

UDK: 616.24+616.379+615.322+616.98

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**EVALUATION AND ANALYSIS OF THE EFFECTS OF MEDICINAL
PLANTS ON IMMUNE RESPONSE AND INFLAMMATORY
BIOMARKERS IN CASES OF TUBERCULOSIS ASSOCIATED WITH
DIABETES MELLITUS**

Annotation. Tuberculosis (TB) and diabetes mellitus (DM) are two prevalent diseases that often coexist, leading to complex clinical manifestations and impaired immune responses. The combined presence of TB and DM significantly increases the risk of complications, prolonged treatment duration, and altered inflammatory processes. Medicinal plants have long been used as complementary therapeutic agents due to their immunomodulatory and anti-inflammatory properties. This study aims to evaluate the effects of selected medicinal plants on immune system parameters and inflammatory biomarkers in patients with concomitant TB and DM. Clinical and laboratory assessments were performed to measure cytokine levels, lymphocyte subpopulations, and key inflammatory markers before and after phytotherapy intervention.

Keywords: Tuberculosis, Diabetes Mellitus, Immune Response, Inflammatory Biomarkers, Medicinal Plants, Phytotherapy, Cytokines, Immunomodulation

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ОЦЕНКА И АНАЛИЗ ВЛИЯНИЯ ЛЕКАРСТВЕННЫХ РАСТЕНИЙ НА ИММУННЫЙ ОТВЕТ И ВОСПАЛИТЕЛЬНЫЕ БИОМАРКЕРЫ ПРИ ТУБЕРКУЛЕЗЕ, СОПРОВОЖДАЮЩЕМСЯ САХАРНЫМ ДИАБЕТОМ

Аннотация. Туберкулётз (ТБ) и сахарный диабет (СД) — два широко распространённых заболевания, которые часто встречаются одновременно, что приводит к сложным клиническим проявлениям и нарушению иммунного ответа. Совместное присутствие ТБ и СД значительно увеличивает риск осложнений, продлевает срок лечения и изменяет воспалительные процессы. Лекарственные растения давно используются в качестве вспомогательных терапевтических средств благодаря своим иммуномодулирующим и противовоспалительным свойствам. Цель данного исследования — оценить влияние выбранных лекарственных растений на показатели иммунной системы и воспалительные биомаркеры у пациентов с сопутствующим ТБ и СД. Были проведены клинические и лабораторные исследования для измерения уровней цитокинов, субпопуляций лимфоцитов и ключевых воспалительных маркеров до и после проведения фитотерапии.

Ключевые слова: Туберкулётз, Сахарный диабет, Иммунный ответ, Воспалительные биомаркеры, Лекарственные растения, Фитотерапия, Цитокины, Иммуномодуляция

Relevance. The coexistence of tuberculosis and diabetes mellitus is a growing global health concern. DM patients are more susceptible to TB due to compromised immunity, leading to more severe disease courses and higher mortality rates. Conventional TB treatments, while effective, may not fully restore immune balance or control systemic inflammation, particularly in diabetic patients. Medicinal plants with immunomodulatory and anti-inflammatory effects offer a promising adjunctive approach. Evaluating their impact on immune response and

inflammatory biomarkers can provide a scientific basis for integrative therapeutic strategies, reduce disease complications, and enhance patient outcomes.

Aim. To investigate the effects of selected medicinal plants on immune system parameters and inflammatory biomarkers in patients with concomitant tuberculosis and diabetes mellitus.

Materials and Methods.

Study Design: A controlled clinical study involving 60 patients diagnosed with TB and DM. Patients were divided into two groups:

- **Control group (n=30):** Standard anti-TB therapy combined with conventional diabetes management.

- **Intervention group (n=30):** Standard therapy plus phytotherapy using selected medicinal plants known for immunomodulatory properties (e.g., *Andrographis paniculata*, *Curcuma longa*, *Glycyrrhiza glabra*).

Inclusion Criteria: Adults aged 18–65, confirmed pulmonary TB, diagnosed type 2 diabetes mellitus, and willingness to participate.

Exclusion Criteria: Severe hepatic or renal impairment, autoimmune diseases, pregnancy, and concurrent use of other herbal preparations.

Laboratory Assessments:

- **Immune Parameters:** Total lymphocyte count, CD4+, CD8+ T-cell populations, NK cell activity.

- **Inflammatory Biomarkers:** C-reactive protein (CRP), interleukin-6 (IL-6), tumor necrosis factor-alpha (TNF- α).

Methodology:

- Blood samples were collected at baseline and after 8 weeks of treatment.
- Immune parameters were analyzed via flow cytometry.
- Cytokine and CRP levels were quantified using ELISA assays.
- Statistical analysis performed using SPSS v.25; $p<0.05$ considered significant.

Results. Intervention with medicinal plants led to a significant increase in CD4+ T-cell count and NK cell activity compared to the control group. Patients who received phytotherapy demonstrated markedly improved immune profiles, with CD4+ lymphocytes showing enhanced proliferation and functional activity. This increase in CD4+ T-cell count indicates a strengthened adaptive immune response, which is critical for combating *Mycobacterium tuberculosis* in the context of compromised immunity due to diabetes mellitus. Additionally, natural killer (NK) cells, which play a vital role in innate immunity and early defense against infections, exhibited higher cytotoxic activity and increased numbers in the intervention group, suggesting that medicinal plants can positively modulate both adaptive and innate immune mechanisms. The enhancement of these immune parameters implies that phytotherapy may contribute to better infection control and potentially reduce the risk of TB progression and complications in diabetic patients.

A substantial reduction in pro-inflammatory cytokines, including interleukin-6 (IL-6) and tumor necrosis factor-alpha (TNF- α), as well as decreased levels of C-reactive protein (CRP), was observed in the intervention group. These findings indicate that medicinal plants exert potent anti-inflammatory effects, helping to mitigate the systemic inflammatory state often present in patients with concomitant TB and DM. Lower cytokine levels reflect a decrease in immune system overactivation and may lead to reduced tissue damage, improved clinical outcomes, and a better overall inflammatory balance. The anti-inflammatory properties of the selected plants are likely responsible for these observed changes, highlighting their potential as adjunctive therapy to conventional treatment regimens.

Patients receiving phytotherapy also reported fewer adverse effects associated with standard TB and diabetes treatments. The tolerability and safety of the herbal intervention were noteworthy, as patients experienced less gastrointestinal discomfort, reduced fatigue, and improved appetite compared to

those in the control group. Subjective assessments indicated enhanced overall clinical well-being, increased energy levels, and a more positive perception of health status. The improvement in quality of life metrics underscores the practical benefits of integrating medicinal plants into patient care plans, particularly for those undergoing long-term therapy for chronic coexisting conditions.

Conclusion. The integration of medicinal plants as adjunctive therapy in patients with concomitant TB and DM positively influences immune function and reduces inflammatory activity. Phytotherapy may enhance the efficacy of conventional treatments, support faster recovery, and mitigate disease complications. These findings provide a scientific basis for incorporating medicinal plants into comprehensive management strategies for TB patients with diabetes, warranting further large-scale studies to optimize dosing and selection of herbal agents.

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