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SCHOLARLY ARTICLE

Comprehensive Assessment of the Impact of MSG and Soybean Consumption on Metabolic Health and Antioxidant Enzyme Activity

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ABSTRACT

OBJECTIVES	*This study aimed to investigate the enduring physiological impacts of prolonged monosodium glutamate (MSG) and soybean consumption in rats, with a specific focus on liver and kidney function, antioxidant enzyme activities, and oxidative stress markers. Gender-specific differences in responses were also explored.*
METHOD	*Female and male rats were subjected to varying doses of MSG and soybeans over a 6-month period. Physiological responses were meticulously analyzed, encompassing liver enzyme concentrations, urea and creatinine levels, as well as antioxidant enzyme activities (superoxide dismutase, catalase, and glutathione peroxidase). Statistical methods were employed to assess the significance of observed alterations.*
RESULT	*Significant perturbations in liver enzyme concentrations were noted, indicative of potential hepatotoxic effects linked to MSG and soybean intake. Changes in urea and creatinine levels suggested potential renal implications, particularly for individuals with kidney-related conditions. Disturbances in antioxidant enzyme activities reflected compromised defense mechanisms against oxidative stress, with heightened malondialdehyde levels indicating increased lipid peroxidation. Gender-specific differences in responses were observed.*
CONCLUSION	*This study underscores the necessity for personalized dietary recommendations, considering individual variations in responses to MSG and soybeans. Caution is warranted for individuals with pre-existing health conditions, particularly those related to liver and kidney function. The findings emphasize the importance of public awareness regarding the risks associated with excessive MSG and soybean consumption. Healthcare providers should integrate these considerations into dietary advice, especially for patients with existing health conditions. Further research is advocated to comprehensively understand the long-term consequences on human health, and regulatory bodies should incorporate these findings into guidelines for ensuring public safety amidst widespread MSG and soybean consumption.*
KEYWORDS	Soybean Consumption; Antioxidant Enzyme Activity; Monosodium Glutamate (MSG); Kidney Function

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Background to the Study

The rapid pace of urbanization and the proliferation of convenience foods have dramatically transformed dietary patterns worldwide. Modern lifestyles are characterized by hectic schedules, leading to a heavy reliance on processed foods rich in preservatives, flavor enhancers, and additives[1]. Among these, monosodium glutamate (MSG), a flavor enhancer commonly used in processed foods, has drawn attention due to its potential health implications. Soybeans, a staple protein source in many cultures, have also come under scrutiny for their diverse effects on human health[2]. As a consequence of these evolving dietary habits, there has been a growing interest in understanding the impact of MSG and soybean consumption on overall well-being.

Recent research studies have underscored the need to investigate the consequences of increased MSG intake, particularly concerning hepatic dysfunction[3]. Liver, a vital organ responsible for metabolism and detoxification, is sensitive to dietary changes[4], making it crucial to assess any adverse effects resulting from MSG consumption. Concurrently, soybeans, touted for their nutritional benefits, have been subjected to intense scrutiny, exploring their influence on metabolic health and the intricate balance of antioxidant enzyme activities within the human body[5].

Recognizing the potential risks associated with MSG and soybean consumption, the present study was meticulously designed to delve deep into the multifaceted aspects of metabolic health. By focusing on key parameters such as liver and kidney functionalities, the researchers aimed to unravel the intricate interplay between these food components and essential physiological processes. Liver enzymes, including alanine aminotransferase (ALT), alkaline phosphatase (ALP), and aspartate aminotransferase (AST), were chosen as reliable indicators of liver health, offering insights into the impact of MSG and soybeans on hepatic function.

In addition to evaluating liver and kidney functionalities, the study took a comprehensive approach by assessing the serum lipid profile and blood glucose concentrations. Serum lipids, encompassing cholesterol and triglycerides, play a pivotal role in cardiovascular health. Any alterations in these lipid markers could indicate a potential risk for heart-related issues, making their evaluation essential. Blood glucose concentrations, on the other hand, are paramount in understanding the impact of MSG and soybeans on glucose metabolism, providing valuable insights into their effects on diabetes risk and insulin sensitivity.

Moreover, the study extended its investigation to the realm of antioxidant defense mechanisms. Catalase, peroxidase, and superoxide dismutase, crucial enzymes in the body's antioxidant network, were meticulously studied to unravel the impact of MSG and soybean consumption on oxidative stress levels. Oxidative stress, arising from an imbalance between antioxidants and harmful free radicals, is implicated in various chronic diseases, making this aspect of the research particularly pertinent in understanding the long-term health consequences of dietary choices.

This study represents a concerted effort to bridge the existing knowledge gap surrounding MSG and soybean consumption. By scrutinizing liver and kidney functionalities, serum lipid profile, blood glucose concentrations, and antioxidant enzyme activities, the research aims to provide a comprehensive understanding of the effects of these dietary components on human health. Such insights are invaluable in guiding public health policies, promoting informed dietary choices, and ultimately fostering a healthier population in the face of evolving dietary landscapes.

Rationale

The rationale behind this study stems from the need to comprehensively assess the impact of MSG and soybean consumption on multiple aspects of metabolic health and antioxidant defense mechanisms. As these food components are widely prevalent in modern diets, understanding their effects on liver and kidney functionalities, lipid metabolism, blood glucose levels, and antioxidant enzyme activities is essential for informing public health recommendations and promoting a balanced and healthy diet. By addressing these objectives, the study aims to contribute valuable data to the existing body of knowledge, enabling a better understanding of the potential health implications associated with MSG and soybean intake. Furthermore, the findings of this research could serve as a basis for developing dietary guidelines and interventions aimed at minimizing the risks associated with excessive consumption of these food components, ultimately promoting better overall health and well-being in the population.

Objectives

a. To measure the effects of MSG and soya bean on the liver and kidney functionalities, serum lipid profile and blood glucose concentrations.
b. To measure the effects of MSG and soya bean on antioxidant enzymes activities such as catalase, peroxidase, and superoxide dismutase.

Literature

Effect of MSG on other Liver Function Indicators

The serum total protein levels remain unaffected by moderate intake of MSG while total bilirubin concentration was mildly suppressed[6]. Albumin on the other hand was significantly decreased in experimental animals subjected to MSG[6]. This indicates severe compromise of the functional integrity of the liver. Albumin and bilirubin estimation enables assessment of the functional states of the liver and suggests particularly the type of liver dysfunction that occurred. Alterations in albumin and bilirubin is suggestive of a chemical-induced hepatocellular injury and correlates with a reduction in the synthetic potentials of the liver arising from higher fluid retention in interstitial spaces of the liver[7]. Furthermore, the γ-glutamyltransaminase were significantly elevated with MSG intake showing liver damage[6]. Onyema *et al.* posited that elevations in serum GGT levels only occurs during liver injury resulting from tissue oxidation, but however can be counteracted with the coadministration of potent antioxidants[8].

Effect of MSG on Kidney Functions

The consumption of MSG distorts the renal functionality[9]. The urea levels have been found to be suppressed by excessive MSG intake[6]. Alterations of the urea cycle are considered the major factor behind the decreased levels of serum urea after MSG rich diets. The serum urea nitrogen levels are diagnostic indicators of kidney function especially with extremely low levels, whereas high levels of serum urea nitrogen suggest possible heart failure, protein-rich diet or low fluid intake.

The status of the kidney can also be examined with the serum creatinine levels. Studies have shown distinct increase in creatine levels after intake of MSG[9-10]. The studies inferred that MSG comprises the functional capacity of the kidney by interfering with creatinine metabolism or its tubular excretion. Another suggestion is the evolution of free radicals that eventually targets and alters the renal tissue architecture[11]. These alterations induced by MSG on the kidney are reversible with antioxidant supplementation[9].

Effect of MSG on Antioxidant Defense System

The assessment of lipid peroxidation is an important indicator of oxidative damage because of the adverse effects reactive oxygen species have on the membranse . The administration of MSG causes the excessive generation of lipid peroxidation products[12] which was attributed to excessive production of reactive oxygen species. In earlier studies, homogenates from body tissues showed higher concentration of reactive oxygen species and lipid peroxidation products after MSG administration[8,10,13].

