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IMPACT OF 1.5% MONOSODIUM GLUTAMATE SOLUTION ON LIPID BIOMARKERS OF ALBINO RATS (*RATTUS NOVERGICUS*)

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Abstract

Monosodium glutamate (MSG) is a common food additive used to enhance flavor in processed foods. Despite being classified as generally safe by regulatory agencies, its potential health effects have been a subject of ongoing research. The trial was done to investigate the effect of MSG on cholesterol level, Triglyceride (TG) level, low density lipoprotein (LDL), and High-density lipoprotein (HDL) level of albino rats. The findings of the current study demonstrate that the effect of MSG on lipid profile (including Free Cholesterol, triglyceride, LDL, and HDL-C) leads to a significant increase in mild doses compared to the control group. It was observed that there was a notable increase in cholesterol levels, triglycerides, and low-density lipoprotein (LDL), accompanied by a decrease in high-density lipoprotein (HDL). The average triglyceride values in the control group of male rats were 122.7320, whereas in the MSG group, it was 122.0340, resulting in a difference of 0.69800. Similarly, the average cholesterol values in the control group were 153.9920, whereas in the MSG group, it was 110.9880, resulting in a group.

INTRODUCTION

Concerns related to the use of MSG in food to cause obesity in humans were raised by data from animal research in which neonatal injection of MSG provided a model of obesity with impaired glucose tolerance and insulin resistance. The mechanisms of MSG's influence on metabolism have been the subject of more theories. The effects of MSG on energy balance include making food more palatable and interfering with the hypothalamus signalling cascade that controls leptin function (He *et al.*, 2011). (Hermanussen and Tresguerres 2003) The inflammatory basis of MSG-induced obesity was revealed in 19-week-old rats that received 2 mg/g and 4 mg/g of MSG subcutaneous injections on postnatal days 2 and 4, respectively, and 6 mg/g and 8 mg/g injections on postnatal days 6, 8 and 10. MSG increased insulin, resisting, and leptin levels in the blood as well as the mRNA expression of

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interleukin-6, tumor necrosis factor-alpha, resisting, and leptin in visceral adipose tissue. It also decreased glucose tolerance (Roman-Ramos *et al.,* 2011).

MSG has been used to make adult laboratory mice obese in the past. This is due to the damage it causes in the hypothalamus' arcuate nucleus, which causes a rise in caloric intake exceeding calorie utilization (Ganong *et al*., 2005). MSG has been demonstrated to cause epileptic seizures in rats. With age, both the frequency and severity of deaths gradually rose. In adult male Wistar rats, MSG has a harmful effect on the test is because it significantly increases aberrant sperm morphology and oligozoospermia in a dose-dependent manner (Onakewhor *et al*., 2017). The sodium salt of the amino acid L-glutamic acid is monosodium glutamate (MSG), also referred to as sodium glutamate. Its IUPAC name is sodium 2-aminopentanedioate, and the carboxyl group's sodium atom stands in for the hydrogen atom. When German chemist Karl Heinrich Ritthausen experimented with wheat gluten and sulfuric acid to discover and identify L-glutamic acid (the natural form of glutamate) in 1866, the word "glutamate" was born. Japanese chemist Kikunae Ikeda discovered the most notable feature of glutamic acid and its salts up until 1908. It all began with a taste assessment of the predominant flavor of dashi (Thuy *et al*., 2020).

Following injection or oral administration of MSG, studies in suckling rodent pups revealed serious physiological abnormalities and substantial obesity. Some of these animal models displayed fasting hyperinsulinemia, hyperleptinemia, adiposity, and a rise in plasma fatty acids and triacylglycerols (Seiva *et al.,* 2012). When MSG is given to newborn rats, the neurons in the hypothalamic arcuate nucleus develop different abnormalities. The loss of neurons affects pituitary and adrenal activity, insulin and leptin signalling, and energy homeostasis (Yin *et al.,* 2013). These effects are primarily related to the young animals' immature blood–brain barriers (Boonnate *et al.,* 2015). The excitatory neurotransmitter glutamate has a significant role in both physiological and pathological processes in the mammalian central nervous system (CNS) (Mattson *et al.,* 2008). There are six different types of glutamate receptors, including three families of ionotropic receptors (NMDA, AMPA, and kainate), and three families of metabotropic receptors (mGluR) (Meldrum *et al.,* 2000). They control numerous essential metabolic and autonomic functions in the central nervous system, which includes the amygdala, hippocampus, and hypothalamus (Collison *et al.,* 2012).

