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Therapeutic Potential of *Momordica charantia* against *Candida albicans*-Induced Hematological Alterations in Albino Mice

Amna Shehzadi[1], Ayesha Ijaz[1], Saima Ashraf[1], Muhammad Anees[1], Ramsha Khan[1], Muhammad Shoban Abid[2], Adeel Khalid[1]*

[1] Department of Zoology, Faculty of Sciences, University of Sialkot, Sialkot, 51310, Pakistan
[2] Department of Biotechnology, Faculty of Sciences, University of Sialkot, Sialkot, 51310, Pakistan.

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A B S T R A C T

Candida albicans is an opportunistic fungal pathogen responsible for a range of infections that often lead to marked hematological and physiological disturbances, primarily through oxidative stress, inflammatory responses, and immune imbalance. The present study aimed to investigate the therapeutic potential of *Momordica charantia* against C. albicans-induced hematological alterations in albino mice. A total of 25 albino mice were randomly allocated into five groups: a normal control group, an infected untreated group, and three treatment groups (T1, T2, and T3) administered graded doses of *M. charantia* extract following fungal infection. Over a 28 days period, hematological parameters and body weight were regularly assessed to evaluate both efficacy and safety of the treatment. The results revealed that C. albicans infection caused significant disruptions in hematological profiles, including reduced hemoglobin (Hb), red blood cell (RBC) count, and packed cell volume (PCV), along with elevated white blood cell (WBC) and lymphocyte levels. These changes were indicative of infection-induced anemia, systemic inflammation, and immune activation. In addition, alterations in liver and renal biomarkers suggested broader physiological stress in infected animals. Conversely, treatment with *M. charantia* extract significantly ($p < 0.05$) improved hematological and biochemical parameters in a dose-dependent manner. Restoration of Hb, RBC, PCV, and platelet indices, along with normalization of WBC counts, highlighted its strong hematoprotective and immunomodulatory effects. Improvements in liver and kidney function further supported its organ-protective potential. Body weight remained stable across all treated groups, indicating good tolerability and absence of toxicity. Overall, *M. charantia* demonstrated notable therapeutic potential against C. albicans-induced hematological disturbances, likely due to its antioxidant and anti-inflammatory phytoconstituents. Further studies are warranted to isolate its active compounds and elucidate underlying molecular mechanisms.

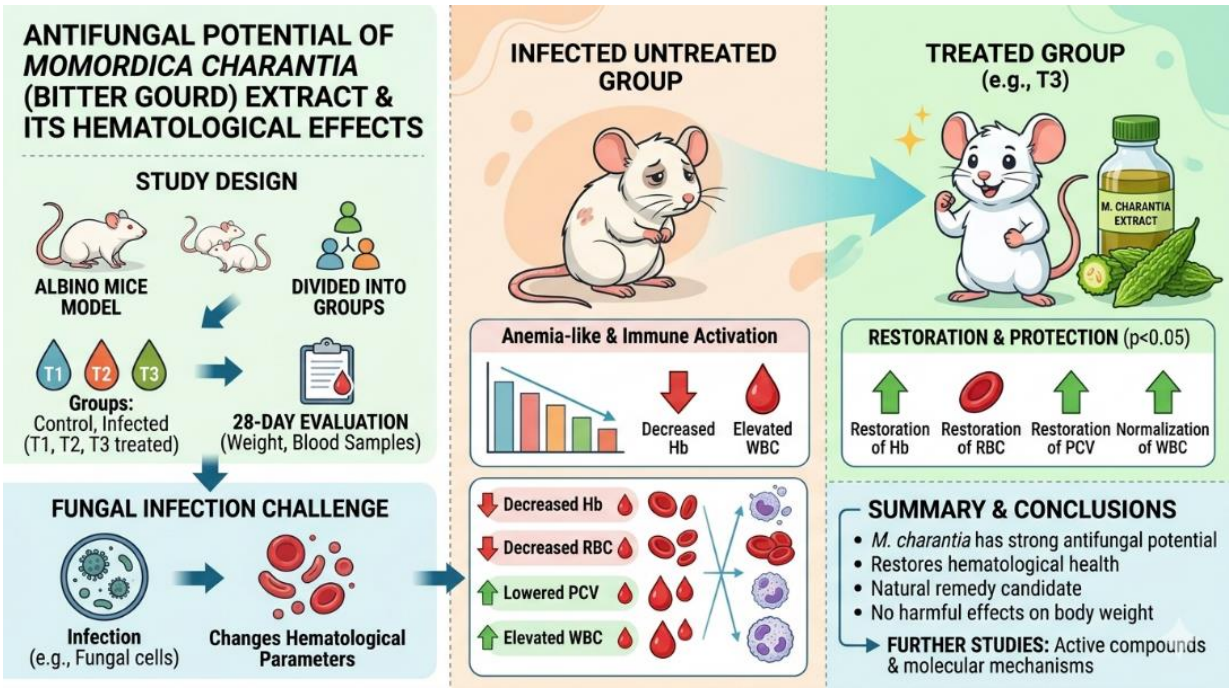
Keywords: *Momordica charantia, Antifungal, Therapeutic effect, Hematological parameters, Abnormalities.*