A compensatory action by the tissues to restore the antioxidant status after MSG administration also generates more lipid peroxidation products[12]. Generally, the levels of non-protein thiols like glutathione in tissue homogenates reveals the degree of MSG-induced lipid peroxidadtion[8,14]. Glutathione plays a crucial role in scavenging of free radicals in the body and its alteration simply indicates high peroxidation of lipid bilayers especially in cells with higher metabolic functions[8]. Glutathione maintains the antioxidant defense system in numerous ways involving direct chelation of free radicals and acyl peroxides which enables the maintenance of membrane integrity during lipid peroxidation[15].

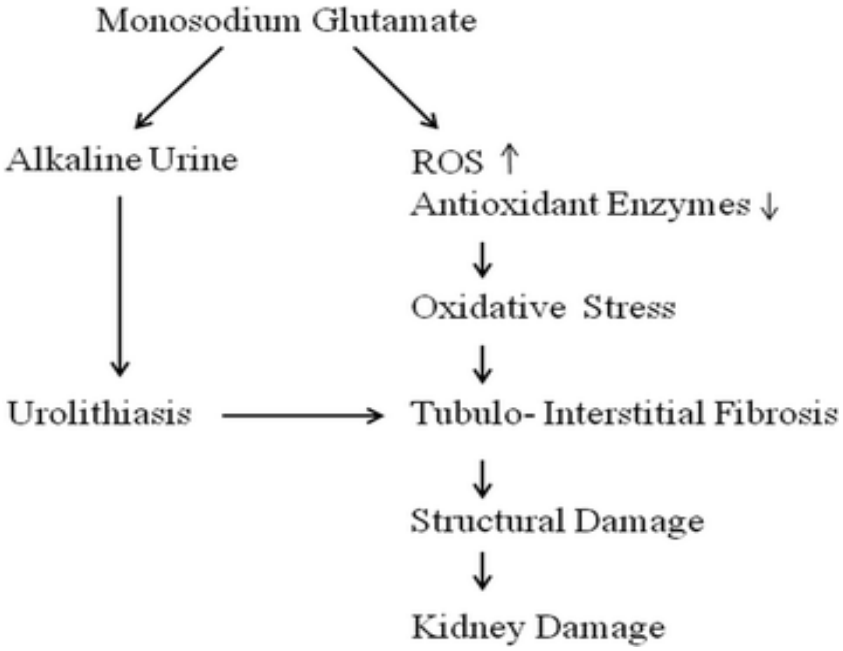

Figure 1: Effect of MSG-induced oxidative stress (Sharma, 2015)

The extent of depletion of glutathione reveals the extent of tissue degeneration[16]. Likewise, the activities of glutathione-s-transferase directly correlates with the amount of tissue glutathione levels and integrity of the antioxidant defense system[17]. Glutathione peroxidase catalysis is the conjugation of glutathione to lipid peroxidation products thereby forming soluble innocuous conjugates[18]. Furthermore, superoxide dismutase and catalase are extensively depleted with administration of MSG showing a compromised antioxidant defense system[14]. Okwudiri *et al.* explained that the low levels of these antioxidant enzymes after MSG intake resulted from glycation or inhibition by reactive oxygen species[12].

Also, as these enzymes become further depleted, lipid peroxidation products increase, thereby depleting the levels of glutathione as the only non-protein thiol capable of binding acyl radicals.

Materials and Methods

Table 1: Equipment and Sources

Equipment	*Sources*
Automatic Electrolyte Analyzer	Shimadzu UV-160A, Lakewood Carlifonia, USA
BT-3000 auto analyzer	Diamond Diagnostics Inc, Holliston, MA, USA
Centrifuge	Shimadzu UV-160A, Lakewood Carlifonia, USA
Colorimeter	Lovibond™ PFXi-995, Tintometer Limited, Amesbury, UK
Dessicator	East Biopharm, Hangzhou, Zhejiang, China
ELISA plate reader	Omega Bio-Tek Inc. - Norcross, Georgia USA
Gas Chromatography	Agilent Technologies 7890A, Santa Clara, Carlifonia, United States
Glucometer	Roche Diagnostics Indianapolis, IN, United States
Hematology Auto-Analyzer	Mindray,Boulevard, New Jersey, USA
Ichroma Machine	Shimadzu UV-160A, Lakewood Carlifonia, USA
Incubator	Shimadzu UV-160A, Lakewood Carlifonia, USA
Microscope	Shimadzu UV-160A, Lakewood Carlifonia, USA
Oven	Shimadzu UV-160A, Lakewood Carlifonia, USA
pH Meter	Uniscope , SM801A, England
Rotary Evaporator	SHB-520, Korea
Soxhlet Extractor	Uniscope , SM801A, England

Steam Bath	East Biopharm, Hangzhou, Zhejiang, China
Thermometer	East Biopharm, Hangzhou, Zhejiang, China
Water Bath	Biotechnics, Aberdeenshire, Scotland UK
Weighing Balance	South Cross Road Bradford

Table 2: Chemicals/Reagents and Sources

Chemicals/reagents	*Sources*
4-dinitrophenyl hydrazine solution	British Drug House (BDH), England
Acetic acid	Sigma Aldrich St. Louis, MO, USA
Biochemical reagent kits	Randox lab Ltd, Antrim, UK.
Butanol	Sigma Aldrich St. Louis, MO, USA
CA 19-9 ELISA kit	Accubind Elisa Microwells, Monobind Inc. Lakeforest, USA
CA-125 ELISA kit	Accubind Elisa Microwells, Monobind Inc. Lakeforest, USA
Carbonate buffer	British Drug House (BDH), England
CEA ELISA kit	Accubind Elisa Microwells, Monobind Inc. Lakeforest, USA
Dimethylether	Sigma Aldrich St. Louis, MO, USA
Ethanol	British Drug House (BDH), England
Ethylene diamine tetraacetic acid	British Drug House (BDH), England
Follicle Stimulating Hormone test kits	Accubind Elisa Microwells, Monobind Inc. Lakeforest, USA
Glutathione reductase	Qualiken fine chemicals, New Delhi, India
Hexane	Sigma Aldrich St. Louis, MO, USA
Hydrogen peroxide	Sigma Aldrich St. Louis, MO, USA
Insulin kits	Syntron Bioresearch (USA).
Luteinizing Hormone Test kits	Accubind Elisa Microwells, Monobind Inc. Lakeforest, USA
Potassium phosphate buffer	Qualiken fine chemicals, New Delhi, India
Propanol	British Drug House (BDH), England
Randox liver function test kits	140 London Wall, London, England
Randox renal function test kits	140 London Wall, London, England
Sodium azide	Omega Bio-Tek Inc. - Norcross, Georgia USA
Sodium bicarbonate	British Drug House (BDH), England
Sodium hydroxide	British Drug House (BDH), England
Sodium phosphate buffer	Qualiken fine chemicals, New Delhi, India
Sodium sulphate	Sigma Aldrich St. Louis, MO, USA
Sulphuric acid	Sigma Aldrich St. Louis, MO, USA
Testosterone Test kits	Accubind Elisa Microwells, Monobind Inc. Lakeforest, USA
Thiobarbituric acid	Sigma Aldrich St. Louis, MO, USA
Trichloroacetic acid	British Drug House (BDH), England

Sample Procurement and Preparation for Comprehensive Study on MSG and Soya Bean Consumption

Objective 1: Measure the effects of MSG and soya bean on liver and kidney functionalities, serum lipid profile, and blood glucose concentrations:

To investigate the impact of monosodium glutamate (MSG) and soya bean consumption on liver and kidney functionalities, serum lipid profile, and blood glucose concentrations, high-quality samples were procured and prepared with utmost care and consistency. A 99% pure MSG brand was sourced from Relief Market, Owerri, Imo State, Nigeria, while top-quality soya beans were obtained from Ekeonunwa Market, Owerri. Both materials were stored in suitable containers, protected from direct sunlight and moisture to maintain their integrity.

Regular aqueous extracts were prepared weekly over the 181-day study period. Stringent methods were employed to ensure uniform extraction processes for both MSG and soya bean samples. The aqueous extracts were meticulously stored in appropriate containers, away from direct sunlight, to preserve their composition until further analysis. These standardized procedures in sample procurement and preparation guaranteed the reliability and

consistency necessary for the accurate assessment of liver and kidney functionalities, serum lipid profile, and blood glucose concentrations in response to MSG and soya bean consumption.