Because liver transaminases were drastically suppressed, researchers surmised that MSG might cause liver damage as a result of nonalcoholic steatohepatitis, which would then increase inflammation. (Roman-Ramos *et al.,* 2011) It has also been demonstrated in 32-week-old C57BL/6J mice whose mothers were fed low-dose dietary monosodium glutamate (0.64 g/l; 97 mg/kg) throughout gestation and were weaned onto the same diet that liver changes are associated with adipose tissue metabolism in nonalcoholic steatohepatitis. MSG raised the expression of numerous adipocyte differentiation-related genes and increased the production of insulin, bile, free fatty acids, and triglycerides in the blood (Collison *et al.,* 2010b). Further investigation into the potential protective benefits of many compounds, particularly antioxidants, was sparked by studies that provided evidence of the harmful consequences of MSG ingestion. Male albino rats' cerebellar cortex was exposed to toxic nerve cell and astrocyte glial fibrillary acidic protein damage for 14 days while receiving vitamin C at a dose of 100 mg/kg/day via a metal orogastric tube along with MSG at a dose of 3 g/kg/day mixed with food (Hashem et al., 2012). The effects of MSG on the superoxide dismutase and catalase activity in the liver, kidney, and brain of MSG-treated rats (4 mg/g, intraperitoneally for 10 days) were effectively mitigated by all vitamins C (200 mg/kg), vitamin E (200 mg/kg), and quercetin (10 mg/kg) when administered orally. These vitamins also modulated glutathione levels and glutathione-Stransferase activity. In serum alanine aminotransferase, aspartate aminotransferase, and -glutamyl transferase, all antioxidants decreased the MSG-increase (Farombi and Onyema 2006).

MSG consumption and its harmful consequences have also been linked to a number of other systems. The subject of MSG as an asthma trigger has received the greatest attention. Despite a few anecdotal reports linking MSG sensitivity to asthma, reviews have revealed that these studies lacked a reliable

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experimental design and could not be replicated in order to provide proof that MSG is connected to an asthma response. (Freeman 2006, Beausoleil *et al.*, 2007). Additionally, a more recent investigation on dietary habits and MSG use in Chinese individuals was unable to establish a link between MSG and asthma (Shi *et al.*, 2012b). Additionally, there is little proof to back up adults with chronic asthma avoiding MSG (Zhou et al. 2012), which is supported by an animal study using a mouse model of ovalbumin-induced asthma that was fed a diet containing 0.5% or 5% MSG for the week leading up to the first ovalbumin injection and for the following three weeks. MSG had no effect on eosinophil infiltration, production of Th2 cytokines, circulating Age concentrations in the lungs, or the induced airway hyperresponsiveness (Yoneda *et al.*, 2011).

There is evidence from numerous researches that MSG-induced obesity is related to other systems. Compared to control rats, MSG-injected obese rats had higher mean arterial blood pressure and less variability in their heart rates, bradycardia, and responses to vigil and sympathetic stimulation at 33 weeks of age (Konrad *et al.*, 2012). While control animals mobilised brown adipose tissue lipids following exposure to 4 degrees Celsius for six hours, obese mice caused by MSG showed a much higher decline in core temperature after acute cold exposure (4 degrees C for two hours). The authors suggested that the decreased activation of thermogenic pathways in brown adipose tissue in MSG-treated mice led to faulty cold-induced thermogenesis (Moss *et al.*, 1985). Monosodium glutamate (MSG) is a common food additive used to enhance flavor in processed foods. Despite being classified as generally safe by regulatory agencies, its potential health conditions effects have been a subject of ongoing research. The impact of MSG on lipid metabolism has been of particular interest, given the association between abnormal lipid profiles and various health conditions. To investigate this further, a study was conducted on 20 wistar rats to assess the effect of MSG on their lipid profile. The results of this study provided insights into the potential impact of MSG consumption on human lipid metabolism and contribute to the development of better-informed public health policies.

MATERIAL AND METHOD

Experimental site:

The trial was conducted in animal house in the Department of Zoology, Islamia University of Bahawalpur, Pakistan. Bahawalpur lies 112 meter above sea level. The climate is hot and dry. The mean annual temperature is 28.33degree centigrade, the month of June being hottest when daily maximum temperature increases.

