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ORIGINAL ARTICLE

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Effect of Monosodium Glutamate on Hepatic and Renal Functions in Albino Rat

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Our present study aimed to evaluate the impact of monosodium glutamate (MSG) on hepatic and renal functions in albino rats, administering doses of 35, 70, and 105 mg/kg body weight daily for 17 days. Significant changes in body weight and the relative weight of liver and kidneys were observed. Notable findings included increased serum glutamic oxaloacetic transaminase (SGOT) activity, reduced total protein content, and elevated total cholesterol and glucose levels in liver and kidney tissues. Additionally, kidney function was adversely affected, indicated by increased serum urea and creatinine levels. These results suggest that MSG induces oxidative stress, leading to hepatic and renal dysfunction.

Key words: Monosodium glutamate (MSG), Body and Organ weight, Biochemical parameters, Hepatic functions, Renal functions

Monosodium glutamate (MSG), a salt derived from glutamic acid, is a common flavour enhancer in Chinese cuisine, canned vegetables, soups, and processed meats, giving foods a distinctive umami taste (Jinap and Hajeb, 2010). It is produced through the fermentation of molasses and is widely used in home kitchens, restaurants, and the food industry (Farombi and Onyema, 2006). Recent studies have focused on the potential adverse effects of MSG, linking it to Chinese restaurant syndrome, characterized by symptoms like headaches, flushing, numbness, muscle tightness, general weakness, and bronchoconstriction in asthma patients (Freeman, 2006). MSG consumption has also been associated with obesity and metabolic syndrome, regardless of physical activity levels and calorie intake (He *et al*., 2008).

The liver, the largest gland in mammals, performs essential metabolic activities, including detoxification, amino acid metabolism, gluconeogenesis, glycogen storage, lipid production, and vitamin storage. Liver function tests evaluate these activities (Johnson, 1995; Stryer, 1995; Guyton, 1996; Ganong, 1999; Nelson, 2000).

The kidneys, located at the back of the abdominal wall, remove toxins and waste from the blood and regulate fluid and electrolyte balance. Renal function is assessed through standard urinalysis, measuring serum levels of urea, creatinine, sodium, potassium, and bicarbonate (Stryer, 1995; Montgomery *et al*., 1990; Burtis and Ashwood, 1999; Merck Manual, 2004).

This research aims to clarify the specific impacts of MSG on albino rats by examining changes in body weight, organ weight, and biochemical markers related to liver and kidney function.

MATERIALS AND METHODS

Adult male albino rats, weighing between 180-200 g, were purchased from Datta Meghe College of Pharmacy, Wardha, and acclimatized prior to the experiment. They were housed under standard hygienic conditions with access to rat chow and water ad libitum, and were fasted for 1 hour before treatment. The experimental protocol was approved by the Institutional Animal Ethics Committee (IAEC) in accordance with the guidelines of the Committee for the Purpose of Control and Supervision of Experiments on Animals (CPCSEA), Government of India (Registration No. 478/GO/Re/S/01/CPCSEA) Monosodium glutamate (MSG) was procured from Himedia Laboratories Private Limited, Mumbai, Maharashtra. The rats were randomly assigned to four groups (n=6): Group 1 (control) received feed without MSG, while Groups 2, 3, and 4 received 35, 70, and 105 mg/kg body weight of MSG, respectively, daily for 17 days. The rats were sacrificed on the 18th day. Body weight was measured before treatment and at sacrifice, and the liver and kidneys were dissected and weighed to obtain relative weights. Blood samples were collected 24 hours post the last dose, centrifuged at 3000 rpm for 15 minutes, and the serum was stored at −20°C for biochemical analysis. Biochemical estimations included protein levels (Lowry's method, 1951), cholesterol levels (Zake's method, 1953), glucose levels (Nelson-Somogyi's method), serum glutamic oxaloacetic transaminase (SGOT) levels (UV-Kinetic method), serum creatinine levels (Jaffe's method, 1886), and serum urea levels (Berthelot's method, 1859). The data were statistically analyzed and expressed as mean ± standard error (SE), with analysis of variance (ANOVA) between control and experimental values performed using Student's t-test with the aid of the GraphPad calculator.

