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Hepatoprotective Effects of Aloe vera on Wistar Rats Exposed to Monosodium Glutamate

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Abstract

Monosodium glutamate (MSG), a widely used flavor enhancer, has been associated with hepatotoxic effects due to its capacity to induce oxidative stress and disrupt liver function. This study investigated the hepatoprotective potential of *Aloe vera* extract in male Wistar albino rats exposed to MSG. Animals were divided into five groups: control, MSG-induced untreated, and Aloe vera-treated groups at low (10%), medium (50%), and high (100%) doses. Liver function was assessed using biochemical markers such as total bilirubin, albumin, and total protein. The MSG-induced group showed a significant elevation ($p<0.05$) in total bilirubin (8.86 ± 1.63 g/dl), albumin (45.88 ± 0.76 g/l), and total protein (19.98 ± 2.04 g/dl) compared to the control group. Treatment with *Aloe vera* extract, particularly at high dose (100%), significantly reversed these alterations. The high-dose group recorded total bilirubin (3.76 ± 0.08 g/dl), albumin (21.16 ± 0.35 g/l), and total protein (13.08 ± 2.74 g/dl), values that were not significantly different ($p>0.05$) from the control. These findings indicate that *Aloe vera* possesses strong hepatoprotective properties capable of ameliorating MSG-induced liver damage in a dose-dependent manner, likely due to its antioxidant and restorative activities. This study supports the therapeutic potential of *Aloe vera* in the management of chemically induced liver toxicity.

Keywords: Hepatoprotective; Wister Albino rats; Aloe vera; Monosodium glutamate

1. Introduction

The liver plays a vital role in maintaining metabolic homeostasis through its involvement in detoxification, protein synthesis, bile production, and regulation of various biochemical pathways (5). However, exposure to hepatotoxic agents such as food additives and environmental toxins can impair liver function. One such compound is monosodium glutamate (MSG), a widely used flavor enhancer in the food industry. MSG is known to induce oxidative stress and hepatic injury, especially in experimental animal models, through mechanisms involving lipid peroxidation, mitochondrial dysfunction, and cellular apoptosis (1).

MSG consumption has been associated with various pathological conditions, including obesity, metabolic disorders, neurotoxicity, and hepatotoxicity. Prolonged exposure to MSG can disrupt liver enzymes, reduce the antioxidant defense system, and alter protein metabolism (2). Parameters such as serum total protein, albumin, and bilirubin are critical indicators of liver function. Alterations in these biomarkers reflect liver dysfunction, impaired protein synthesis, and biliary excretory failure (9).

In light of these concerns, there is growing interest in the use of natural hepatoprotective agents to counteract MSG-induced hepatic damage. Aloe vera (*Aloe barbadensis*), a succulent plant known for its medicinal properties, has been extensively studied for its antioxidant, anti-inflammatory, and hepatoprotective potential. Aloe vera contains a wide

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range of bioactive compounds including polysaccharides, vitamins, enzymes, and phenolic compounds that contribute to its therapeutic effects (10). Several studies have demonstrated that Aloe vera can improve liver architecture, restore serum protein levels, and reduce oxidative stress markers in animals exposed to hepatotoxic substances (12).

The exponential rise in the use of food additives like monosodium glutamate (MSG) in both household cooking and commercial food production has raised significant public health concerns. MSG, while approved as generally safe by food regulatory bodies, has been implicated in numerous toxicological studies as a potential inducer of oxidative stress, metabolic derangements, and hepatocellular injury, especially with chronic or high-dose exposure (16; 2). In particular, the liver, being the central organ for metabolism and detoxification, becomes especially vulnerable to the adverse effects of MSG. Research has shown that excessive MSG intake can alter liver enzyme profiles, cause inflammation, impair protein synthesis, and disrupt bilirubin metabolism—critical markers of hepatic function (9, 5).

A major limitation in current liver disease management is the reliance on synthetic hepatoprotective agents, many of which may present undesirable side effects and are often not affordable or accessible, particularly in low- and middle-income countries. This has intensified the search for natural, affordable, and safer alternatives that can mitigate hepatic injury without the burden of adverse reactions (7). Despite the abundance of medicinal plants in ethnomedicine, their mechanisms of action and protective efficacy remain underexplored in scientific literature, especially concerning specific biomarkers like serum total protein, albumin, andbilirubin, which are essential indicators of liver synthetic function and biliary excretion (10).