***Corresponding Author:** *Adeel Khalid*
Email: adeelkhalid27@yahoo.com; adeel.khokar@uskt.edu.pk

INTRODUCTION

Fungal infections represent one of the most prevalent infectious diseases affecting both humans and animals globally, ranging from superficial skin and nail infections to life-threatening systemic mycoses, particularly in immunocompromised individuals (Lass-Flörl & Steixner, 2023; Reddy et al., 2022). The increasing incidence of fungal diseases, coupled with the emergence of antifungal-resistant strains, has become a major global public health concern (Mendonça et al., 2022; WHO, 2023). Although conventional antifungal agents such as amphotericin B, fluconazole, itraconazole, and ketoconazole are widely used, their prolonged administration is often associated with serious adverse effects, including hepatotoxicity, nephrotoxicity, and hypersensitivity reactions (Drew et al., 2022; Hetta et al., 2025).

GRAPHICAL ABSTRACT



Moreover, limited access to expensive antifungal therapies in low-income regions has intensified the need for safer, affordable, and effective alternative treatments (Sharma et al., 2025; Bhattacharya et al., 2024). Historically, medicinal plants have played a vital role in traditional healing systems such as Ayurveda, Unani, and Traditional Chinese Medicine, serving as a rich source of therapeutic compounds (Mahfooz et al., 2022; Parveen et al., 2025). These plants contain diverse bioactive constituents, including alkaloids, flavonoids, tannins, terpenoids, saponins, and glycosides, which exhibit potent antimicrobial, antifungal, antioxidant, and anti-inflammatory activities (Ramalhete et al., 2022). Consequently, plant-derived antifungal agents are increasingly recognized as promising alternatives due to their multi-targeted action and comparatively lower toxicity profiles (Rabaan et al., 2022).

Among medicinal plants, *Momordica charantia* (bitter gourd/bitter melon), belonging to the family Cucurbitaceae, has gained significant pharmacological attention. It is widely cultivated in tropical and subtropical regions of Asia, Africa, and South America (Çiçek et al., 2022). Traditionally, it has been used to treat a variety of ailments, including diabetes, gastrointestinal disorders, wounds, fever, and microbial infections (Gayathry & John, 2022; Oyelere et al., 2022). Different plant parts such as leaves, fruits, seeds, and roots are utilized in folk medicine. Its medicinal properties are attributed to a rich phytochemical profile comprising charantin, momordicin, cucurbitacins, polypeptide-p, vicine, flavonoids, and phenolic compounds, which exhibit strong antimicrobial activity against bacteria, viruses, and fungi (Wang et al., 2022; Bara et al., 2025). Recent studies have particularly highlighted its antifungal potential, which is increasingly important due to the rising prevalence of opportunistic fungal infections driven by immunosuppression, poor hygiene, and environmental exposure (Muribeca et al., 2022; Ihsan et al., 2023).

Fungal pathogens such as *Candida albicans*, *Aspergillus* spp., *Trichophyton*, *Microsporum*, and *Cryptococcus* are responsible for a wide range of infections in humans and animals. Among these, *Candida albicans* is a major opportunistic pathogen causing oral thrush, vaginal candidiasis, and systemic candidemia (Mora et al., 2022; Chaouhan et al., 2022). Severe infections may lead to systemic complications, tissue damage, and chronic inflammatory responses (Janik-Karpinska et al., 2022). The increasing resistance of fungal pathogens to conventional antifungal drugs has further complicated treatment strategies, emphasizing the urgent need for novel, plant-based antifungal agents. Therefore, the present study, titled "Therapeutic Potential of *M. charantia* Against *Candida albicans*-Induced Hematological Alterations in Albino Mice," aims to provide scientific evidence regarding the

antifungal, hematoprotective, and therapeutic efficacy of *M. charantia*. This research may contribute to the development of safer and more cost effective plant-based antifungal therapies, particularly for populations relying on traditional medicine. Ultimately, the findings could support the integration of herbal medicine into modern antifungal strategies and promote the discovery of novel bioactive compounds for improved management of fungal infections.

