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OXIDATIVE STRESS–INDUCED INTERNAL ORGAN DYSFUNCTION AND ITS CORRECTION USING CENTAUREA IBERICA EXTRACT

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Annotation: Oxidative stress plays a crucial role in the development of dysfunctions in internal organs such as the liver, kidneys, heart, and brain. Excessive formation of reactive oxygen species disrupts cellular redox balance, leading to lipid peroxidation, protein oxidation, and DNA damage. Recent experimental studies highlight the potential of medicinal plant extracts as natural antioxidants. This article analyzes the mechanisms of oxidative stress–induced internal organ dysfunction and evaluates the corrective effects of Centaurea iberica extract based on experimental and scientific data. The antioxidant, anti-inflammatory, and cytoprotective properties of Centaurea iberica are discussed with reference to biochemical and morphological indicators.

Keywords: Oxidative stress, internal organs, antioxidant activity, lipid peroxidation, Centaurea iberica, medicinal plants

Introduction

Oxidative stress is defined as an imbalance between the production of reactive oxygen species (ROS) and the antioxidant defense system of the organism. According to scientific studies, oxidative stress is a key pathogenic factor in many diseases, including hepatic, renal, cardiovascular, and neurodegenerative disorders [1]. Under physiological conditions, ROS are neutralized by endogenous antioxidant enzymes such as superoxide dismutase, catalase, and glutathione peroxidase. However, under pathological conditions, excessive ROS production leads to cellular and tissue damage.

In recent years, increasing attention has been paid to plant-derived antioxidants as safer alternatives to synthetic drugs. Centaurea iberica, a representative of the Asteraceae family, is traditionally used in folk medicine and has been scientifically proven to possess antioxidant and anti-inflammatory properties [2]. This article aims to analyze oxidative stress–related internal organ dysfunction and the corrective potential of Centaurea iberica extract.

Methodology

The methodological basis of this study consists of a comparative analysis of experimental and laboratory research data published in national and regional scientific sources. Biochemical indicators such as malondialdehyde (MDA), catalase activity, superoxide dismutase activity, and reduced glutathione levels were used to assess oxidative stress intensity [3].

Experimental models of oxidative stress were induced using chemical agents such as carbon tetrachloride and hydrogen peroxide, which are widely applied in laboratory studies to simulate oxidative damage in internal organs [4]. The corrective effect of Centaurea iberica extract was evaluated through oral administration at experimentally justified doses. Morphological changes in tissues were assessed using histological staining methods.

Results

Experimental results demonstrate that oxidative stress significantly increases lipid peroxidation levels in internal organs. Elevated MDA concentrations were observed in liver and kidney tissues, indicating membrane damage [5]. At the same time, antioxidant enzyme activities showed a marked decrease.

Administration of Centaurea iberica extract resulted in a statistically significant reduction in MDA levels and restoration of antioxidant enzyme activity. Catalase and superoxide dismutase activities increased compared to the untreated oxidative stress group [6]. Histological

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examination revealed reduced cellular degeneration, improved tissue architecture, and decreased inflammatory infiltration in internal organs.

Analysis and Discussion

The obtained results clearly demonstrate that oxidative stress is a fundamental pathogenic mechanism underlying dysfunctions of internal organs. Numerous experimental and clinical studies confirm that excessive generation of reactive oxygen species disrupts the balance between prooxidant and antioxidant systems, leading to cellular and tissue damage [7]. The present findings support this concept by showing elevated lipid peroxidation markers and reduced antioxidant enzyme activity in internal organs under oxidative stress conditions.

One of the most important consequences of oxidative stress is lipid peroxidation of cellular membranes. Malondialdehyde, as a secondary product of lipid peroxidation, is widely recognized as a reliable indicator of oxidative damage. Increased MDA levels observed in liver and kidney tissues indicate destabilization of membrane structures and increased permeability, which ultimately impairs cellular metabolism and organ function [5]. Similar patterns have been reported in experimental models where oxidative stress was induced by chemical agents such as carbon tetrachloride and hydrogen peroxide, resulting in hepatocellular necrosis and renal tubular degeneration [8].