RESULTS AND DISCUSSION

Body weight and Organs weight

The study revealed a significant increase in final body weight compared to initial body weight in groups treated with monosodium glutamate (MSG) (groups 2, 3, and 4), contrasting with the control group (group 1). This increase in body weight was particularly notable in MSG-treated animals, indicating a dose-dependent effect. Furthermore, there was a substantial rise in both liver and kidney weights following MSG administration across varying doses. These findings suggest that MSG consumption may contribute to significant weight gain and organ hypertrophy, underscoring potential metabolic implications associated with MSG intake in experimental models.

Biochemical Estimation

The results of the study indicate that the administration of varying doses of monosodium glutamate (MSG) on the concentrations of protein, cholesterol, and glucose in the liver and kidney tissues was examined. The control group exhibited the highest levels of protein, cholesterol, and glucose in both liver and kidney tissues. As the MSG dosage increased, a significant decrease in protein concentration was observed in both liver and kidney tissues across all treated groups. Conversely, cholesterol and glucose concentrations showed a marked increase in both liver and kidney tissues with escalating MSG doses. The changes were statistically significant, indicating that MSG has a dose-dependent effect on the biochemical parameters in liver and kidney tissues.

Liver and Kidney Functions

Serum glutamic-oxaloacetic transaminase (SGOT)

In this study, the concentrations of SGOT (Serum Glutamic Oxaloacetic Transaminase) were evaluated across different experimental groups. Group I, treated with normal saline and serving as the control, exhibited a baseline level of SGOT. Groups II, III, and IV were administered increasing doses of MSG (Monosodium Glutamate), resulting in progressively higher SGOT concentrations compared to the control group. These findings suggest a dose-dependent relationship between MSG exposure and SGOT levels, indicating potential hepatocellular damage or stress. Further analysis and interpretation of these results could provide insights into the physiological impacts of MSG ingestion at varying doses.

Serum Urea

In this study, the concentration of serum urea was measured across four groups to evaluate the effect of monosodium glutamate (MSG) on renal function. The control group, which received normal saline, exhibited baseline serum urea levels. In contrast, the groups administered with increasing doses of MSG (35 mg/kg, 70 mg/kg, and 105 mg/kg body weight) demonstrated a significant, dose-dependent decrease in serum urea concentrations. These findings suggest that MSG administration leads to a reduction in serum urea levels, with higher doses resulting in more pronounced decreases. The statistical significance of these results highlights the impact of MSG on renal function, indicating potential alterations in urea metabolism or renal excretion mechanisms.

Serum Creatinine

The results indicate a clear dose-dependent increase in serum creatinine levels across the groups treated with different doses of monosodium glutamate (MSG). The control group, which received normal saline, maintained baseline serum creatinine levels. However, as the dosage of MSG increased from 35 mg/kg bw to 105 mg/kg bw, there was a significant rise in serum creatinine levels in all treated groups, with the highest dosage group exhibiting the most pronounced increase. These findings suggest that MSG has a significant impact on renal function, as evidenced by the elevated serum creatinine levels in a dose-dependent manner.

Table 1. Changes in body, liver and kidneys weight of control and rats treated with monosodium glutamate (MSG) expressed in grams for 17 days duration

Groups	Initial Body Weight (gm)	Final Body Weight (gm)	Liver weight (gm)	Kidney weight (gm)
Group I (Control)	160±3.65	176.6±5.58	5.63±0.049	0.64±0.013
Group II (35 mg/kg bw MSG)	161.6±2.78	181.6±7.15^{NS}	5.71±0.057^{NS}	0.70±0.009*
Group III (70 mg/kg bw MSG)	160±1.82	195.8±5.39*	5.85±0.042**	0.73±0.013**
Group IV (105 mg/kg bw MSG)	162.6±2.80	219.1±2.39***	6.05±0.036***	0.77±0.018***

Values expressed as mean ± SE (n=6 for each group) $p \leq 0.05$*, $p \leq 0.001$**, $p \leq 0.0001$***, indicates a significant difference between the compared means. NS= Not significant.