MATERIALS AND METHODS

Preparation of *Momordica charantia* Extract

Fresh fruits of *Momordica charantia* were collected, washed thoroughly with distilled water, and shade-dried under laboratory conditions. After complete drying, the plant material was ground into fine powder using an electric grinder. Approximately 500 g of powdered *M. charantia* material was selected for extraction. The powdered sample was placed into a filter paper thimble and subjected to Soxhlet extraction using ethanol as the solvent. The Soxhlet apparatus was assembled by placing the thimble containing the powdered plant material into the extraction chamber, while 2500 mL of ethanol was added to the round-bottom boiling flask.

The extraction process was initiated by heating the flask on an electric heater. Continuous heating caused the ethanol to evaporate and rise into the extraction chamber, where it dissolved and extracted the bioactive compounds present in *M. charantia*. The solvent carrying the dissolved phytochemicals then condensed through the condenser and returned to the boiling flask, allowing repeated extraction cycles. This extraction process was continued for approximately 6–8 hours to ensure maximum recovery of therapeutically active constituents. After completion of extraction, the ethanolic extract was filtered through Whatman filter paper to remove insoluble residues and impurities. The filtrate was then concentrated and stored in sterile, airtight glass containers under refrigerated conditions until further use in experimental trials. The prepared extract was utilized to evaluate the therapeutic potential of *M. charantia* against *Candida albicans*-induced hematological alterations in albino mice.

Experimental Design

A total of 25 healthy albino mice were used in the present investigation. The animals were obtained from the wildlife enclosure of Baba Guru Nanak University and were selected on the basis of nearly similar body weight and age. The mice were housed in clean polypropylene cages under standard laboratory conditions, including a controlled temperature of 23 to 27°C, relative humidity of 30 to 40%, and a normal light/dark cycle. All animals were provided with standard feed and clean drinking water ad libitum. Prior to the initiation of the experiment, the mice were acclimatized to laboratory conditions for seven days.

The animals were randomly divided into five groups, with five mice in each group. Group I served as the normal control group and received only standard diet and water. Group II served as the infected untreated group and was inoculated with *C. albicans* to induce fungal infection. Groups III, IV, and V were designated as treatment groups (T1, T2, and T3) and received *C. albicans* inoculation along with different doses of *M. charantia* extract. The extract was administered orally at doses of 200, 250, and 300 mg/kg body weight for T1, T2, and T3, respectively. The experimental trial continued for 28 days to evaluate the therapeutic efficacy of the plant extract against infection-induced hematological disturbances. On the 29th day, blood samples were collected from all experimental animals for hematological analysis and assessment of physiological responses.

Table 1: Division of Groups treated with both.

Groups	Carrageenan and SAE Dosage
C (Control)	Under Control environment
P (Positive)	*C. albicans* wound and regular saline were injected
T1 (Treatment 1)	*C. albicans* wound injection and 200 mg/kg of *M. charantia* treatment
T2 (Treatment 2)	*C. albicans* wound injection and 250 mg/kg of *M. charantia* treatment
T3 (Treatment 3)	*C. albicans* wound injection and 300 mg/kg of *M. charantia* treatment

Sample Collection

After 28 days of treatment, blood samples were collected from overnight-fasted mice through the tail vein using sterile syringes. The blood was transferred into EDTA coated tubes for hematological evaluation. Prior to sample collection and sacrifice, the mice were anesthetized using ketamine hydrochloride at a dose of 30 mg/kg body weight to minimize pain and stress. The collected blood samples were immediately subjected to laboratory analysis.

Hematological Analysis

Hematological parameters were analyzed using an automated hematology analyzer. Complete blood count

(CBC) analysis was performed to determine various blood indices, including red blood cell count (RBC), hemoglobin concentration (Hb), white blood cell count (WBC), lymphocyte count (LYMP), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), packed cell volume (PCV), and platelet count (PLT). These parameters were evaluated to assess the impact of *C. albicans* infection and the therapeutic efficacy of *M. charantia* extract in restoring hematological balance.

Evaluation of Antifungal Activity

The antifungal activity of *M. charantia* extract against *C. albicans* was evaluated using the agar diffusion method. Sterile Petri plates containing nutrient agar medium were prepared and inoculated with *C. albicans* culture. Different concentrations of *M. charantia* extract were then applied to the inoculated agar plates. Three replicates were maintained for each treatment group to ensure experimental accuracy and reproducibility. The inoculated plates were incubated under suitable laboratory conditions for 24 hours. Following incubation, the antifungal activity was assessed by measuring the zone of inhibition around the treated areas. A larger inhibition zone indicated stronger antifungal activity of the plant extract against *C. albicans*.