Chemicals:

Monosodium glutamate

L-glutamic acid, a flavoring agent that naturally occurs in many foods, is the source of monosodium glutamate (MSG). L-glutamic acid is a non-essential amino acid, which means that it may be produced by your body on its own and is not dependent on food sources. MSG is a crystalline powder that is white, flavourless, and frequently used as a food additive. It is referred to as E621 in the food business. With little effort, it dissolves in water and separates into sodium and free glutamate. It affects an animal's liver, kidney, lipid profile, and hematology.

Test Organisms

10 wistar albino rats were purchased from CIDS (cholistan institute of desert) .All of these rats having different ages, different weight but same gender i.e. males. All of these rats were kept in a small wooden box according to their groups. Rats were given with basic rat diet in the form of pallets two times in a day. Water was given as tap water to group C(control group) and in the form of stock solution of MSG and ditilled water. Suitable room temperature and light was provided to rats.

Experimental Design:

The rats kept in the large wood box having many parts. Wooden box having wooden floor, three walls of iron mesh, having height 3.5 ft, having length of 2ft, it was placed inside the room. The rat room temperature was maintained 24 to 29 degree centigrade with 40 to 45 percent humidity conditions and it was provided by normal photoperiod all over the day. All the rats were divided into two groups and the groups were B and C. Group B and C having 5 rats in each where C group was considered as control group having 5 rats.

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Group B exposed to certain concentration of monosodium glutamate respectively. Control group was provided with tap water. All of these rats kept under hygienic conditions and in the same environment. Salt i.e. MSG was given in water to rats by making certain solution.

Dose preparation:

Stock solution of 1.5% sodium chloride was prepared by dissolving 15g of sodium chloride in distilled water to make a final volume of 1000 ml solution. Then this stock solution was administrated daily at ad-labitum in the form of water feeder bottles with open access to each animal. This solution was freshly prepared and replaced daily.

Sample/Blood Collection:

Albino rats were anesthetized with chloroform and blood was collected for the purpose of serum separation. Blood was collected in test tubes having clot activator and then blood was collected in separate Eppendorf. Blood was divided into two parts. One for the study of hematological parameters and second for serum biochemical profiling. Serum samples were frozen and stored at -20°C until used for biochemical analysis. Firstly, blood was collected in serum separator tube. Then it was centrifuge by using centrifugation machine at 2000rpm for 15 min.

Statistical Analysis:

After calculating, concentration of all parameters of lipid profile, data was organized using Microsoft Excel 2007 and for the comparison of mean values of control group and treatment group. Student t-test was applied using IBM SPSS statistics 2020 version 27.0.1.0

RESULTS

Table No. 4.1. Effects of 1.5% Monosodium glutamate solution on the lipid profile of male albino rats (Rattus novergicus)

Lipid biomarkers	Mean±SEM		F-value	P-value	Significance
	CG	EG			
Triglyceroide	122.7±12.5	122±13.1	0.0	0.999	SNS
LDL	85.8±8.87	89±7.86	0.048	0.833	SNS
Cholestrol	153.9±23.7	110.9±14.6	3.098	0.116	SNS
HDL	45.4±8.83	49.0±7.26	0.536	O.485	SNS

CG=Control group, EG=Experimental group, SEM=Standard error mean, SNS=statistically not significant

Sample test was useful to estimate the effect of 1.5% monosodium glutamate solution in albino rats as compared to control group. It is observed that the concentration of Triglycerides in experimental group (122±13.1) is same as control group(122.7±12.5) .It is detected that the concentration of cholesterol is non-significantly decreased in experimental group(110.9±14.6) provided with 1.5% MSG solution as compared to control group(153.9±23.7) provided with tap water. It is considered that concentration of LDL is non-significantly increased in experimental group (89±7.86) as compared to control group(85.8±8.87).It is detected that the concentration of HDL is non-significantly increased in experimental group(49.0±7.26) as compared to control group (45.4±8.83).The test was useful to estimate the effects of 1.5% MSG in experimental group as compared to control group.

Discussion

Cholesterol is a waxy substance found in blood of all animals. Body of organisms needs cholesterol to build healthy cells, but high levels of cholesterol can increase your risk of heart disease. 1.5% monosodium glutamate may increase the cholesterol level in rat. Our analysis showed that 1.5% monosodium glutamate resulted in decrease in cholesterol about 43 mg/dL (153.9±23.7 to 110.9±14.6) in 15days. These represents non-

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significant effect (p=0.116). These results agree with (Olaleye *al.,* 2014). There results show significant change in cholesterol level. The Mean±SEM values of cholesterol level changed form 1.37±1.00 to 2.39 ± 0.21 mmol/l.