Objective 2: Measure the effects of MSG and soya bean on antioxidant enzymes activities:

In evaluating the impact of MSG and soya bean consumption on antioxidant enzyme activities, including catalase, peroxidase, superoxide dismutase, and glutathione peroxidase levels, the same high-quality MSG and soya bean samples were utilized. Aqueous extracts were consistently prepared on a weekly basis throughout the study's duration, following stringent protocols to maintain uniformity. These extracts were stored in controlled conditions to prevent degradation and preserve their integrity for analysis.

By adhering to standardized procurement and preparation methods, the study ensured the reliability of results for both objectives. The meticulous handling of MSG and soya bean samples and the consistent preparation of aqueous extracts formed the foundation for accurate assessments of their impact on liver and kidney functionalities, serum lipid profile, blood glucose concentrations, and antioxidant enzyme activities.

Determination of Urea[19]

In the determination of urea levels, following the protocol established by Quraishi et al.[19], precise and meticulous steps were undertaken to ensure accurate results. The procedure was conducted as follows:

1. **Sample and Standard Preparation:**
    a. Ten microlitres (10 µl) of the sample were dispensed into test tube 1 (labeled as "sample").
    b. Similarly, ten microlitres (10 µl) of standard urea solution were dispensed into test tube 2 (labeled as "standard").
    c. Test tube 3 (labeled as "blank") received ten microlitres (10 µl) of distilled water to serve as a reference.
2. **Reagent Dispensation and Mixing:**
    a. Fifty microlitres (50 µl) of reagent labeled as "1" were added to all test tubes (sample, standard, and blank).
    b. Thorough mixing of the contents in the test tubes was ensured.
3. **Incubation:**
    a. The mixed contents in all test tubes were incubated at 37°C for 10 minutes.
    b. After the initial incubation, 2.50 ml of standard reagents labeled as "2" and "3" were dispensed into all test tubes.
    c. Further incubation at 37°C was conducted for 15 minutes, followed by thorough mixing.
4. **Color Observation and Spectrophotometry:**
    a. A stable blue color, observed for at least 8 hours, indicated the completion of the reaction.
    b. The contents of the test tubes were then transferred into cuvettes.
    c. Using a spectrophotometer, the absorbance of the sample, standard, and blank was measured.
    d. Absorbance values of both the sample and the standard were recorded.
5. **Calculation of Urea Concentration:**

    The concentration of urea in the sample was calculated using the formula:

$$\text{Concentration of Urea in sample} = \frac{\Delta A_{sample} \times \text{Standard Conc. (mg/dl)}}{\Delta A_{standard}}$$

where ΔA_{sample} represents the absorbance of the sample, $\Delta A_{standard}$ represents the absorbance of the standard, and "Standard conc." represents the concentration of the standard urea solution in milligrams per deciliter (mg/dl).

By following this meticulous procedure, the study ensured accurate determination of urea levels in the samples, providing reliable data for the assessment of kidney functionality in response to MSG and soya bean consumption.

Determination of Malondialdehyde (MDA)

The determination of Malondialdehyde (MDA) levels, following the method established by Ohkawa et al. in 1979[22], involved a series of precise steps to assess oxidative stress in the serum samples. The protocol was executed as follows:

1. **Sample Preparation:**

   0.5 ml of normal saline was pipetted into a test tube containing 0.5 ml of the serum sample.

2. **Addition of TBA/TCA Mixture:**

   a. Approximately 2 ml of the thiobarbituric acid (TBA)/trichloroacetic acid (TCA) mixture was added to the test tube.

   b. The mixture was then allowed to boil for 1 hour to facilitate the reaction.

3. **Cooling and Centrifugation:**

   a. After boiling, the mixture was cooled to room temperature.

   b. Subsequently, the test tube was centrifuged at 4000 rpm for 5 minutes.

4. **Supernatant Reading:**

   The clear supernatant, obtained after centrifugation, was transferred to a cuvette.

5. **Spectrophotometric Reading:**

   a. The absorbance of the supernatant was measured at 535 nm using a spectrophotometer.

   b. Absorbance values of the test sample were recorded.

6. **Calculation of MDA Concentration:**

   The concentration of MDA (in nanomoles per milliliter, nmol/ml) was calculated using the following formula:

   $$\textbf{Concentration of the test} = \frac{\text{Abs(test)} - \text{Abs(blank)}}{1.56} \times 1000000$$

   where Abs(test) represents the absorbance of the test sample, and Abs(blank) represents the absorbance of the blank solution.

   By adhering to this method, the study accurately determined the concentration of Malondialdehyde (MDA) in the serum samples. This measurement provided valuable insights into lipid peroxidation and oxidative stress levels in response to the consumption of monosodium glutamate (MSG) and soya bean, contributing crucial data to the comprehensive assessment of their impact on antioxidant enzyme activities.

Determination of Catalase (CAT) Activity

The determination of Catalase (CAT) activity, as outlined by Aebi in 1984[20], involved a precise protocol to assess the enzyme's ability to decompose hydrogen peroxide. The procedure was conducted as follows:

1. **Reagent Preparation:**
    a. 2.5 ml of distilled water was pipetted into a test tube.
    b. To this, 0.5 ml of hydrogen peroxide (H2O2) was added.
2. **Sample Addition and Mixing:**
    a. Approximately 40 µl of the sample was added to the test tube containing distilled water and hydrogen peroxide.
    b. The contents were mixed thoroughly to ensure uniform distribution.
3. **Spectrophotometric Reading:**
    a. The rate of decomposition of hydrogen peroxide was measured at 240 nm.
    b. Readings were taken at 30-second intervals for a duration of 5 minutes.
4. **Calculation of CAT Activity:**

    CAT activity was determined using the following formula:

    CAT Activity = (Decrease in absorbance×100)1 ÷ (Protein amount in mg ÷ Time in min)

    In this formula, the decrease in absorbance represents the change in absorbance readings observed during the reaction. The protein amount, expressed in milligrams, is divided by the time taken for the reaction in minutes.

    By following this method, the study accurately determined Catalase (CAT) activity, providing valuable insights into the enzyme's efficiency in decomposing hydrogen peroxide. This measurement offered crucial data for evaluating the antioxidant capabilities of the samples and contributed significantly to the comprehensive assessment of the impact of monosodium glutamate (MSG) and soya bean consumption on antioxidant enzyme activities.

Superoxide Dismutase (SOD) Activity Assay

The determination of Superoxide Dismutase (SOD) activity, as described by Marklund in 1980[21], involved a spectrophotometric method to assess the enzyme's ability to inhibit the autoxidation of adrenaline. The protocol for SOD activity assay was carried out as follows:

1. **Preparation of Reaction Mixture:**
    a. 20 ml of the sample extract was mixed with 2.5 ml of 0.05 M carbonate buffer (pH 10.2).
    b. The mixture was equilibrated in the spectrophotometer.
2. **Addition of Adrenaline:**
    a. 0.3 ml of freshly prepared 0.3 mM adrenaline solution was added to the reaction mixture.
    b. The contents were mixed by inversion to ensure uniform distribution.
3. **Spectrophotometric Monitoring:**
    a. The increase in absorbance at 480 nm was monitored spectrophotometrically.
    b. Readings were taken at 30-second intervals for a duration of 3 minutes.

The assay monitored the ability of the sample extract to inhibit the autoxidation of adrenaline, and the rate of inhibition was measured by the increase in absorbance at 480 nm. This method provided valuable information about the SOD activity in the samples, shedding light on their antioxidant capabilities. The results contributed significantly to the comprehensive assessment of the impact of monosodium glutamate (MSG) and soya bean consumption on antioxidant enzyme activities.

Glutathione Peroxidase (GSH-Px) Activity Assay

The determination of Glutathione Peroxidase (GSH-Px) activity was performed based on a modified method proposed by Paglia and Valentine in 1967. The assay measured the ability of the enzyme to catalyze the reduction of hydrogen peroxide (H2O2) using reduced glutathione (GSH) and NADPH as substrates. The protocol for GSH-Px activity assay was conducted as follows:

Reagents and Reaction Medium:

a. Potassium phosphate buffer: 171 mM

b. Sodium azide: 4.28 mM

c. EDTA: 2.14 mM

d. Reduced glutathione (GSH): 6 mM

e. NADPH: 0.9 mM

f. Glutathione reductase: 2 U/mL

Procedure:

1. **Preparation of Reaction Medium:**

   The reaction medium was prepared by combining the specified concentrations of potassium phosphate buffer, sodium azide, EDTA, reduced glutathione, NADPH, and glutathione reductase.