Culture Media and Microorganism Used

Nutrient agar and liquid culture media were used during the experimental procedures for culturing and maintaining fungal growth. All culture media and laboratory materials were sterilized before use to avoid contamination. The fungal strain used in the present study was *C. albicans*, which served as the pathogenic organism for induction of fungal infection in albino mice and for evaluating the antifungal efficacy of *M. charantia* extract.

Statistical Analysis

The collected experimental data were analyzed using MS Excel 2016 and R statistical software. Mean values and standard deviations were calculated for all hematological parameters. Statistical significance among experimental groups was determined using analysis of variance (ANOVA), and differences were considered significant at $p < 0.05$. Graphical representations and comparative visual analyses of hematological parameters were also generated using the R software environment.

RESULTS

Throughout the 28-day experimental period, no significant fluctuations ($p > 0.05$) in body weight were observed among the control and *M. charantia*-treated groups. The administration of *M. charantia* extract did not produce any adverse effects on growth performance or general health status, as evidenced by the relatively stable mean body weights of albino mice during the study. In mice infected with *Candida albicans*, treatment with *M. charantia* extract maintained body weight values comparable to those of the control group by the end of week 4, indicating good tolerability and physiological safety of the extract. These findings suggest that the therapeutic use of *M. charantia* against *C. albicans*-induced hematological alterations did not induce toxicity, appetite suppression, or treatment-related weight loss during the experimental period. Overall, the results demonstrate that the extract was well tolerated and did not negatively affect normal body weight or health condition, as presented in Table 1.

Table 1: Body weight of mice after 28 days.

Groups	Four Weeks Exposure				
C	38.60±0.587	44.63±0.894	50.41±0.547	55.24±0.836	61.61±1.341
PC	39.67±0.707	43.226± 0.894	47.34±1.224	44.82±1.643	39.44±0.547
T1	39.6±0.707	44.29±0.836	48.23±0.836	46.61±1.341	40.42±0.542
T2	38.89±0.836	44.63± 0.894	49.21±1	53.22±0.836	56.21±0.836
T3	39.40±0.894	44.83±1.095	50.83± 0.836	56.43± 0.707	61.09±1

Hematological analysis

To evaluate the effect of fungal infection and the therapeutic potential of *M. charactia* extract on blood parameters in albino mice, hematological analysis was conducted. The results showed that, in comparison to the normal control group (G1), the infected untreated group (G2) showed discernible changes in hematological indices. Hemoglobin (Hb) concentration, red blood cell (RBC) count, and packed cell volume (PCV) were substantially reduced in G2, confirming the emergence of anemia-like conditions brought on by systemic stress and fungal infection. In addition, it was discovered that the infected group had an increased total leukocyte count (WBC), which indicates an immunological reaction to the fungal pathogen. These outcomes demonstrate that fungal infection may adversely influence mice's hematological profile, resulting in disruptions in normal body physiology.

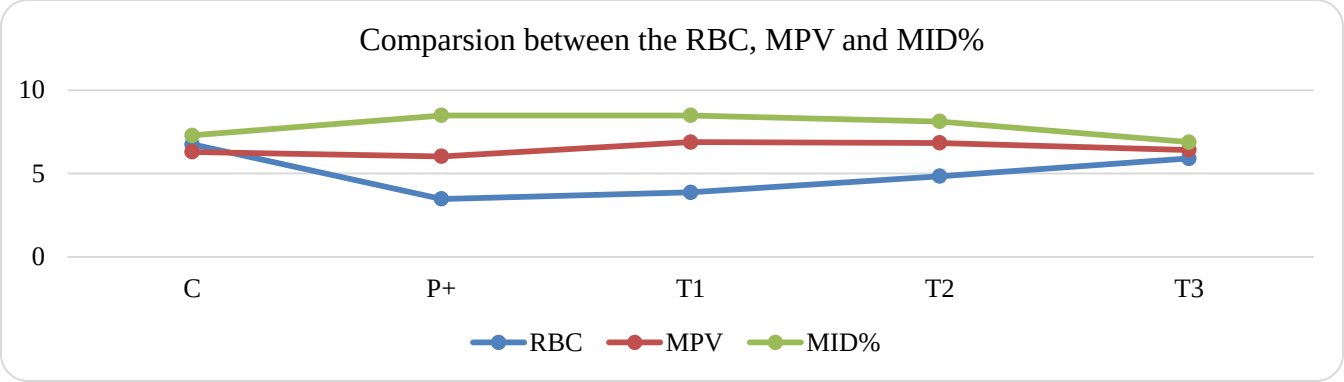


Figure 1: Effect of *Momordica charantia* extract on red blood cell (RBC), mean platelet volume (MPV), and MID% levels in i-infected albino mice. Data indicate significant hematological alterations in the infected untreated group and dose-dependent recovery in treated groups.