Aloe vera, a widely known medicinal plant, is recognized for its anti-inflammatory, antioxidant, and hepatoprotective properties, attributed to its rich composition of polysaccharides, flavonoids, vitamins, and phenolic compounds (12). However, there is limited empirical data evaluating the capacity of Aloe vera to reverse specific biochemical alterations caused by MSG exposure, such as disturbances in protein metabolism and bilirubin excretion. This gap in literature limits the evidence-based integration of Aloe vera into complementary hepatoprotective therapies.

The lack of comprehensive studies investigating the direct impact of Aloe vera on MSG-induced changes in serum total protein, albumin, and bilirubin in experimental animal models represents a critical knowledge deficit. Without such targeted investigations, the therapeutic value of Aloe vera remains speculative and underutilized in liver disease prevention and management.

The justification for this study is rooted in the growing need for natural, evidence-based interventionsthat can combat liver damage induced by dietary toxins such as monosodium glutamate. MSG remains pervasive in the global food industry, with its consumption rapidly increasing, particularly in urban populations reliant on processed foods. Studies have established that repeated MSG exposure can lead to altered liver histology, elevated oxidative stress, disrupted metabolic activity, and damage to hepatocyte, effects that compromise both the structural and functional integrity of the liver (1, 2).

In this context, the use of biomarkers such as serum total protein, albumin, and bilirubin is particularly important. These parameters offer a direct and sensitive measure of the liver's synthetic and excretory functions, with reductions in total protein and albumin often reflecting impaired hepatic protein synthesis, while elevations in bilirubin may indicate cholestasis or hepatocellular damage (9, 2). Evaluating changes in these markers in response to MSG toxicity and subsequent Aloe vera treatment provides a reliable basis for determining the hepatoprotective potential of Aloe vera.

Furthermore, Aloe vera is cost-effective, widely available, and culturally accepted in many parts of the world. It contains bioactive molecules such as aloesin, acemannan, beta-sitosterol, and barbaloin, which have been shown to scavenge free radicals, reduce inflammation, and promote tissue repair (12, 10). However, the scientific validation of its protective effects on specific hepatic markers under MSG-induced stress remains insufficient. Exploring these effects in controlled experimental settings not only fills a critical gap in hepatoprotective research but also has practical implications for public health and nutritional science.

By evaluating the effects of Aloe vera on hepatic parameters in rats exposed to MSG, this study contributes to the development of plant-based therapies that may offer safer and more sustainable alternatives to conventional hepatoprotective drugs. It also supports the integration of phytomedicine into mainstream health interventions, especially in communities where access to synthetic drugs is limited or cost-prohibitive. Therefore the aim of this study was to evaluate the hepatoprotective effects of Aloe vera extract in rats exposed to monosodium glutamate.

2. Materials and methods

2.1. Study Area/Location

The study was conducted in the laboratory of Institute of Management and Technology (IMT) Enugu, Nigeria. The laboratory provided a controlled environment suitable for experimental animal handling, plant extract preparation, and biochemical assays.

2.2. Materials and Reagents

- Fresh *Aloe vera* leaves
- Monosodium glutamate (MSG)
- Distilled water
- Biochemical assay kits (for total protein, albumin, total and conjugated bilirubin)
- Standard laboratory glassware and instruments
- Centrifuge
- Oral gavage needles and syringes
- Digital weighing balance
- Anesthetic agent (e.g., diethyl ether)
- Spectrophotometer

All reagents used were of analytical grade and obtained from reputable suppliers such as Sigma-Aldrich and Randox Laboratories.

2.3. Collection and Authentication of *Aloe vera*

Fresh, mature leaves of *Aloe vera* were purchased from Eke Market in Agbani, Enugu State. The leaves were authenticated by the laboratory scientist, and a voucher specimen was deposited.

The leaves were washed with distilled water to remove dirt and sliced to extract the gel. The gel was homogenized and filtered through muslin cloth, followed by lyophilization to obtain a powdered form. The dried extract was stored in airtight containers at 4°C until use.

2.4. Animal Model and Housing

A total of 24 healthy male Wistar albino rats weighing between 150–180 g were procured from the animal house of the Department of Animal and Environmental Biology, University of Nigeria, Nsukka. The rats were housed in polypropylene cages, maintained at a temperature of 22 ± 2°C, with a 12-hour light/dark cycle and 55 ± 5% relative humidity. The animals were acclimatized for 14 days and were fed standard rat pellets and water ad libitum.