Table 2. Biochemical Parameters of control and rats treated with monosodium glutamate (MSG) for 17 days duration

Groups	Concentration of protein (mg/100mg)		Concentration of Cholesterol (mg/100mg)		Concentration of Glucose (mg/100mg)	
	Liver	Kidney	Liver	Kidney	Liver	Kidney
Group I (Control)	26±0.37	20.8±0.48	90.50±0.85	89.2±0.60	61.2±0.62	56.8±1.35
Group II (35 mg/kg bw MSG)	23.8±0.48**	19 ±0.37*	94.3±0.67**	92.5±0.76**	66.2±1.01**	63.2±1.26**
Group III (70 mg/kg bw MSG)	22.8±0.60**	17.5±0.62**	96.6±1.36**	95.06±1.29**	69.5±1.9**	65±1.24**
Group IV (105 mg/kg bw MSG)	21±0.37***	15.7±0.31***	100.1±1.17***	98±0.37***	74.1±1.07***	72.8±1.45***

Values expressed as mean ± SE (n=6 for each group) $p \leq 0.05$*, $p \leq 0.001$**, $p \leq 0.0001$***, indicates a significant difference between the compared means.

Table 3. Liver and Kidney function indexes of the control and treated rats with mono-sodium glutamate (MSG)

Groups	Concentration Of SGOT (IU/L)	Concentration Of Serum Urea(mg/dl)	Concentration Of Serum Creatinine(mg/dl)
Group I (Control) Normal saline	41.1 ±0.60	40.0±0.37	0.44±0.0037
Group II (MSG) 35mg/kg bw	44.3±1.12*	36.6±1.20*	0.52±0.0022**
Group III (MSG) 70 mg/kg bw	48.8±0.24***	34.5±1.38**	0.57±0.034**
Group IV (MSG) 105 mg/kg bw	53.4±0.13***	28.2±0.48***	0.60±0.029***

Values expressed as mean ± SE. (n=6 for each group) $p \leq 0.05$*, $p \leq 0.001$**, $p \leq 0.0001$***, indicates a significant difference between the compared means.

DISCUSSION

In the present study, significant increases in body weight were observed in the treated groups compared to the control group, indicating that MSG intake may lead to higher energy intake and obesity, as suggested by previous studies (Bergen *et al*., 1998; Mozes *et al*., 2004; Diniz *et al*., 2004). Our findings align with those of Oluba *et al*., 2011, Inuwa *et al*., 2011, Tawfik and Al-Badr, 2012 and Adam *et al*., 2019.

The treated groups also showed significant increases in liver and kidney weights, likely due to inflammation in these tissues (Park *et al*., 2000). This is consistent with Tawfik and Al-Badr (2012), who reported hepatic impairment and elevated liver enzymes after 14 days of MSG administration. The increased serum glutamic-oxaloacetic transaminase (SGOT) levels in MSG-treated rats suggest liver damage, potentially caused by ammonium ion overload and oxidative stress (Tawfik and Al-Badr, 2012; Al-Mamary, 2002; Poli *et al*., 1990).

Additionally, significant elevations in serum urea and creatinine were observed, indicating renal impairment possibly due to changes in renal function and oxidative stress (El-Sheikh and Khali, 2011; Tawfik and Al-Badr, 2012). The decrease in total protein levels in the liver and kidney (hypoproteinemia) in the treated groups compared to controls suggests liver damage, corroborating findings by Tawfik and Al-Badr, 2012 and Ezeokeke and Ezekwe, 2017.

Cholesterol and glucose levels in the liver and kidney also increased (hypercholesterolemia and hyperglycemia) in the treated groups, consistent with the findings of Alwaleedi, 2016. These results highlight the potential adverse effects of MSG on hepatic and renal functions.

CONCLUSIONS

The results of the present investigation demonstrate that monosodium glutamate (MSG) at doses of 35, 70, and 105 mg/kg body weight adversely affects hepatic and renal functions in albino rats. There was an increase in body weight and relative liver and kidney weight. Elevated serum glutamic oxaloacetic acid transaminase (SGOT) activity, reduced total protein content, and increased total cholesterol and glucose levels in liver and kidney tissues indicate significant hepatic and renal dysfunction. Additionally, the rise in serum urea and creatinine levels points to impaired renal function. These biochemical changes likely result from oxidative stress induced by MSG. Our findings highlight the need for further research into the health implications and potential risks of MSG consumption.

CONFLICTS OF INTEREST

The authors declare that they have no potential conflicts of interest.

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