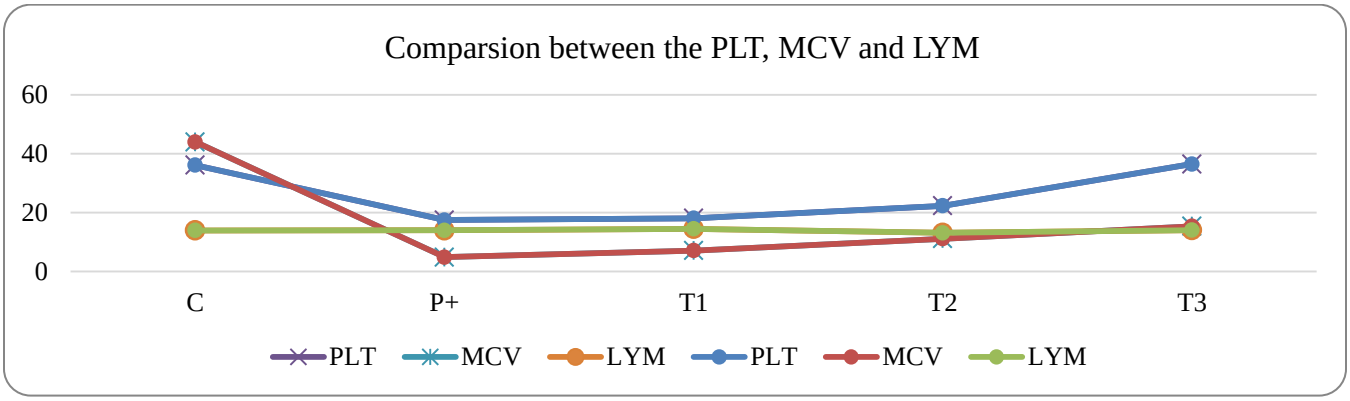


Figure 2: Effect of *Momordica charantia* extract on platelet count (PLT), mean corpuscular volume (MCV), and lymphocyte percentage (LYM%) in *Candida albicans*-infected albino mice showing restoration of altered hematological parameters in a dose-dependent manner.

Figures 1-5 collectively demonstrate the hematological, hepatic, and renal alterations induced by *Candida albicans* infection in albino mice and the therapeutic efficacy of *Momordica charantia* treatment in restoring these physiological disturbances. In the infected untreated group (P), a significant reduction in red blood cell (RBC) count, platelet count (PLT), mean corpuscular volume (MCV), monocyte levels, platelet distribution width (PDW), and other hematological indices was observed compared with the control group, indicating infection-associated anemia, immune dysregulation, and impaired hematopoietic function. Conversely, increased levels of MID%, lymphocyte percentage (LYM%), and mean platelet volume (MPV) reflected activation of inflammatory and immune responses due to *Candida albicans* infection. Liver function test revealed a marked elevation in lactate dehydrogenase (LDH), alanine aminotransferase (ALT), and alkaline phosphatase (ALP), accompanied by altered aspartate aminotransferase (AST) activity, suggesting hepatic stress and tissue injury caused by fungal infection. Similarly, renal function disturbances were evident in the infected group, indicating systemic toxicity and physiological imbalance.

However, treatment with *Momordica charantia* extract in groups G1, G2, and G3 significantly ameliorated these alterations in a dose-dependent manner. The gradual normalization of hematological, liver, and renal biomarkers in treated groups suggests that *M. charantia* possesses potent hematoprotective, hepatoprotective, nephroprotective, antioxidant, and immunomodulatory activities. The highest dose showed the most pronounced therapeutic recovery, indicating the effectiveness of the plant extract in reducing fungal-induced oxidative stress, inflammation, and organ dysfunction. Overall, the graphical results strongly support the therapeutic potential of *Momordica charantia* against *Candida albicans*-induced hematological and physiological disturbances in albino mice.