Triglycerides are a type lipid that circulates in blood of organisms. They are the most common type of fat. Our study shows that 1.5% monosodium glutamate solution show no change in triglycerides in 15 days. These represents non-significant effect (p=0.9). These results disagree with (Olaleye*et al.,* 2014). There results show significant change in triglycerides level. The Mean±SEM values of triglycerides level changed form 0.33 ± 0.03 to 1.51± 0.22 mmol/l.

LDL (low-density lipoprotein) cholesterol, sometimes called "bad" cholesterol, makes up most of body's cholesterol. High levels of LDL cholesterol raise your risk for heart disease and stroke. 1.5% monosodium glutamate solution may increase LDL level. Our results show that1.5% monosodium glutamate solution results in increase of 4 mg/dL(85.5±8.87 to 89±7.86) LDL cholesterol in 15 days. These results agree with (Olaleye *at al.,* 2014). There results show significant change in LDL cholesterol level. The Mean±SEM values of LDL cholesterol level changed form 0.18 ± 0.05 to 0.9 ± 0.04 mmol/l.

HDL (high-density lipoprotein) cholesterol, sometimes called "good" cholesterol, absorbs cholesterol in the blood and carries it back to the liver. The liver then flushes it from the body. Our results show that1.5% monosodium glutamate solution results in increase of 4mg/dL(45.4±8.83 to 49±7.26) HDL cholesterol in 15 days. These results agree with (Olaleye*et al.,* 2014). There results show slight change in HDL cholesterol level. The Mean±SEM values of HDL cholesterol level changed form 0.80 ± 0.04 to 0.35 ± 0.13 mmol/l.

ADD MORE DATA.....

CONCLUSION

The present study concluded that MSG effect on lipid profile (Free Cholesterol, triglyceride, LDL and HDL-C) is significance increase in mild dose compared with control. There is observed significant increase in cholesterol level, triglycerides, and low density lipoprotein but decrease in high density lipoprotein. The mean values of triglycerides control group and MSG group of male rats 122.7320 and 122.0340 respectively and there difference is 0.69800.The mean values of cholesterol control group and MSG group of male rats 153.9920 and 110.9880 respectively and there difference is 43.00400 .The mean values of LDL control group and MSG group of male rats 85.8000 and 89.0000 respectively and there difference -3.20000.The mean values of LDL control group and MSG group of male rats 45.4800 and 49.0100 respectively and there difference is -3.53000 MSG increases cholesterol, TG, and LDL level in the body while decrease HDL level.

REFERENCES:

Ahmed, R. R., Abdul-Hamid, M., Galaly, S. R., & Hamdalla, H. M. (2019). Monosodium glutamate-induced liver microscopic and biochemical changes in male rats, and the possible amendment of quercetin. *Egyptian Journal of Zoology*, *71*(71), 44-55.

Amati , P., Peláez, B., Blazquez, J. L., Pastor, F. E., & Sánchez, A. (1999) Lectinhistochemistry and ultrastructure of microglial response to monosodium glutamate-mediated neurotoxicity in the arcuate nucleus *Histology and histopathology*, *14*(1), 165-174.

Balogun, M. E., Besong, E. E., Obimma, J. N., Iyare, E. E., & Nwachukwu, D. C. (2019). Ameliorative effect of aqueous extract of Hibiscus sabdariffa (Roselle) on salt-induced hypertension in wistar rats. *Pharmacologyonline*, *2*, 247-258.

Banerjee, A., Mukherjee, S., & Maji, B. K. (2021) Worldwide flavor enhancer monosodium glutamate combined with high lipid diet provokes metabolic alterations and systemic anomalies: An overview. *Toxicology Reports*, *8*, 938-961.

Banerjee, A. , Mukherjee, S., & Maji, B. K. (2021). Monosodium glutamate causes hepato-cardiac derangement in male rats. *Human & Experimental Toxicology*, *40*(12_suppl), S359-S369.

Beausoleil, J. L., Fiedler, J., & Spergel, J. M. (2007) Food Intolerance and childhood asthma: what is the link? *Pediatric Drugs*, *9*, 157-163.