2. **Initiation of Reaction:**

   The reaction was initiated by adding hydrogen peroxide (H_2O_2) at a concentration of 0.72 mM to the reaction medium.

3. **Spectrophotometric Monitoring:**

   a. The absorbance of the samples was measured at 340 nm using a spectrophotometer.

   b. Measurements were taken every 15 seconds for a total duration of 300 seconds (5 minutes).

4. **Calculation of GSH-Px Activity:**

   The GSH-Px enzymatic activity was expressed in enzymatic units per mL of sample (U/mL). The specific calculation formula for the activity was not provided in the given description.

This assay allowed the assessment of GSH-Px enzymatic activity, providing valuable insights into the antioxidant defense mechanism of the samples. The results contributed significantly to the comprehensive evaluation of the impact of monosodium glutamate (MSG) and soya bean consumption on antioxidant enzyme activities.

Results

Liver Enzyme Concentrations

The hepatic dysfunction markers of rats administered MSG and soybeans are shown in Table 3. The ALT, ALP, and AST levels of the female rats were significantly ($p<0.05$) elevated after 2 months of administration of H.D MSG and

soya beans. After 4 months administration of MD and HD MSG to the female rats, the ALT levels (120.86 and 123.32 U/L respectively), and ALP levels (311.73 and 320.99 U/L) were significantly ($p<0.05$) elevated when compared to the control. The result showed that 6 months administration of MD and HD soya bean to the female rats also significantly ($p<0.05$) elevated the ALT, ALP, and AST levels, when compared to the control. In the male rats, the low dose administration of MSG and soya beans for 2 months produced no significant ($p>0.05$) changes in the ALT, ALP and AST levels when compared to the control levels, whereas the ALT levels were significantly ($p<0.05$) increased by the MD and HD MSG, while the AST levels was significantly ($p<0.05$) increased by administration of MD and HD soya beans. After 4 months administration of MD and HD of soya bean, the ALT levels (139.20 and 135.08 U/L), the ALP (504.50 and 509.50 U/L), and the AST levels (274.00 and 280.50 U/L) were significantly ($p<0.05$) increased when compared to the control levels. Furthermore, all the doses of soya bean administered for 6 months significantly ($p<0.05$) elevated the ALT, ALP, and AST levels when compared to the control levels.

Table 3: Liver Function Parameters of Rats Administered Monosodium Glutamate and Soya Beans

DURATION	GRPS	ALT (U/L)	ALT (U/L)	ALP (U/L)	ALP(U/L)	AST(U/L)	AST (U/L)
		MSG	SOY	MSG	SOY	MSG	SOY
2 MONTHS				FEMALES			
	C	87.00±7.07^{a*}	87.00±7.07^{a*}	261.00±18.38^{a*}	261.00±18.38^{a*}	149.00±29.69^{a*}	149.00±29.69^{a*}
	LD	82.50±9.19^{a*}	94.00±21.21^{b**}	277.00±31.11^{a*}	353.00±16.97^{b**}	163.00±16.97^{a*}	176.00±24.04^{b**}
	MD	83.00±4.24^{a*}	95.00±14.14^{b**}	421.50±19.09^{b*}	393.00±14.14^{c**}	153.50±20.50^{a*}	187.50±13.43^{c**}
	HD	96.00±7.07^{b*}	107.50±13.43^{c*}	456.50±16.26^{be*}	407.50±23.33^{c**}	179.50±14.84^{b*}	184.50±6.36^{c*}
4 MONTHS							
	C	104.86±3.31^{c*}	104.86±3.31^{c*}	293.14±6.63^{c*}	293.14±6.63^{ad*}	176.55±9.12^{b*}	176.55±9.12^{b*}
	LD	101.46±9.66^{c*}	115.51±5.81^{d**}	288.56±11.22^{c*}	283.63±14.47^{b*}	170.80±10.46^{b*}	180.45±14.07^{bc*}
	MD	120.86±7.02^{de*}	118.90±5.09^{d*}	311.73±3.72^{d*}	286.65±31.32^{b**}	179.00±13.43^{b*}	208.00±12.44^{d**}
	HD	123.32±5.40^{d*}	134.06±6.59^{e**}	320.99±10.74^{d*}	301.45±14.49^{d*}	192.00±12.12^{b*}	199.40±14.28^{d*}
6 MONTHS							
	C	116.16±5.17^{e*}	116.16±5.17^{d*}	471.90±12.86^{e*}	471.90±12.86^{c*}	209.40±12.72^{a*}	209.40±12.72^{d*}
	LD	122.85±9.26^{de*}	161.25±9.97^{fg**}	591.05±17.05^{f*}	599.05±33.58^{d*}	218.75±10.67^{a*}	259.25±9.82^{e**}
	MD	125.35±7.00^{d*}	155.30±6.78^{f**}	575.00±15.27^{f*}	635.85±20.15^{e**}	266.70±20.08^{c*}	297.70±20.08^{f**}
	HD	143.55±7.14^{f*}	170.75±4.87^{g**}	580.80±16.26^{f*}	671.70±13.01^{f**}	261.90±17.53^{c*}	305.90±20.50^{f**}
2 MONTHS				MALES			
	C	119.50±12.02^{g*}	119.50±12.02^{hc*}	430.00±18.38^{g*}	430.00±18.38^{g*}	184.50±14.84^{d*}	184.50±14.84^{gc*}
	LD	118.00±14.14^{g*}	119.00±24.04^{hc*}	425.50±30.40^{g*}	416.00±15.55^{g*}	187.50±9.19^{d*}	215.50±17.67^{hl*}
	MD	132.50±12.02^{hj*}	128.50±14.84^{h*}	445.00±38.18^{gh*}	501.00±21.21^{h**}	193.00±14.14^{d*}	266.00±9.89^{i**}
	HD	145.00±22.62^{h*}	143.00±7.07^{i*}	458.50±14.84^{gh*}	512.50±28.99^{hj**}	203.50±19.09^{d*}	288.50±10.60^{j**}
4 MONTHS							
	C	122.03±3.71^{i*}	122.03±3.71^{h*}	463.00±18.38^{h*}	463.00±18.38^{i*}	198.00±11.31^{d*}	198.00±11.31^{kld*}
	LD	116.81±5.04^{i*}	123.97±4.75^{h*}	453.50±13.43^{h*}	471.50±14.84^{i**}	188.90±12.58^{d*}	207.00±4.24^{ld**}
	MD	120.95±6.57^{i*}	139.20±5.26^{ie**}	462.50±9.19^{h*}	504.50±12.02^{h**}	208.65±13.64^{d*}	274.00±7.07^{m**}
	HD	133.80±7.60^{j*}	135.08±6.2^{ie*}	449.50±27.57^{h*}	509.50±23.33^{hj**}	217.90±18.24^{de*}	280.50±12.02^{mj**}
6 MONTHS							
	C	127.70±4.10^{i*}	127.70±4.10^{h*}	523.95±9.40^{i*}	523.95±9.40^{j*}	227.00±5.37^{e*}	227.00±5.37^{h*}
	LD	126.50±8.90^{i*}	141.40±8.76^{i**}	511.40±25.17^{i*}	657.20±43.84^{k**}	234.35±10.25^{f*}	252.70±9.05^{ne**}
	MD	140.20±13.29^{h*}	157.30±9.19^{jf**}	552.25±4.31^{j*}	663.05±16.61^{k**}	245.15±7.56^{g*}	260.70±13.85^{nie**}
	HD	152.00±5.23^{h*}	166.95±10.25^{j**}	582.50±11.73^{j*}	713.30±28.99^{l**}	257.35±16.89^{h*}	295.95±12.23^{of**}

Values are means ± standard deviations n=5. Values with different superscript letter(s) (a-n) down the column or symbols (and **) across the row for each parameter, are significantly different ($p < 0.05$). MSG-Monosodium glutamate, SOY-Soya bean, ALT-Alanine Transaminase, ALP – Alkaline Phosphatase, AST-Aspartate transaminase*

The above analysis shows the impact of different doses and durations of MSG and soybean administration on the levels of ALT (alanine aminotransferase), ALP (alkaline phosphatase), and AST (aspartate aminotransferase) enzymes in both female and male rats.

Here's a summary of the findings:

Female Rats:

After 2 months:

H.D MSG and soybean administration significantly elevated ALT, ALP, and AST levels.

After 4 months:

a. MD and HD MSG elevated ALT and ALP levels significantly.
b. MD and HD soybean administration elevated ALT, ALP, and AST levels significantly.