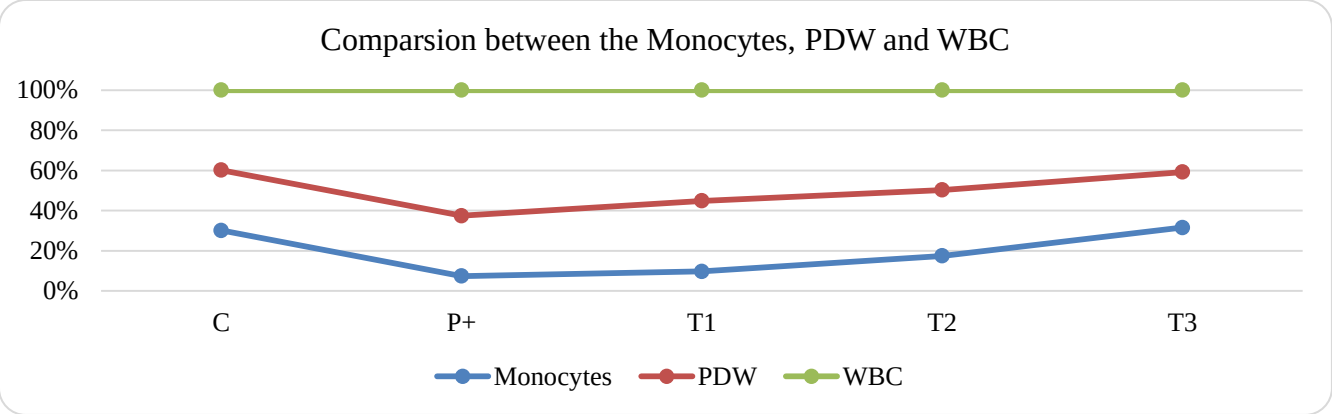


Figure 3: level of WBC, MPV and MID% among the 5 groups C, P, G1, G 2 and G3 and observed significant decrease in Monocytes and PDW of mice exposed with *C. albicans* while healing effects were observed in dose dependent manner in treated groups.

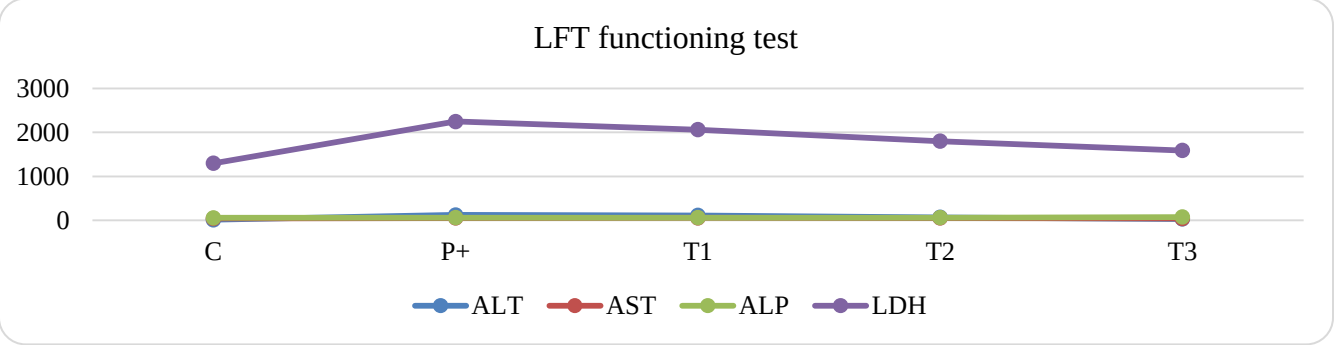


Figure 4: Effect of *Momordica charantia* extract on liver function test (LFT) parameters, including LDH, ALT, ALP, and AST, in *Candida albicans*-infected albino mice showing hepatoprotective activity of the plant extract.