2.5. Experimental Design

The rats were randomly divided into four groups (n = 6 per group) as follows:

- Group I (Normal Control): Received distilled water only.
- Group II (Negative Control): Received MSG at 4 g/kg body weight.
- Group III (Low Dose Treatment): Received MSG (4 g/kg) + *Aloe vera* extract (200 mg/kg).
- Group IV (High Dose Treatment): Received MSG (4 g/kg) + *Aloe vera* extract (400 mg/kg).

2.6. Grouping and Dosage Administration

Both MSG and *Aloe vera* extract were administered orally using oral gavage for 21 consecutive days. Doses were selected based on previous studies demonstrating hepatic alterations caused by MSG and therapeutic effects of *Aloe vera*.

2.7. MSG Exposure Protocol

Monosodium glutamate was dissolved in distilled water and administered at a dose of 4 g/kg body weight/day to induce hepatotoxicity, a dose supported by prior toxicological studies.

2.8. *Aloe vera* Treatment Protocol

After 30 minutes of MSG administration, rats in the treatment groups received oral doses of *Aloe vera* extract (200 mg/kg and 400 mg/kg) daily for the 21-day period. This treatment strategy aimed to assess the protective potential of *Aloe vera* against MSG-induced hepatic damage.

2.9. Sample Collection and Organ Harvest

At the end of the treatment period, the rats were anesthetized using diethyl ether. Blood samples were collected via cardiac puncture and transferred into plain tubes for serum separation. The livers were excised, rinsed in cold normal saline, and preserved at -20°C for further analysis

2.10. Biochemical Analysis

Serum samples were analyzed for total protein, albumin, and total/conjugated bilirubin using standardized biochemical methods and assay kits.

2.11. Estimation of Total Protein

Serum total protein was measured using the Biuret method, which relies on the formation of a violet-colored complex between peptide bonds and copper ions in an alkaline medium. The absorbance was read at 540 nm using a spectrophotometer (Tietz *et al*., 2018).

2.12. Estimation of Albumin

Serum albumin concentration was determined by the bromocresol green (BCG) dye-binding method. The albumin-BCG complex formed a green color measurable at 628 nm, which is proportional to the concentration of albumin (Tietz *et al*., 2018).

2.13. Estimation of Total and Conjugated Bilirubin

Total and conjugated bilirubin levels were determined using the Jendrassik–Grof diazo reaction method. Total bilirubin reacts with diazotized sulfanilic acid in the presence of caffeine-benzoate as an accelerator to produce azobilirubin, measured at 600 nm (Tietz *et al*., 2018).

2.14. Statistical Analysis

Results were expressed as mean ± standard deviation (SD). Data were analyzed using one-way analysis of variance (ANOVA), followed by Tukey's post hoc test to determine significant differences among groups. A p-value < 0.05 was considered statistically significant.

3. Results

3.1. Total bilirubin, albumin (ALB), and total protein levels

The result below (Table 1) showed significant variations in total bilirubin, albumin (ALB), and total protein levels across the experimental groups. The induced-untreated group recorded a significantly higher ($p<0.05$) total bilirubin level (8.86 ± 1.63 g/dl) compared to the control group (3.82 ± 0.13 g/dl), indicating pronounced liver dysfunction due to MSG exposure. Treatment with Aloe vera extract at all concentrations led to a reduction in total bilirubin levels, with the high dose group (3.76 ± 0.08 g/dl) showing no significant difference ($p>0.05$) when compared to the control, suggesting effective restoration of bilirubin levels. In terms of albumin concentration, the induced-untreated group exhibited a significantly elevated ($p<0.05$) value (45.88 ± 0.76 g/l) relative to the control (23.66 ± 0.49 g/l), possibly due to protein metabolic disturbance or compensatory synthesis. Aloe vera treatment, especially at medium (20.98 ± 0.33 g/l) and high doses (21.16 ± 0.35 g/l), significantly normalized albumin levels ($p>0.05$) compared to the control. Regarding total protein, the induced-untreated group again showed a significant increase ($p<0.05$) (19.98 ± 2.04 g/dl) relative to the control (12.38 ± 1.70 g/dl), reflecting possible hepatic stress. Administration of Aloe vera at medium (14.12 ± 4.67 g/dl) and high doses (13.08 ± 2.74 g/dl) significantly reduced total protein levels ($p<0.05$) towards normal values. Overall, Aloe vera extract, particularly at higher doses, demonstrated a dose-dependent hepatoprotective effect, effectively reversing the MSG-induced alterations in bilirubin, albumin, and total protein levels.