After 6 months:

MD and HD soybean administration significantly increased ALT, ALP, and AST levels.

Male Rats:

After 2 months:

a. Low dose MSG and soybean administration showed no significant changes in ALT, ALP, and AST levels.
b. MD and HD MSG elevated ALT levels significantly.
c. MD and HD soybean administration increased AST levels significantly.

After 4 months:

MD and HD soybean administration significantly elevated ALT, ALP, and AST levels.

After 6 months:

All doses of soybean administration significantly increased ALT, ALP, and AST levels.

These findings suggest a correlation between MSG and soybean consumption and liver dysfunction in rats, particularly at higher doses and longer durations of exposure.

Urea and Creatinine Levels

The urea and creatinine levels of rats administered MSG and soya beans are shown in Table 4. Soya bean administration for 2 months had no significant ($p>0.05$) effect on urea levels, whereas after 4 months, the high dose soya bean significantly ($p<0.05$) decreased the urea and creatinine levels. All doses of MSG significantly ($p<0.05$) decreased the urea levels at both 2 and 4 months administration while the creatinine levels were significantly ($p<0.05$) decreased by the MD and HD MSG administration. The administration of all doses of MSG to the female rats for 6 months significantly ($p<0.05$) decreased the urea and creatinine levels, while the low dose of soya bean administered for 6 months to the female rats produced comparable creatinine levels (7.00 mmol/l) to the control (7.35 mmol/l). The male rats administered LD, MD, and HD MSG for 2 months showed significantly ($p<0.05$) reduced urea levels (42.50, 43.50, and 43.00 mmol/l respectively) when compared to the control (58.70 mmol/l), while the creatinine level was significantly ($p<0.05$) increased by MD and HD MSG (7.45 and 7.95 mmol/l respectively) when compared to the control levels (6.30 mmol/l). No significant (>0.05) change was observed on the creatinine levels of rats administered soya beans, while the urea levels were significantly ($p<0.05$) decreased. Also, the 4 months administration of LD, MD, and HD MSG to male rats significantly ($p<0.05$) decreased the urea and creatinine levels, while LD and MD soya bean administration produced no significant ($p>0.05$) effects on the urea and creatinine levels. After 6 months, the urea and creatinine levels of the male rats were significantly ($p<0.05$) decreased by administration of LD, MD and HD MSG, while no significant ($p>0.05$) changes were observed in the creatinine levels of male rats administered LD and MD soya beans for 6 months.

Table 4: Urea and Creatinine Levels of Rats Administered Monosodium Glutamate and Soya Beans

DURATION	GROUPS	Urea (mmol/l)	Urea (mmol/l)	Creatinine (umol/l)	Creatinine (mmol/l)
		MSG	SOY	MSG	SOY
2 MONTHS			FEMALES		
	C	58.50±3.53^{a*}	58.50±3.53^{a*}	5.15±0.49^{ad*}	5.15±0.49^{a*}
	LD	46.50±6.36^{b*}	27.95±3.18^{a**}	5.40±0.56^{a*}	5.75±0.49^{a*}
	MD	43.50±4.94^{b*}	29.80±3.22^{a**}	5.70±0.56^{a*}	5.60±0.56^{a*}
	HD	44.50±0.70^{b*}	29.40±3.37^{a**}	6.65±0.35^{b*}	6.65±0.49^{b*}
4 MONTHS					
	C	55.50±6.36^{a*}	55.50±6.36^{b*}	5.10±0.28^{ad*}	5.10±0.28^{a*}
	LD	44.00±5.65^{b*}	56.00±4.24^{b**}	5.45±0.35^{a*}	4.90±0.56^{a**}
	MD	43.50±2.12^{b*}	56.50±2.12^{b**}	7.15±0.35^{c*}	5.55±0.49^{a**}
	HD	38.50±2.12^{c*}	48.50±2.12^{c**}	7.55±0.77^{c*}	6.50±0.42^{b**}
6 MONTHS					
	C	62.70±4.94^{d*}	62.70±4.94^{d*}	4.90±0.14^{d*}	7.35±0.63^{c*}
	LD	42.05±3.18^{b*}	51.70±3.39^{b**}	5.50±0.56^{a*}	7.00±0.00^{c**}
	MD	38.05±4.87^{c*}	52.60±7.63^{b**}	5.70±0.28^{a*}	8.45±0.07^{d**}
	HD	34.55±2.47^{c*}	37.80±5.65^{a*}	7.35±0.63^{c*}	8.05±0.21^{d**}
2 MONTHS			MALES		
	C	58.70±9.19^{ega*}	58.50±9.19^{e*}	6.30±0.42^{eb*}	6.30±0.42^{eb*}
	LD	42.50±3.53^{fb*}	43.00±2.82^{f*}	6.35±0.77^{eb*}	6.65±0.49^{eb*}
	MD	43.50±3.53^{fb*}	44.50±3.53^{f*}	7.45±0.63^{f*}	6.00±1.13^{eb**}
	HD	43.00±1.41^{fb*}	42.00±2.82^{f*}	7.95±0.49^{f*}	5.95±0.35^{eb**}
4 MONTHS					
	C	61.00±8.48^{e*}	61.00±8.48^{e*}	6.50±0.42^{e*}	6.50±0.42^{eb*}
	LD	52.50±3.53^{ga*}	61.00±2.82^{e*}	7.25±0.21^{fc*}	6.85±0.21^{eb**}
	MD	43.00±1.41^{fb*}	58.00±7.07^{eb**}	7.45±0.63^{fc*}	6.95±0.49^{eb**}
	HD	41.50±4.94^{fb*}	63.50±6.36^{e**}	9.20±0.42^{g*}	7.85±0.49^{f**}
6 MONTHS					
	C	55.90±4.38^{g*}	55.90±4.38^{eb*}	9.00±1.27^{g*}	9.00±1.27^{g*}
	LD	38.80±2.40^{hc*}	54.35±5.30^{eb**}	11.10±1.55^{h*}	9.00±0.56^{g**}
	MD	37.55±5.30^{hc*}	47.20±4.80^{f**}	11.50±1.55^{h*}	10.30±1.69^{g*}
	HD	29.80±4.24^{i*}	38.90±2.12^{ga**}	13.05±1.48^{i*}	10.65±0.63^{h**}

Values are means ± standard deviations n=5. Values with different superscript letter(s) (a-j) down the column or symbols (and **) across the row for each parameter, are significantly different (p < 0.05). MSG - Monosodium glutamate, SOY – Soya bean*

The study assessed urea and creatinine levels, which are important indicators of kidney function. Here's a summary of the findings based on the provided data:

Urea Levels:

1. Two Months Administration:

a. Soya bean administration had no significant effect on urea levels.
b. All doses of MSG significantly decreased urea levels.

2. Four Months Administration:

a. High dose soya bean significantly decreased urea levels.

b. All doses of MSG significantly decreased urea levels.

3. Six Months Administration:

a. All doses of MSG significantly decreased urea levels.

b. Low dose soya bean administration for 6 months produced comparable urea levels to the control.

Creatinine Levels:

1. Two Months Administration:

Creatinine levels increased significantly with MD and HD MSG administration.

2. Four Months Administration:

a. LD, MD, and HD MSG administration significantly decreased creatinine levels.

b. Soya bean administration had no significant effect on creatinine levels.

3. Six Months Administration:

a. LD, MD, and HD MSG administration significantly decreased creatinine levels.

b. LD and MD soya bean administration had no significant effect on creatinine levels.

The study shows that MSG and soya bean administration had varying effects on urea and creatinine levels in rats over different durations. MSG administration consistently led to significant reductions in both urea and creatinine levels, indicating potential alterations in kidney function. Soya bean administration, on the other hand, had mixed effects, with no significant changes observed in creatinine levels and reductions observed in urea levels, particularly at higher doses and longer durations.

These findings suggest that both MSG and soya bean consumption can impact kidney functionalities in rats, highlighting the importance of further research to understand the underlying mechanisms and potential implications for human health.