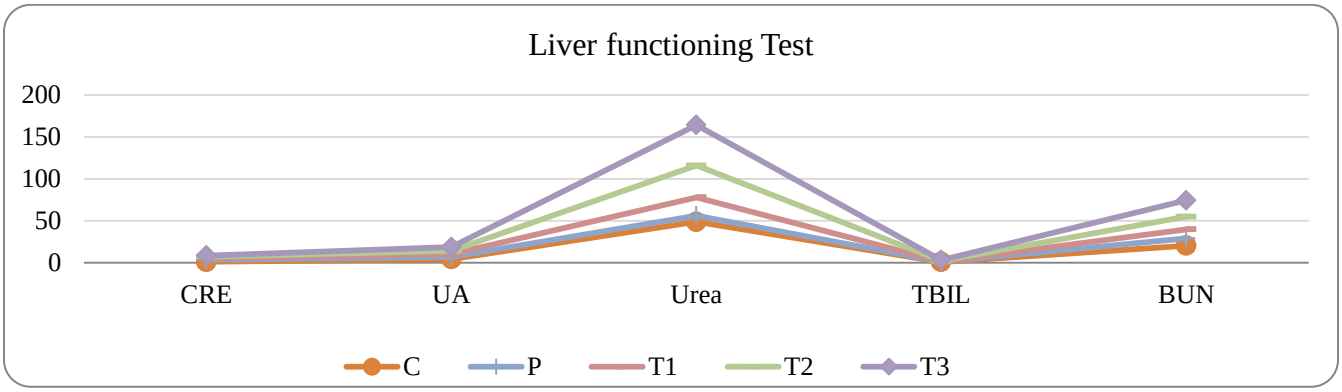


Figure 5: Effect of *Momordica charantia* extract on renal function parameters in *Candida albicans*-infected albino mice, indicating improvement of infection-induced renal dysfunction in treated groups.

DISCUSSION

The present study was designed to investigate the therapeutic potential of *Momordica charantia* against *Candida albicans*-induced hematological alterations in albino mice. The findings revealed that *C. albicans* infection markedly disrupted normal hematological parameters, whereas treatment with *M. charantia* extract significantly improved these alterations and restored physiological balance. These outcomes indicate that *M. charantia* possesses substantial hematoprotective, antioxidant, immunomodulatory, and therapeutic properties that may alleviate fungal infection-associated pathological changes. The observed recovery in treated mice highlights the medicinal significance of this plant as a potential natural

therapeutic agent against candidiasis-induced hematological dysfunction.

In the infected untreated group, significant reductions in hemoglobin (Hb), red blood cell (RBC) count, and packed cell volume (PCV) were observed, along with elevated white blood cell (WBC) counts. These hematological disturbances are characteristic manifestations of systemic fungal infections and are often associated with inflammation, oxidative stress, and impaired erythropoiesis. *Candida albicans* infection is known to induce the release of pro-inflammatory cytokines and reactive oxygen species (ROS), which can damage erythrocyte membranes and reduce oxygen-carrying capacity (Rahman et al., 2021). Similar observations were reported by Islam et al. (2023), who demonstrated that fungal infections can cause anemia-like conditions through oxidative injury and inflammatory suppression of hematopoietic tissues. The reduction in RBC-related parameters observed in the present study therefore confirms the pathogenic influence of *C. albicans* on hematological homeostasis.

The increased WBC count observed in infected mice indicates activation of host immune responses against fungal invasion. Leukocytosis is considered a protective physiological response that reflects stimulation of immune cells during pathogenic stress. Previous investigations have shown that *C. albicans* infection activates neutrophils, macrophages, and lymphocytes through inflammatory signaling pathways, resulting in elevated leukocyte production (Khan et al., 2022). Excessive leukocyte proliferation, however, may also contribute to inflammatory tissue damage and oxidative stress if prolonged. Therefore, persistent elevation of WBCs in the infected untreated group suggests ongoing inflammatory burden and immune dysregulation caused by candidal infection. Administration of *M. charantia* extract significantly restored Hb levels, RBC count, and PCV toward normal values, indicating its protective influence on erythrocytes and hematopoietic tissues. This restorative effect may be attributed to the presence of several bioactive phytochemicals, including flavonoids, phenolic acids, alkaloids, terpenoids, glycosides, and saponins, which possess potent antioxidant and anti-inflammatory activities (Nawaz et al., 2020). These compounds are capable of scavenging ROS and minimizing oxidative damage to blood cells. The antioxidant activity of *M. charantia* may therefore protect erythrocyte membranes from lipid peroxidation and enhance the survival and integrity of circulating blood cells during fungal infection.