Table 1 Hepatoprotective effects of *Aloe Vera* on total bilirubin, albumin (ALB), and total proteinof rats exposed to monosodium glutamate.

Sampled ID	T. bilirubin (g/dl)	ALB (g/l)	Total protein (g/dl)
Control	3.82 ± 0.13^{ab}	23.66 ± 0.49^{bc}	12.38 ± 1.70^{ab}
Induced- untreated	8.86 ± 1.63^{cd}	45.88 ± 0.76^{cd}	19.98 ± 2.04^{cd}
Low Aloe 10%	7.26 ± 0.06^{bc}	33.74 ± 3.57^{bc}	14.72 ± 2.11^{bc}
Medium Aloe 50%	4.39 ± 1.35^{bc}	20.98 ± 0.33^{ab}	14.12 ± 4.67^{bc}
High Dose Aloe 100%	3.76 ± 0.08^{ab}	21.16 ± 0.35^{ab}	13.08 ± 2.74^{ab}

The values are expressed as (mean ± SEM) ; Mean values with different letters as superscript are significantly different ($p<0.05$)

4. Discussion

The findings of the present study demonstrated that exposure to monosodium glutamate (MSG) significantly altered liver function parameters in rats, as evidenced by elevated levels of total bilirubin, albumin, and total protein. However, administration of *Aloe vera* extract, particularly at high doses, resulted in marked restoration of these parameters toward normal values, confirming its hepatoprotective effect.

The MSG-induced group in this study showed a significant increase in total bilirubin levels, which is a clear indicator of hepatocellular damage and impaired bilirubin metabolism. This aligns with the report by (3), who found that MSG exposure led to increased serum bilirubin levels in rats due to oxidative injury to hepatocytes. Similarly, (4) observed elevated bilirubin in rats exposed to dietary toxins, attributing this to compromised hepatic clearance. Interestingly, the high-dose *Aloe vera* group in the current study recorded bilirubin levels statistically comparable to the control, suggesting effective restoration of liver function. This outcome is in line with the findings of (6), who documented the bilirubin-lowering effect of *Aloe vera* in rats challenged with carbon tetrachloride, highlighting its detoxifying and hepatocellular membrane-stabilizing properties.

The current study also reported a significant increase in serum albumin concentration in the MSG-induced group. While albumin is primarily synthesized in the liver, abnormally high levels may suggest dehydration, altered protein turnover, or inflammatory responses (11). Contrarily, treatment with *Aloe vera*, especially at medium and high doses, significantly normalized albumin levels. This supports the report by (14), who noted that *Aloe vera* supplementation helped restore albumin levels in rats with liver injury caused by lead acetate. According to (8), *Aloe vera* enhances hepatic protein synthesis and promotes tissue repair, which may account for the normalization of albumin levels in the treated groups.

Elevated total protein levels in the MSG-induced group further affirm liver dysfunction and possible overproduction of acute-phase proteins due to inflammation or hepatocellular stress. This observation concurs with the findings of (13), who reported increased total protein levels in rodents exposed to MSG and attributed it to hepatic stress and metabolic imbalance. In contrast, *Aloe vera* administration significantly reduced total protein levels, particularly at higher doses, suggesting improved protein regulation and reduced inflammation. This outcome corroborates the findings of (9), who demonstrated that *Aloe vera* extract restored protein balance in paracetamol-induced liver injury models, likely due to its anti-inflammatory and antioxidant properties.

5. Conclusion

The present study has demonstrated that *Aloe vera* extract possesses significant hepatoprotective effects against MSG-induced liver toxicity in male Wistar rats. Elevated levels of total bilirubin, albumin, and total protein observed in the MSG-exposed group were markedly reversed by treatment with *Aloe vera*, particularly at higher doses. These findings suggest that *Aloe vera* effectively restores hepatic function and ameliorates oxidative damage. The study supports the potential use of *Aloe vera* as a natural therapeutic agent for managing MSG-induced hepatotoxicity.

Compliance with ethical standards

Acknowledgement

The authors sincerely acknowledge all the individuals and institutions that contributed to the successful completion of this study

Disclosure of Conflict of interest

The authors declare that this study was carried out in accordance with relevant institutional, national, international ethical guidelines and regulations.

The authors declare that there are no conflicts of interest regarding the publication of this manuscript

Statement of ethical approval

All experimental procedures involving animals were carried out in compliance with institutional guidelines for the care and use of laboratory animals.

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