Total cholesterol and triacylglycerols

Table 5 shows the concentration of total cholesterol (TC) and triacylglycerols (TAG) following LD, MD and HD administration of MSG and soya beans for 2, 4, and 6 months to male and female rats. No significant ($p>0.05$) changes on the TC and TAG were observed after administration of soya beans for 2 and 4 months on the female rats while for the 2 months administration, the MD and HD MSG significantly ($p<0.05$) increased the TC and TAG levels. The LD and MD MSG produced no significant ($p>0.05$) changes in the TC levels when administered for 4 months to the female rats when compared to the control rats, while all the MSG doses significantly ($p<0.05$) elevated the triacylglycerol levels (5.10, 5.50, and 5.75 mmol/l) when compared to the control level (4.40 mmol/l). The administration of the MSG doses for 6 months to female rats significantly ($p<0.05$) increased their TC and TAG levels while only the MD and HD administration of soya beans significantly increased the TC and TAG levels when compared to the control. For the 2 months duration, the male rats administered LD, MD, and HD MSG had comparable TC levels to the control, whereas the soya bean doses produced no significant ($p>0.05$) changes to the TAG levels when

compared to the control. Both the MD and HD MSG and soya bean significantly ($p<0.05$) increased the TC levels after 4 months administration to the male rats, while the administration of HD MSG significantly increased the TAG levels (5.70 mmol/l) when compared to the control level (4.25 mmol/l). The 6 months administration of the MSG and soya beans to the male rats significantly ($p<0.05$) elevated the TC and TAG levels when compared to their control levels.

Table 5: Total cholesterol and triacylglycerol levels of rats administered monosodium glutamate and soyabeans

DURATION	GROUPS	TC (mmol/l)	TC (mmol/l)	TG (mmol/l)	TG (mmol/l)
		MSG	SOY	MSG	SOY
2 MONTHS			FEMALES		
	C	$3.85\pm0.23^{a*}$	$3.85\pm0.23^{a*}$	$2.60\pm0.29^{a*}$	$2.60\pm0.29^{a*}$
	LD	$3.92\pm0.16^{a*}$	$3.65\pm0.07^{a*}$	$3.87\pm0.17^{b*}$	$2.65\pm0.27^{a**}$
	MD	$4.75\pm0.16^{b*}$	$3.80\pm0.14^{a**}$	$4.40\pm0.28^{c*}$	$2.24\pm0.07^{a**}$
	HD	$5.08\pm0.40^{c*}$	$3.56\pm0.23^{a**}$	$4.60\pm0.28^{c*}$	$2.60\pm0.14^{a**}$
4 MONTHS					
	C	$6.05\pm0.35^{d*}$	$6.05\pm0.35^{b*}$	$4.40\pm0.56^{c*}$	$4.40\pm0.56^{b*}$
	LD	$6.15\pm0.35^{d*}$	$5.65\pm0.49^{b**}$	$5.10\pm0.42^{d*}$	$4.30\pm0.28^{b**}$
	MD	$6.75\pm0.77^{d*}$	$5.85\pm0.21^{b**}$	$5.50\pm0.42^{d*}$	$4.40\pm0.14^{b**}$
	HD	$7.40\pm0.42^{e*}$	$5.95\pm0.21^{bd**}$	$5.75\pm0.21^{d*}$	$4.35\pm0.35^{b**}$
6 MONTHS					
	C	$6.10\pm0.28^{d*}$	$6.10\pm0.28^{de*}$	$4.10\pm0.14^{c*}$	$4.10\pm0.14^{b*}$
	LD	$7.45\pm0.63^{e*}$	$6.20\pm0.28^{e**}$	$6.05\pm0.21^{e*}$	$4.25\pm0.21^{b**}$
	MD	$7.50\pm0.14^{e*}$	$6.85\pm0.35^{f**}$	$5.85\pm0.21^{e*}$	$5.05\pm0.35^{c**}$
	HD	$9.05\pm0.35^{f*}$	$5.60\pm0.15^{c**}$	$6.30\pm0.42^{e*}$	$5.00\pm0.14^{c**}$
			MALES		
2 MONTHS					
	C	$3.43\pm0.04^{ga*}$	$3.43\pm0.04^{a*}$	$2.37\pm0.17^{fa*}$	$2.37\pm0.17^{a*}$
	LD	$3.87\pm0.08^{ga*}$	$3.54\pm0.17^{a**}$	$3.25\pm0.07^{g*}$	$2.47\pm0.24^{a**}$
	MD	$3.86\pm0.24^{ga*}$	$3.92\pm0.09^{g*}$	$3.22\pm0.24^{g*}$	$2.62\pm0.24^{a**}$
	HD	$4.10\pm0.53^{ha*}$	$4.05\pm0.05^{g*}$	$3.42\pm0.24^{gj*}$	$2.52\pm0.10^{a**}$
4 MONTHS					
	C	$4.65\pm0.21^{h*}$	$4.65\pm0.21^{h*}$	$4.25\pm0.21^{hc*}$	$4.25\pm0.21^{b*}$
	LD	$7.35\pm0.35^{ie*}$	$4.75\pm0.07^{hi**}$	$4.75\pm0.21^{h*}$	$4.50\pm0.14^{b*}$
	MD	$7.10\pm0.28^{ie*}$	$4.85\pm0.49^{ij**}$	$4.60\pm0.56^{kh*}$	$4.15\pm0.21^{b*}$
	HD	$7.40\pm0.28^{ie*}$	$5.20\pm0.28^{j**}$	$5.70\pm0.28^{ike*}$	$4.25\pm0.35^{b**}$
6 MONTHS					
	C	$5.50\pm0.42^{j*}$	$5.50\pm0.42^{b*}$	$3.70\pm0.14^{j*}$	$3.70\pm0.14^{d*}$
	LD	$7.40\pm0.42^{ie*}$	$6.00\pm0.14^{de**}$	$5.35\pm0.21^{i*}$	$4.30\pm0.14^{b**}$
	MD	$8.15\pm0.35^{k*}$	$6.45\pm0.21^{e**}$	$5.25\pm0.35^{i*}$	$4.95\pm0.35^{c**}$
	HD	$8.85\pm0.49^{kf*}$	$7.45\pm0.49^{f**}$	$6.05\pm0.35^{ke*}$	$5.20\pm0.42^{c**}$

Values are means ± standard deviations n=5 Values with different superscript letter(s) (a-m) down the column or symbols (* and **) across the row for each parameter, are significantly different ($p < 0.05$). MSG - Monosodium glutamate, SOY – Soya bean, TC – Total Cholesterol, TAG – triacylglycerol

Superoxide Dismutase and Catalase Levels

Table 6 shows the superoxide dismutase and catalase levels of rats administered monosodium glutamate and soya beans for 2, 4, and 6 months. The result showed no significant ($p>0.05$) changes occurred in the SOD and CAT levels following 2 and 4 months administration of LD, MD, and HD soya beans, while all the doses of MSG significantly ($p<0.05$) decreased the SOD and MSG after 4 months administration. The soya bean administration significantly ($p<0.05$) decreased the SOD and CAT levels when administered for 6 months, while the MD and HD administration of MSG significantly ($p<0.05$) decreased the SOD levels (29948.50 and 27647.00 U/gHb respectively) when compared to the control (38049.50 U/gHb) and CAT levels (25.85 and 25.40 U/gHb) when compared to the control (45.85

U/gHb). For the male rats, the administration of LD, MD, and HD MSG for 2 months significantly ($p<0.05$) increased the SOD levels, while the administration LD and MD soya bean for 2 months produced SOD levels comparable to the control. The CAT levels of male rats administered LD and MD of MSG and soya beans were comparable to the control levels. The SOD levels of male rats administered MD and HD MSG and soya beans were significantly ($p<0.05$) lower than their control levels, while no significant changes were observed in the CAT levels of the male rats administered the soya bean doses for 4 months. The 6 months administration of MD and HD MSG significantly ($p<0.05$) decreased the SOD levels of the male rats when compared to the control, while the administration of MD and HD soya bean for 6 months significantly ($p<0.05$) decreased the CAT levels of the male rats. The SOD levels of the male rats administered LD, MD, and HD soya beans (24277.50, 27166.50, and 26967.50 U/gHb respectively) were significantly ($p<0.05$) lower than the control rats (47060 U/gHb).

