with MSG AM. J. Physiol 241: G 461-G468.

The IISTE is a pioneer in the Open-Access hosting service and academic event management. The aim of the firm is Accelerating Global Knowledge Sharing.

More information about the firm can be found on the homepage:
http://www.iiste.org

CALL FOR JOURNAL PAPERS

There are more than 30 peer-reviewed academic journals hosted under the hosting platform.

Prospective authors of journals can find the submission instruction on the following page: http://www.iiste.org/journals/ All the journals articles are available online to the readers all over the world without financial, legal, or technical barriers other than those inseparable from gaining access to the internet itself. Paper version of the journals is also available upon request of readers and authors.

MORE RESOURCES

Book publication information: http://www.iiste.org/book/

Academic conference: http://www.iiste.org/conference/upcoming-conferences-call-for-paper/

IISTE Knowledge Sharing Partners

EBSCO, Index Copernicus, Ulrich's Periodicals Directory, JournalTOCS, PKP Open Archives Harvester, Bielefeld Academic Search Engine, Elektronische Zeitschriftenbibliothek EZB, Open J-Gate, OCLC WorldCat, Universe Digtial Library , NewJour, Google Scholar