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

Boonnate, P., Waraasawapati, S., Hipkaeo, W., Pethlert, S., Sharma, A., Selmi, C., & Cha'on, U.(2015). Monosodium glutamate dietary consumption decreases pancreatic β-cell mass in adult Wistar rats. *PLoS One*, *10*(6), e0131595.

Cho, T. M., Peng, N., Clark, J. T., Novak, L., Roysommuti, S., Prasain, J., & Wyss, J. M. (2007). Genistein attenuates the hypertensive effects of dietary NaCl in hypertensive male rats. *Endocrinology*, *148*(11), 5396-5402.

Collison, K. S., Makhoul, N. J., Zaidi, M. Z., Al-Rabiah, R., Inglis, A., Andres, B. L., ... & Al-Mohanna, F. A. (2012). Interactive effects of neonatal exposure to monosodium glutamate and aspartame on glucose homeostasis. *Nutrition & metabolism*, *9*, 1-13.

Collison, K. S., Makhoul, N. J., Zaidi, M. Z., Al-Rabiah, R., Inglis, A., Andres, B. L., & Al-Mohanna, F. A. (2012). Interactive effects of neonatal exposure to monosodium glutamate and aspartame on glucose homeostasis *Nutrition & metabolism*, *9*, 1-13

Collison, K. S., Maqbool, Z. M., Inglis, A. L., Makhoul, N. J., Saleh, S. M., Bakheet, R. H., ... & Al-Mohanna, F. A. (2010). Effect of dietary monosodium glutamate on HFCS-induced hepatic steatosis: expression profiles in the liver and visceral fat. *Obesity*, *18*(6), 1122-1134.

Das, R. S., & Ghosh, S. K. (2010) Long term effects of monosodium glutamate on spermatogenesis following neonatal exposure in albino mice–a histological study. *Nepal Med Coll J*, *12*(3), 149-153.

Das, R. S., & Ghosh, S. K. (2011) Long term effects in ovaries of the adult mice following exposure to Monosodium glutamate during neonatal life–a histological study. *Nepal Medical College Journal*, *13*(2), 77-83.

De Filippo, C., Cavalieri, D., Di Paola, M., Ramazzotti, M., Poullet, J. B., Massart, S., & Lionetti, P. (2010). Impact of diet in shaping gut microbiota revealed by a comparative study in children from Europe and rural Africa *Proceedings of the National Academy of Sciences*, *107*(33), 14691-14696.

Dolnikoff, M., Martin-Hidalgo, A., Machado, U.F., Lima, F. B., & Herrera, E. (2001).Decreased lipolysis and enhanced glycerol and glucose utilization by adipose tissue prior to development of obesity in monosodium glutamate (MSG) treated-rats. *International journal of obesity*, *25*(3), 426-433.

El Malik, A., & Sabahelkhier, M. K (2019). Changes in lipid profile and heart tissues of wistar rats induce by using monosodium glutamate as food additive. *International of Journal Biochemistry and Physiology*, *4*(1), 141-147.

El-Ezaby, M. M., Abd-El Hamide, N. A. H., El-Maksoud, M. A. E., Shaheen, E. M., & Embashi, M. M. (2018). Effect of some food additives on lipid profile, kidney function and liver function of adult male albino rats. *J Bas Environ Sci*, *5*, 52-59.

Eweka, A. O., Eweka, A., & Om'Iniabohs, F. A. (2010) Histological studies of the effects of monosodium glutamate of the fallopian tubes of adult female Wistar rats. *North American journal of medical sciences*, *2*(3).

Eweka, A. O., Igbigbi, P. S., & Ucheya, R. E. (2011) Histochemical studies of the effects of monosodium glutamate on the liver of adult Wistar rats. *Annals of medical and health sciences research*, *1*(1), 21-30.

Farombi, E. O., & Onyema, O. O. (2006) Monosodium glutamate-induced oxidative damage and genotoxicity in the rat: modulatory role of vitamin C, vitamin E and quercetin. *Human & experimental toxicology*, *25*(5), 251-259.

Freeman, M. (2006) reconsidering the effects of monosodium glutamate: a literature review. *Journal of the American Academy of Nurse Practitioners*, *18*(10), 482-486.

Freeman, M. (2006) reconsidering the effects of monosodium glutamate: a literature review. *Journal of the American Academy of Nurse Practitioners*, *18*(10), 482-486.