Table 6: Superoxide Dismutase and Catalase Levels of Rats Administered Monosodium Glutamate and Soya Beans

DURATION	GROUPS	SOD (U/gHb)	SOD (U/gHb)	CAT(U/gHb)	CAT(U/gHb)
		MSG	SOY	MSG	SOY
2 MONTHS					
			FEMALES		
	C	$20320.00\pm1583.91^{a*}$	$20320.00\pm1583.91^{a*}$	$45.85\pm1.34^{a*}$	$45.85\pm1.34^{a*}$
	LD	$16645.50\pm1378.15^{b*}$	$21245.00\pm544.47^{a**}$	$35.15\pm2.61^{b*}$	$49.00\pm1.41^{a**}$
	MD	$16402.00\pm562.85^{b*}$	$22530.00\pm3436.53^{a**}$	$25.85\pm2.47^{c*}$	$47.50\pm1.26^{a**}$
	HD	$8880.50\pm1074.09^{c*}$	$19625.00\pm1308.14^{a**}$	$25.40\pm5.09^{c*}$	$46.50\pm3.53^{a**}$
4 MONTHS					
	C	$20835.00\pm739.63^{ai*}$	$20835.00\pm739.63^{a*}$	$47.50\pm2.12^{a*}$	$47.50\pm2.12^{ad*}$
	LD	$18103.00\pm506.28^{b*}$	$22315.00\pm302.64^{a**}$	$32.50\pm3.53^{b*}$	$43.50\pm4.94^{ad**}$
	MD	$16818.50\pm1144.80^{b*}$	$19348.50\pm101.11^{a**}$	$29.00\pm4.24^{c*}$	$44.50\pm2.12^{ad**}$
	HD	$11248.50\pm1646.85^{c*}$	$18978.50\pm936.91^{a**}$	$27.50\pm0.70^{c*}$	$33.50\pm3.53^{b**}$
6 MONTHS					
	C	$38049.50\pm2358.20^{d*}$	$38049.50\pm2358.20^{b*}$	$45.85\pm1.34^{a*}$	$45.85\pm1.34^{a*}$
	LD	$34350.00\pm5389.56^{dl*}$	$23163.00\pm2172.23^{a**}$	$35.15\pm2.61^{b*}$	$39.70\pm3.67^{b*}$
	MD	$29948.50\pm2137.58^{el*}$	$18746.50\pm4489.42^{a**}$	$25.85\pm2.47^{c*}$	$38.25\pm2.47^{bc**}$
	HD	$27647.00\pm1927.57^{e*}$	$13825.00\pm2432.44^{c**}$	$25.40\pm5.09^{c*}$	$33.20\pm2.82^{bc**}$
			MALES		
2 MONTHS					
	C	$19014.50\pm303.34^{fa*}$	$19014.50\pm303.34^{da*}$	$28.00\pm4.24^{dc*}$	$38.00\pm4.24^{ce**}$
	LD	$12820.50\pm2093.74^{g*}$	$17805.00\pm289.91^{d**}$	$29.00\pm4.24^{df*}$	$36.50\pm3.53^{c**}$
	MD	$12798.00\pm704.27^{g*}$	$17668.00\pm243.24^{d**}$	$30.50\pm4.94^{df*}$	$32.00\pm2.82^{c*}$
	HD	$7973.50\pm504.16^{hc*}$	$13844.00\pm670.33^{e**}$	$23.00\pm4.24^{c*}$	$34.50\pm2.12^{c**}$
4 MONTHS					
	C	$23165.00\pm2787.41^{i*}$	$23165.00\pm2787.41^{fa*}$	$44.00\pm4.24^{eg*}$	$44.00\pm4.24^{dfa*}$
	LD	$22791.00\pm2647.40^{i*}$	$15482.50\pm1802.41^{g**}$	$33.50\pm3.53^{f*}$	$40.50\pm4.94^{de**}$
	MD	$19061.00\pm311.12^{fa*}$	$12442.50\pm2137.58^{g**}$	$29.50\pm6.36^{df*}$	$41.50\pm2.12^{de**}$
	HD	$15197.00\pm688.72^{j*}$	$13504.00\pm336.58^{g**}$	$24.00\pm5.65^{dc*}$	$43.00\pm7.07^{da**}$
6 MONTHS					
	C	$47060.50\pm1694.93^{k*}$	$47060.50\pm1694.93^{hb*}$	$48.65\pm2.61^{e*}$	$48.65\pm2.61^{fa*}$
	LD	$46037.00\pm4821.05^{k*}$	$24277.50\pm1820.79^{fa**}$	$42.00\pm1.55^{g*}$	$48.15\pm1.90^{fa**}$
	MD	$32480.00\pm2539.92^{l*}$	$27166.50\pm1347.03^{fa*}$	$33.20\pm2.54^{f*}$	$38.55\pm3.88^{ce**}$
	HD	$33392.00\pm2527.19^{l*}$	$26967.50\pm3260.46^{fa*}$	$26.15\pm2.89^{c*}$	$36.00\pm6.78^{c**}$

The above table shows the analysis of superoxide dismutase (SOD) and catalase (CAT) levels in rats administered monosodium glutamate (MSG) and soybeans over varying durations (2, 4, and 6 months). The results showed distinct patterns of changes in these antioxidant enzyme levels based on the different doses and durations of MSG and soybean administration.

Superoxide Dismutase (SOD) Levels:

1. Two Months Administration:

a. For female rats, LD and MD soya bean administration did not cause significant changes in SOD levels.

b. For male rats, LD and MD MSG and soya bean administration increased SOD levels significantly.

2. Four Months Administration:

a. Female rats: No significant changes in SOD levels for LD, MD, and HD soya bean doses.

b. Male rats: MD and HD MSG and soya bean administration significantly decreased SOD levels compared to the control. No significant changes were observed in CAT levels for the soya bean doses.

3. Six Months Administration:

a. Female rats: Soya bean administration significantly decreased SOD levels. MD and HD MSG administration also significantly decreased SOD levels.

b. Male rats: MD and HD MSG administration significantly decreased SOD levels. LD, MD, and HD soya bean administration significantly decreased SOD levels compared to the control.

Catalase (CAT) Levels:

1. Two Months Administration:

No significant changes in CAT levels for all doses of MSG and soya beans in both female and male rats.

2. Four Months Administration:

a. Female rats: No significant changes in CAT levels for all soya bean doses.

b. Male rats: No significant changes in CAT levels for all soya bean doses. MD and HD MSG administration significantly decreased CAT levels compared to the control.

3. Six Months Administration:

a. Female rats: Soya bean administration significantly decreased CAT levels.

b. Male rats: MD and HD soya bean administration significantly decreased CAT levels compared to the control.

These findings indicate that the duration and dosage of MSG and soybean administration have distinct effects on SOD and CAT levels in both female and male rats. While some doses and durations did not lead to significant alterations in these enzyme levels, others, especially at higher doses and longer durations, caused significant decreases, suggesting a potential impact on the rats' antioxidant defense mechanisms. Further analysis and interpretation of these results are necessary to understand the implications of these changes in SOD and CAT levels for the overall health and well-being of the rats involved in the study.

Glutathione Peroxidise and Malondialdehyde Levels

Table 7 shows the concentration of glutathione peroxidise and malondialdehyde of rats administered MSG and soya beans. The glutathione peroxidase levels of the female rats were significantly ($p<0.05$) decreased by the administration of MSG and soya beans for 2 months while no significant changes were observed on the malondialdehyde levels after the 2 months administration of MSG and soya beans. The 4 months administration of LD, MD, and HD MSG significantly ($p<0.05$) decreased the glutathione levels (66.95, 54.40, and 50.85 U/L) and increased the MDA levels (55.00, 51.00, and 81.00 nmol/ml respectively) when compared to their respective controls (76.05 U/L and 35.00 nmol/ml respectively). The 6 months administration of MSG significantly reduced the GPx levels and significantly ($p<0.05$) elevated the MDA levels. No significant difference was observed in the GPx and MDA levels

of rats administered LD soya bean for 6 months relative to the control levels. For the male rats the LD administration of MSG and soya bean for 2 months has no significant ($p>0.05$) effect on the GPx and MDA levels. After 4 months administration, the LD, MD and HD MSG significantly ($p<0.05$) decreased the GPx levels and elevated the MDA levels when compared to the control. No significant effect was observed on the GPx levels of the rats administered the various soya bean doses, for 4 months, while the LD and MD administration of soya bean to the male rats for 4 months significantly ($p<0.05$) increased the MDA levels (37.50 and 41.50 nmol/ml respectively) The administration of MD and HD MSG and soya bean, significantly ($p<0.05$) decreased the GPx levels and significantly ($p<0.05$) increased the MDA levels.