Recent studies have further demonstrated that *M. charantia* enhances endogenous antioxidant defense systems by increasing the activity of antioxidant enzymes such as superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GPx). Ahmed et al. (2024) reported that administration of *M. charantia* extract significantly reduced oxidative stress markers and improved antioxidant enzyme activity in experimentally infected animals. Enhancement of these enzymatic defenses may explain the improved hematological recovery observed in the treated mice of the present study. Reduction of oxidative stress not only protects blood cells but also supports normal bone marrow function and erythropoiesis. The normalization of WBC counts in treated groups further supports the immunomodulatory potential of *M. charantia*. While elevated WBC counts in infected untreated mice reflected inflammatory stress and immune activation, the reduction observed following treatment suggests effective control of fungal infection and restoration of immune balance. Several pharmacological studies have shown that *M. charantia* regulates immune responses by modulating cytokine production and suppressing excessive inflammation (Zhang et al., 2021). The plant has been reported to inhibit inflammatory mediators such as tumor necrosis factor-alpha (TNF-α), interleukin-6 (IL-6), and nuclear factor kappa-B (NF-κB), thereby reducing inflammatory tissue damage and promoting recovery (Ali et al., 2025). Such immunoregulatory effects likely contributed to the improved hematological profile observed in the treated animals. The therapeutic efficacy of *M. charantia* against *C. albicans* infection may also be associated with its direct antifungal activity. Previous investigations have reported that phenolic compounds, triterpenoids, and cucurbitane-type compounds present in *M. charantia* interfere with fungal membrane integrity, inhibit fungal enzyme systems, and suppress microbial proliferation (Singh et al., 2023). These phytochemicals may disrupt the ergosterol biosynthesis pathway of fungal cells, thereby impairing fungal growth and survival. The reduction in infection severity following treatment could therefore explain the normalization of hematological parameters and physiological recovery observed in this study.

Another important observation of the present study was the maintenance of body weight in mice treated with *M. charantia* extract. Body weight is widely considered an important indicator of physiological well-being and systemic toxicity in experimental studies. Infections caused by *C. albicans* are often associated with reduced appetite, metabolic disturbances, and weight loss due to inflammatory stress. However, treated mice maintained relatively stable body weight throughout the experimental

period, suggesting that *M. charantia* not only reduced infection severity but also improved general physiological condition. This observation is supported by Yusuf et al. (2022), who confirmed the safety and non-toxic nature of *M. charantia* when administered within therapeutic ranges in laboratory animals. The findings of the present study are also consistent with growing evidence supporting the medicinal importance of plant-derived therapeutics in infectious diseases. Natural products rich in antioxidants and antimicrobial compounds are increasingly being explored as alternatives to synthetic drugs due to their lower toxicity and broader pharmacological activities. Synthetic antifungal agents are frequently associated with adverse effects such as hepatotoxicity, nephrotoxicity, and immune suppression, especially after prolonged use. In contrast, herbal therapies such as *M. charantia* offer comparatively safer therapeutic options with additional antioxidant and immune protective benefits. Therefore, the observed hematological recovery in treated mice highlights the promising role of *M. charantia* as a complementary therapeutic agent against fungal infections. Furthermore, the hematoprotective activity observed in the present investigation may be linked to the nutritional composition of *M. charantia*. The plant is rich in essential vitamins, minerals, amino acids, and iron-containing compounds that may contribute to improved erythropoiesis and blood cell regeneration. Vitamin C and polyphenolic compounds present in *M. charantia* are known to enhance iron absorption and reduce oxidative injury, thereby supporting recovery from infection-associated anemia. This nutritional contribution may have synergistically enhanced the therapeutic effects observed in the treated groups.

The present findings also suggest that *M. charantia* may help regulate oxidative-inflammatory pathways activated during candidiasis. Fungal infections stimulate ROS generation and inflammatory cascades that collectively contribute to cellular injury and hematological dysfunction. By suppressing oxidative stress and modulating inflammatory mediators, *M. charantia* may interrupt the progression of infection-induced tissue damage. Such dual antioxidant and anti-inflammatory activities significantly enhance its therapeutic value in infectious disease management. Overall, the results of this study strongly support the therapeutic potential of *Momordica charantia* against *Candida albicans*-induced hematological disturbances in albino mice. The plant extract effectively restored altered blood parameters, normalized immune responses, reduced inflammatory stress, and maintained physiological stability without apparent toxic effects. These findings indicate that *M. charantia* may serve as a promising natural antifungal and hematoprotective agent for the management of candidiasis-associated hematological abnormalities.

CONCLUSION

In conclusion, the present study demonstrates that *Momordica charantia* possesses significant therapeutic potential against *Candida albicans*-induced hematological alterations in albino mice. Administration of the plant extract effectively improved hemoglobin concentration, RBC count, PCV, and normalized elevated WBC levels, indicating substantial hematoprotective and immunomodulatory activity. The beneficial effects observed may be attributed to the antioxidant, anti-inflammatory, and antifungal properties of the bioactive phytochemicals present in *M. charantia*. Moreover, the maintenance of body weight and absence of apparent toxicity further support its safety and therapeutic applicability. These findings suggest that *M. charantia* could be developed as a potential natural therapeutic agent for the management of fungal infection-associated hematological disturbances. However, further investigations involving dose-dependent studies, molecular analyses, antifungal mechanism evaluation, and histopathological assessments are recommended to validate its long-term efficacy, safety, and clinical relevance.

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