Ganong, W. (2005) Review of Medical Physiology, 22nd Edn. 928 pp. *Appleton and Lange, USA.*

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

Gonzalez-Burgos, I., Perez-Vega, M. I., & Beas-Zarate, C. (2001) Neonatal exposure to monosodium glutamate induces cell death and dendritic hypotrophy in rat prefrontocortical pyramidal neurons. *Neuroscience letters*, *297*(2), 69-72.

Guven, S., El-Bershawi, A., Sonnenberg, G. E., Wilson, C. R., Hoffmann, R. G., Krakower, G. R., & Kissebah, A. H. (1999). Plasma leptin and insulin levels in weight-reduced obese women with normal body mass index: relationships with body composition and insulin. *Diabetes*, *48*(2), 347-352.

Hashem, H. E., El-Din Safwat, M. D., & Algaidi, S. (2012) The effect of monosodium glutamate on the cerebellar cortex of male albino rats and the protective role of vitamin C (histological and immunohistochemical study). *Journal of molecular histology*, *43*, 179-186.

Hazzaa, S. M., El-Roghy, E. S., Abd Eldaim, M. A., & Elgarawany, G. E. (2020). Monosodium glutamate induces cardiac toxicity via oxidative stress, fibrosis, and P53 proapoptotic protein expression in rats. *Environmental Science and Pollution Research*, *27*, 20014-20024.

He, K., Du, S., Xun, P., Sharma, S. Wang, H., Zhai, F., & Popkin, B. (2011) Consumption of monosodium glutamate in relation to incidence of overweight in Chinese adults: China Health and Nutrition Survey (CHNS). *The American journal of clinical nutrition*, *93*(6), 1328-1336.

Helal, E. G., El-Sayed, R. A., & El-Gamal, M. S. (2017). Assessment of the physiological changes induced by sodium nitrite, annatto or mono sodium glutamate in male albino rats. *The Egyptian Journal of Hospital Medicine*, *67*(1), 330-335.

Hermanussen, M, & Tresguerres, J. A. F. (2003) Does high glutamate intake cause obesity?. *Journal of Pediatric Endocrinology and Metabolism*, *16*(7), 965-968.

Hernández-Bautista, R. J., Alarcón-Aguilar, F. J., Escobar-Villanueva, M. D. C., Almanza-Pérez, J. C., Merino-Aguilar, H., Konigsberg Fainstein, M., & López-Diazguerrero, N. E. (2014). Biochemical alterations during the obese-aging process in female and male monosodium glutamate (MSG)-treated mice. *International journal of molecular sciences*, *15*(7), 11473-11494.

Ibegbulem, C. O., Chikezie, P. C., Ukoha, A. I., & Opara, C. N. (2016). Effects of diet containing monosodium glutamate on organ weights, acute blood steroidal sex hormone levels, lipid profile and erythrocyte antioxidant enzymes activities of rats. *Journal of Acute Disease*, *5*(5), 402-407.

J., Tang, M., Liu, Y., Xu, J., & Xu, X. (2022). Xu function and flora in mice. *Food Science and Human Wellness*, Safety assessment of monosodium glutamate based on intestinal *11*(1), 155-164.,

Kazmi, Z., Fatima, I., Perveen, S., & Malik, S. S. (2017). Monosodium glutamate: Review on clinical reports. *International Journal of food properties*, *20*(sup2), 1807-1815.

Kesl, S. L., Poff, A. M., Ward, N. P., Fiorelli, T. N., Ari, C., Van Putten, A. J., ... & D'Agostino, D. P. (2016). Effects of exogenous ketone supplementation on blood ketone, glucose, triglyceride, and lipoprotein levels in Sprague–Dawley rats. *Nutrition & metabolism*, *13*(1), 1-15.

Konrad, S. P., Farah, V., Rodrigues, B., Wichi, R. B., Machado, U. F., Lopes, H. F., D'Agord Schaan, B., De Angelis, K. & Irigoyen, M. C. (2012) "Monosodium Glutamate Neonatal Treatment Induces Cardiovascular Autonomic Function Changes in Rodents," Clinics (Sao Paulo), 67(10), 1209-14.

Meldrum, B. S. (2000). Glutamate as a neurotransmitter in the brain: review of physiology and pathology. *The Journal of nutrition*, *130*(4), 1007S-1015S.