Table 7: Glutathione Peroxidise and Malondialdehyde Concentrations of Rats Administered MSG and Soya Beans

DURATION	GROUPS	GPx (U/L)	GPx (U/L)	MDA (nmol/ml)	MDA (nmol/ml)
		MSG	SOY	MSG	SOY
2 MONTHS			FEMALES		
	C	$76.70\pm2.26^{a*}$	$76.70\pm2.26^{ad*}$	$22.00\pm5.65^{a*}$	$22.00\pm5.65^{a*}$
	LD	$63.45\pm2.19^{b*}$	$42.40\pm4.24^{b**}$	$23.00\pm4.24^{a*}$	$18.50\pm7.77^{a*}$
	MD	$55.70\pm0.98^{c*}$	$56.90\pm5.23^{c*}$	$25.50\pm6.36^{a*}$	$20.00\pm9.89^{a*}$
	HD	$44.10\pm5.79^{d*}$	$44.15\pm8.98^{b*}$	$20.00\pm4.24^{a*}$	$19.50\pm9.19^{a*}$
4 MONTHS					
	C	$76.05\pm5.30^{a*}$	$76.05\pm5.30^{c*}$	$35.00\pm2.82^{b*}$	$35.00\pm2.82^{b**}$
	LD	$66.95\pm4.45^{b*}$	$77.75\pm3.88^{c**}$	$55.00\pm4.24^{c*}$	$25.50\pm2.12^{a**}$
	MD	$54.40\pm5.51^{c*}$	$68.60\pm8.90^{d**}$	$51.00\pm1.41^{c*}$	$20.00\pm2.82^{a**}$
	HD	$50.85\pm2.05^{c*}$	$62.85\pm4.59^{d**}$	$81.00\pm4.24^{d}*$	$24.50\pm2.12^{a**}$
6 MONTHS					
	C	$70.70\pm2.26^{a*}$	$70.70\pm2.26^{c*}$	$31.41\pm3.53^{a*}$	$31.50\pm3.53^{b*}$
	LD	$54.45\pm4.15^{b*}$	$73.65\pm3.32^{c**}$	$40.00\pm4.24^{b*}$	$35.00\pm4.24^{b*}$
	MD	$47.62\pm3.04^{d*}$	$68.05\pm2.75^{d**}$	$52.50\pm6.36^{c*}$	$36.00\pm2.82^{b**}$
	HD	$40.31\pm2.11^{d*}$	$59.40\pm3.39^{a**}$	$93.00\pm4.24^{e*}$	$41.00\pm1.41^{c**}$
			MALES		
2 MONTHS					
	C	$84.75\pm3.74^{e*}$	$84.75\pm3.74^{e*}$	$19.00\pm4.24^{a*}$	$19.00\pm4.24^{da*}$
	LD	$79.35\pm3.60^{ea*}$	$88.50\pm3.25^{e**}$	$18.00\pm1.41^{a*}$	$18.50\pm3.53^{da*}$
	MD	$67.30\pm4.52^{fgb*}$	$86.95\pm3.74^{e**}$	$24.50\pm6.36^{a*}$	$31.00\pm4.24^{e*}$
	HD	$62.30\pm5.65^{fb*}$	$81.85\pm2.33^{e**}$	$36.50\pm4.94^{b*}$	$36.00\pm1.55^{e*}$
4 MONTHS					
	C	$92.65\pm5.02^{g*}$	$92.65\pm5.02^{f*}$	$31.50\pm3.53^{d*}$	$31.50\pm3.53^{eb*}$
	LD	$82.95\pm2.33^{e*}$	$93.75\pm2.05^{f**}$	$35.00\pm1.41^{b*}$	$33.00\pm2.82^{ef*}$
	MD	$67.50\pm4.66^{fb*}$	$90.80\pm6.74^{f**}$	$40.00\pm2.82^{b*}$	$37.50\pm2.12^{fg*}$
	HD	$70.15\pm3.32^{fb*}$	$91.80\pm2.96^{f**}$	$48.00\pm2.82^{c*}$	$41.50\pm2.12^{g**}$
6 MONTHS					
	C	$81.85\pm1.76^{e*}$	$81.85\pm1.76^{e*}$	$36.50\pm2.12^{b*}$	$36.50\pm2.12^{fb*}$
	LD	$71.95\pm3.88^{ga*}$	$82.75\pm3.46^{e**}$	$40.50\pm2.12^{b*}$	$35.50\pm1.94^{fb**}$
	MD	$61.95\pm2.61^{f*}$	$72.50\pm2.26^{hc**}$	$52.50\pm3.53^{c*}$	$42.00\pm1.41^{gc**}$
	HD	$52.45\pm2.19^{hb*}$	$65.90\pm3.53^{gd**}$	$61.00\pm4.24^{e*}$	$47.00\pm2.82^{hc**}$

Values are means ± standard deviations n=5. Values with different superscript letter(s) (a-h) down the column or symbols (and **) across the row for each parameter, are significantly different ($p < 0.05$). MSG - Monosodium glutamate, SOY – Soya bean, GPx – Glutathione peroxidise, MDA – Malondialdehyde*

Summary of Findings from Table 6

1. Glutathione Peroxidase (GPx) Levels:

a. Administration of MSG and soya beans significantly decreased GPx levels in both female and male rats after 2, 4, and 6 months.

b. The 4 and 6 months administration of MSG significantly reduced GPx levels in female rats, while in male rats, MSG and soya bean administration for 4 months significantly decreased GPx levels.

2. Malondialdehyde (MDA) Levels:

a. MDA levels increased significantly after 4 months of MSG administration in female and male rats.

b. The administration of LD and MD soya bean to male rats for 4 months significantly increased MDA levels.

Both MSG and soya bean administration led to significant decreases in glutathione peroxidase levels, indicating a potential disruption in the rats' antioxidant defense mechanisms. Additionally, the observed increases in malondialdehyde levels, particularly after 4 months of MSG and specific soya bean administration, suggest an elevated oxidative stress environment, as malondialdehyde is a marker of lipid peroxidation and oxidative stress. These findings highlight the impact of MSG and soya bean consumption on oxidative stress levels in the rats, which can have implications for their overall health and well-being.

Implication of Findings

1. **Liver Enzyme Concentrations:**

   The significant elevation in ALT, ALP, and AST levels in both female and male rats administered MSG and soybeans indicates potential hepatotoxic effects. These findings emphasize the importance of monitoring liver enzyme levels in individuals consuming diets high in MSG and soybeans, especially for an extended period.

2. **Renal Function and Urea/Creatinine Levels:**

   Changes in urea and creatinine levels, particularly the decrease observed after 4 months of soybean administration, suggest possible effects on renal function. Individuals with kidney issues should exercise caution in consuming soybeans, while the decrease in urea levels after MSG intake highlights the need for further investigation into its impact on kidney health.

3. **Antioxidant Enzyme Activities (SOD, CAT, GPx):**

   Significant alterations in SOD, CAT, and GPx levels indicate disturbances in the body's antioxidant defense mechanisms. This disruption may lead to increased oxidative stress, potentially contributing to various diseases. Individuals relying heavily on MSG and soybeans in their diets may face compromised antioxidant responses.

4. **Malondialdehyde (MDA) Levels:**

   Elevated MDA levels, indicative of lipid peroxidation, suggest heightened oxidative stress. This can adversely affect cell membranes and biomolecules, potentially leading to tissue damage. High MSG and soybean intake might contribute to oxidative damage, emphasizing the need for antioxidant-rich diets to counter these effects.

5. **Gender Differences and Individual Variations:**

   Gender-specific variations in response to MSG and soybeans underline the importance of personalized dietary recommendations. Individuals, especially those vulnerable to liver and kidney issues, should be mindful of their unique physiological responses to these dietary components.

6. **Public Health and Awareness:**

   These findings raise concerns about the widespread consumption of MSG and soybeans. Public health initiatives should focus on raising awareness about potential health risks associated with excessive intake. Additionally, healthcare providers should consider these factors when advising patients on dietary choices, especially those with pre-existing health conditions.

7. **Further Research and Regulation:**

   Further studies are crucial to comprehensively understand the long-term effects of MSG and soybeans on human health. Regulatory bodies should consider these findings when setting guidelines, ensuring public safety and well-being. Continued research can aid in developing evidence-based dietary recommendations for the general population.

The study's results underscore the importance of mindful consumption of MSG and soybeans due to their potential impact on liver and kidney health, antioxidant defense mechanisms, and overall oxidative stress. These implications emphasize the need for informed dietary choices, personalized nutrition advice, and ongoing research to safeguard public health.

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