The decrease in endogenous antioxidant enzyme activity under oxidative stress conditions represents another critical mechanism contributing to organ dysfunction. Superoxide dismutase and catalase play a central role in neutralizing superoxide radicals and hydrogen peroxide, respectively. Reduction of their activity leads to accumulation of reactive oxygen species, thereby amplifying oxidative damage [6]. The results of this study are consistent with previously published data demonstrating that oxidative stress suppresses enzymatic antioxidant defenses in vital organs, particularly in the liver and kidneys [3].

The corrective effect observed following administration of Centaurea iberica extract indicates its significant antioxidant potential. Restoration of antioxidant enzyme activity and reduction of lipid peroxidation products suggest that the extract effectively counteracts oxidative stress at both biochemical and cellular levels. This effect can be attributed to the presence of biologically active compounds such as flavonoids, phenolic acids, and sesquiterpene lactones, which have been identified in representatives of the Centaurea genus [9].

Flavonoids are known to exhibit strong free radical scavenging activity due to their ability to donate hydrogen atoms or electrons to reactive oxygen species. In addition, they are capable of chelating transition metal ions, thereby preventing the formation of highly reactive hydroxyl radicals through Fenton reactions [10]. Phenolic compounds, in turn, contribute to the stabilization of cellular membranes and protection of lipids from oxidative degradation. The combined action of these compounds enhances the overall antioxidant capacity of the extract.

Another important aspect of the protective effect of Centaurea iberica extract is its anti-inflammatory activity. Oxidative stress is closely linked with inflammatory processes, as excessive reactive oxygen species activate proinflammatory signaling pathways and cytokine production. Inflammation further exacerbates tissue damage and contributes to the progression of organ dysfunction [7]. The observed reduction in inflammatory infiltration and improvement of tissue morphology in treated groups suggest that the extract may modulate inflammatory responses, thereby providing additional cytoprotective effects.

Histological analysis provides further evidence supporting the protective role of Centaurea iberica extract. Structural preservation of hepatocytes and renal tubules, along with reduced signs of degeneration, indicates that the extract not only improves biochemical parameters but also prevents morphological damage. These findings are in agreement with earlier studies on medicinal plants with antioxidant properties, where improvement of tissue architecture was associated with enhanced antioxidant defense [11].

Comparative evaluation of Centaurea iberica with other medicinal plants used for oxidative stress correction reveals its competitive advantages. While many plant extracts exhibit

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antioxidant activity, some are associated with dose-dependent toxicity or limited bioavailability. Experimental data indicate that Centaurea iberica demonstrates a favorable safety profile at therapeutically effective doses, making it a promising candidate for further pharmacological development [10]. This is particularly relevant in the context of long-term prevention and treatment of chronic oxidative stress–related conditions.

The relevance of using plant-based antioxidants is further emphasized by the increasing incidence of diseases associated with oxidative stress, including metabolic disorders, cardiovascular diseases, and neurodegenerative conditions. Synthetic antioxidants, although effective, may cause adverse effects with prolonged use. Therefore, the identification and scientific validation of natural antioxidant sources remain a priority in modern biomedical research [1].

The results of this study also align with the conclusions of Uzbek researchers who emphasize the importance of local medicinal flora as a source of biologically active compounds. The rich biodiversity of the region provides significant opportunities for the development of phytopreparations aimed at preventing and correcting oxidative stress–induced disorders [11]. Incorporation of such plant extracts into therapeutic strategies may contribute to the development of safer and more accessible treatment options.

Despite the promising findings, certain limitations should be acknowledged. Most available data are derived from experimental models, and extrapolation to clinical conditions requires caution. Further studies involving detailed pharmacokinetic analysis, dose optimization, and clinical trials are necessary to fully establish the therapeutic potential of Centaurea iberica extract. In addition, investigation of molecular mechanisms underlying its antioxidant and anti-inflammatory effects would provide deeper insight into its mode of action.

Conclusion

Oxidative stress is a significant pathogenic factor leading to dysfunction of internal organs. Experimental evidence confirms that Centaurea iberica extract effectively reduces oxidative damage by suppressing lipid peroxidation and restoring antioxidant enzyme activity. The plant extract demonstrates pronounced antioxidant and cytoprotective effects, supporting its potential use in the prevention and correction of oxidative stress–induced organ dysfunction. Further clinical and pharmacological studies are recommended to substantiate its therapeutic application.

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