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

Millichap, J. G., & Yee, M. M. (2003) The diet factor in pediatric and adolescent migraine. *Pediatric neurology*, *28*(1), 9-15.

Miskowiak , B., & Partyka, M. (2000) Neonatal treatment with monosodium glutamate (MSG): structure of the TSH-immunoreactive pituitary cells. *Histology and histopathology*, *15*(2), 415-420.

Miśkowiak, B., Limanowski, A., & Partyka, M. (1993) Effect of perinatal administration of monosodium glutamate (MSG) on the reproductive system of the male rat. *Endokrynologia Polska*, *44*(4), 497-505.

Mohamed, M. A., El-Nahrawy, W. A., Zaher, A. M., & Amer, A. S. (2022). Therapeutic role of nanocurcumin versus monosodium glutamate toxicity. *Egyptian Academic Journal of Biological Sciences, B. Zoology*, *14*(1), 55-65.

Moss, D., Ma, A. & Cameron, D. P. (1985)"Defective Thermoregulatory Thermogenesis in Monosodium Glutamate-Induced Obesity in Mice," Metabolism, 34(7), 626-30.

Mozes, S., Sefcikova, Z., Lenhardt, L., & Racek, L. (2004). Obesity and changes of alkaline phosphatase activity in the small intestine of 40-and 80-day-old rats subjected to early postnatal overfeeding or monosodium glutamate. *Physiological research*, *53*(2), 177-186.

Nardelli, T. R., Ribeiro, R. A., Balbo, S. L., Vanzela, E. C., Carneiro, E. M., Boschero, A. C., & Bonfleur, M. L. (2011). Taurine prevents fat deposition and ameliorates plasma lipid profile in monosodium glutamate-obese rats. *Amino acids*, *41*, 901-908.

Niaz, K., Zaplatic, E., & Spoor, J. (2018). Extensive use of monosodium glutamate: A. *EXCLI journal*, *17*, 273.

Ogbuagu, E. O., Airaodion, A. I., Okoroukwu, V. N., & Ogbuagu, U. (2019). Hyperglycemic and hypocholesterolemic effect of monosodium glutamate in Wistar rats. *International Journal of Research and Reports in Hematology*, *2*(3), 1-7.

Ogbuagu, O. E., Nweke, I. N., & Unekwe, P. C. (2015) Organ toxicity of monosodium glutamate in adult albino Wistar rats. *Journal of Medical Investigations and Practice*, *10* (1) 1

Okediran, B. S., Olurotimi, A. E., Rahman, S. A., Michael, O. G., & Olukunle, J. O. (2014). Alterations in the lipid profile and liver enzymes of rats treated with monosodium glutamate. *Sokoto journal of veterinary sciences*, *12*(3), 42-46.

Olaleye, M. T., Crown, O. O., Akinmoladun, A. C., & Akindahunsi, A. A. (2014). Rutin and quercetin show greater efficacy than nifedipin in ameliorating hemodynamic, redox, and metabolite imbalances in sodium chloride-induced hypertensive rats. *Human & experimental toxicology*, *33*(6), 602-608.

Olorunnisola, O. S., Adegbola, P. I., Ajilore, B. S., Akintola, O. A., & Fadahunsi, O. S. (2021). The role of poly-herbal extract in sodium chloride-induced oxidative stress and hyperlipidemia in male wistar rats. *Medicines*, *8*(6), 25.

Olumakaiye, M. F., Atinmo, T., & Olubayo-Fatiregun, M. A. (2010) Food consumption patterns of Nigerian adolescents and effect on body weight. *Journal of nutrition education and behavior*, *42*(3), 144-151

Onakewhor, J. U., Oforofuo, I. A., & Singh, S. P. (2017) Chronic administration of monosodium glutamate induces oligozoospermia and glycoen accumulation in Wistar rat testes. *African Journal of Reproductive Health*, *2* (2)

Park, E., Yu, K. H., Kim, D. K., Kim, S., Sapkota, K., Kim, S. J., & Chun, H. S. (2014). Protective effects of N-acetylcysteine against monosodium glutamate-induced astrocytic cell death *Food and chemical toxicology*, *67*, 1-9.

Rivera-Cervantes, M. C., Torres, J. S., Feria-Velasco, A., Armendariz-Borunda, J., & Beas-Zárate, C. (2004) NMDA and AMPA receptor expression and cortical neuronal death are associated with p38 in glutamate-induced

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

excitotoxicity in vivo. *Journal of neuroscience research*, *76*(5), 678-687.

Roman-Ramos, R., Almanza-Perez, J. C., Garcia-Macedo, R., Blancas-Flores, G., Fortis-Barrera, A., Jasso, E. I., . & Alarcon-Aguilar, F. J. (2011). Monosodium glutamate neonatal intoxication associated with obesity in adult stage is characterized by chronic inflammation and increased mRNA expression of peroxisome proliferator-activated receptors in mice. *Basic & clinical pharmacology & toxicology*, *108*(6), 406-413.

Seiva, F. R., Chuffa, L. G. A., Braga, C. P., Amorim, J. P. A., & Fernandes, A. A. H. (2012). Quercetin ameliorates glucose and lipid metabolism and improves antioxidant status in postnatally monosodium glutamate-induced metabolic alterations. *Food and Chemical Toxicology*, *50*(10), 3556-3561.

Seiva, F. R., Chuffa, L. G. A., Braga, C. P., Amorim, J. P. A., & Fernandes, A. A. H. (2012). Quercetin ameliorates glucose and lipid metabolism and improves antioxidant status in postnatally monosodium glutamate-induced metabolic alterations. *Food and Chemical Toxicology*, *50*(10), 3556-3561.

Shi, Z., Yuan, B., Wittert, G. A., Pan, X., Dai, Y., Adams, R., & Taylor, A. W. (2012) Monosodium glutamate intake, dietary patterns and asthma in Chinese adults. *PloS one*, *7* (12), e51567

Singh, K., & Ahluwalia, P. (2012) Effect of monosodium glutamate on lipid peroxidation and certain antioxidant enzymes in cardiac tissue of alcoholic adult male mice. *Journal of cardiovascular disease research*, *3*(1), 12-18.

Singh, K., Sharma, J., Kaur, A., & Ahluwalia, P. (2011). Alteration upon oral ingestion of monosodium glutamate in various lipid and lipoprotein fractions in serum of adult male rat. *Journal of Life Sciences*, *3*(1), 17-21.

Škultétyová, I., Kiss, A., & Ježová, D. (1998) Neurotoxic lesions induced by monosodium glutamate result in increased adenopituitary proopiomelanocortin gene expression and decreased corticosterone clearance in rats. *Neuroendocrinology*, *67*(6), 412-420.

Thiam, I., Samba, K., & Lwanga, D. (2006) Diet related chronic disease in the West Africa Region. *SCN news*, *33*(5).

Thuy, L. N., Salanta, L., Tofana, M., Socaci, S. A., Fărcaş, A. C., & Pop, C. R. (2020) A mini review about monosodium glutamate. *Bulletin UASVM Food Science and Technology*, *77*(1), 1-12.

Tunc-Ata, M., Altintas, F., Senol, H., Nizamoglu, E., & Kucukatay, V. (2021). Ileal interposition improves metabolic syndrome parameters in a rat model of metabolic syndrome induced by monosodium glutamate. *Life Sciences*, *266*, 118846.

Yin, G. S., Lin, S. D., Xu, D. C., Sun, R. Q., Lin, K., & Lin, C. J. (2013). Handle region peptide ameliorating insulin resistance but not β cell functions in male rats neonatally treated with sodium L-glutamate. *International journal of endocrinology*, *2013*.

Yoneda, J., Chin, K., Torii, K., & Sakai, R. (2011) Effects of oral monosodium glutamate in mouse models of asthma. *Food and Chemical Toxicology*, *49*(1), 299-304.

Zanfirescu, A., Ungurianu, A., Tsatsakis, A. M., Niţulescu, G. M., Kouretas, D., Veskoukis, A., ... & Margină, D. (2019). A review of the alleged health hazards of monosodium glutamate. *Comprehensive reviews in food science and food safety*, *18*(4), 1111-1134.

Zhang, N., Huan, Y., Huang, H., Song, G. M., Sun, S. J., & Shen, Z. F. (2010). Atorvastatin improves insulin sensitivity in mice with obesity induced by monosodium glutamate. *Acta Pharmacologica Sinica*, *31*(1), 35-42.

1. Zhou, Y., Yang, M., & Dong, B. R. (2012)

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

Monosodium glutamate avoidance for chronicasthma in adults and children. *Cochrane Database of Systematic Reviews*, (6)