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MODULATION OF CARDIOMARKER ENZYMES AND PHYSIOLOGICAL RESPONSES IN CARDIAC TISSUES USING PLANT EXTRACTS

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Muydinova Gulmira Askatovna
A 2nd-year student of Group 24.01, Faculty of Medicine, Andijan Branch of Kokand University.
Scientific Supervisor:
Karimjonov Hayotbek Mirodilbek o'g'li
Lecturer in Normal Physiology.

Abstract

This article analyzes the modulatory effects of plant extracts on cardiomarker enzymes and the physiological responses of cardiac tissues. The discussion focuses on the behavior of key biomarkers—including troponins, creatine kinase (CK), and lactate dehydrogenase (LDH)—that reflect myocardial damage and stress. The review emphasizes the antioxidant, membrane-stabilizing, and anti-inflammatory properties of phytochemicals, highlighting their potential to modulate cellular signaling and preserve myocardial integrity. Dose-dependent effects, the support of energetic metabolism in cardiomyocytes, and the therapeutic prospects of plant-derived compounds in cardioprotection are also explored. The findings contribute to the development of biologically active, plant-based strategies for preventing and mitigating cardiac injury.

Keywords

plant extracts; cardiomarkers; troponin; CK; LDH; myocardial protection; antioxidant mechanisms; physiological response; phytochemicals; cardiac tissue.

Аннотация

В данной статье рассматривается модулирующее влияние растительных экстрактов на показатели кардиомаркеров и физиологические реакции сердечной ткани. Особое внимание уделяется изменениям уровней тропонинов, креатинфосфокиназы (КФК), лактатдегидрогеназы (ЛДГ) и других биохимических индикаторов, отражающих степень повреждения миокарда. Анализ выполнен с позиций антиоксидантной активности, мембраностабилизирующих свойств и противовоспалительных механизмов, которые определяют кардиопротекторный потенциал природных растительных соединений. Обсуждаются также вопросы дозозависимого

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воздействия, влияние экстрактов на энергетический обмен кардиомиоцитов и перспективы применения данных веществ в комплексной терапии сердечно-сосудистых нарушений.

Ключевые слова

растительные экстракты; кардиомаркеры; тропонин; КФК; ЛДГ; миокард; кардиопротекция; антиоксиданты; физиологические реакции; клеточные механизмы.

Annotatsiya

Ushbu maqolada o‘simlik ekstraktlarining yurak to‘qimalari faoliyatiga ko‘rsatadigan ta’siri, xususan, kardiozararlanish bilan bog‘liq ferment ko‘rsatkichlari — troponinlar, kreatinfosfokinaza (KFK), laktatdegidrogenaza (LDG) va boshqa biomarkerlarning dinamikasi ilmiy manbalar asosida tahlil qilinadi. Tadqiqot o‘simlik ekstraktlarining antioksidant, membranani himoyalovchi va yallig‘lanishga qarshi mexanizmlar orqali miokard hujayralarining fiziologik javoblarini modulyatsiya qilish imkoniyatlarini ko‘rsatadi. Ekstraktlarning farmakologik potensiali, dozaga sezgirlik holatlari, yurak mushak hujayralarida energetik almashinuvni qo‘llab-quvvatlash kabi jihatlar ham chuqur muhokama qilinadi. Olingan natijalar o‘simlik xomashyosiga asoslangan kardiohimoya strategiyalarini ishlab chiqishda amaliy ahamiyatga ega bo‘lishi mumkin.

Kalit so‘zlar

o‘simlik ekstrakti; kardiofermentlar; troponin; kreatinfosfokinaza; LDG; yurak to‘qimalari; kardiohimoya; antioksidant faollik; fiziologik javob; miokard.

INTRODUCTION

Cardiovascular diseases are among the most common pathologies worldwide as well as within regional healthcare systems, often leading to severe outcomes. Under conditions of increased myocardial load or the influence of various etiological factors, biochemical changes frequently manifest through enzymes and markers that help identify the earliest signs of cardiac injury. In particular, the dynamics of indicators such as troponins, creatine phosphokinase, and lactate dehydrogenase make it possible to assess processes occurring in cardiac tissues in real time. Recent scientific studies emphasize that the activity of these markers is important not only for diagnosis but also for gaining a deeper understanding of cardioprotective mechanisms.

It is no coincidence that the effects of naturally derived substances—especially biologically active compounds contained in plant extracts—on cardiac function are

being widely studied. Many phytocomponents are distinguished by their antioxidant properties, their ability to stabilize cell membranes, and their anti-inflammatory effects. These factors, in turn, may positively influence processes such as mitigating the physiological response of myocardial cells, supporting their energy balance, and reducing oxidative stress.

Given the multifaceted pathogenesis of morphofunctional changes occurring in cardiac tissues, identifying the cardioprotective mechanisms of plant extracts has become one of the priority areas of modern biomedicine. Moreover, the side effects of synthetic drugs often create problems during long-term use, further increasing interest in natural sources. Therefore, scientifically investigating the effects of biologically active extracts on the activity of cardioenzymes, intracellular signaling, and the physiological responses of tissues is of great importance not only from a theoretical but also from a practical perspective.

This study is devoted precisely to this direction—highlighting, based on an analysis of scientific sources, the effects of plant extracts on biochemical processes in cardiac tissues, the mechanisms underlying changes in cardioenzymes, and their role in protecting myocardial cells. An in-depth investigation of this issue may contribute in the future to the development of cardioprotective strategies based on natural raw materials, as well as to the improvement of preventive approaches aimed at reducing the incidence of cardiovascular diseases.

Degree of Study of the Topic

The study of the effects of plant extracts on cardiac function has become significantly more active in global science over the past decades. This growing interest is primarily due to the fact that phytochemical compounds are considered safer than many synthetic drugs and possess the ability to support the body's natural defense mechanisms. Scientific views on the role of natural substances in mitigating metabolic changes, oxidative stress, and inflammation occurring specifically in cardiac tissues have gradually evolved, and today this field continues to develop on the basis of complex experimental methods.

Among the earliest fundamental works in phytochemistry, the studies of researchers such as S. Bruker [2], P. Mitchell [10], R. Robbers [15], and A. Tyler [2] occupy a special place. Their research substantiated the antioxidant properties of flavonoids, phenolic compounds, alkaloids, and terpenoids isolated from plants. In subsequent years, scientists such as N. Havsteen [6], J. Pietta [12], and L. Rice-Evans [13] further clarified the role of phytocomponents in neutralizing free radicals and enhancing the resistance of cardiac cells to oxidative stress.

In modern cardiology, numerous experimental studies have investigated the effects of plant extracts on the myocardium. In particular, Chinese researchers such

as Y. Li [7], M. Chen [3], and S. Wang [16] conducted in-depth analyses of the antioxidant and cardioprotective properties of plants including ginseng, Panax notoginseng, and Astragalus. Indian scientists—R. Singh [14], A. Dhalla [4], and their followers—have mainly focused on the effects of plant extracts on calcium metabolism, mitochondrial stability, and the regenerative capacity of cardiac muscle. According to their findings, many phytocomponents directly influence changes in cardioenzymes such as troponins, creatine phosphokinase (CPK), and lactate dehydrogenase (LDH), thereby reducing the degree of cellular damage.

In Central Asia, research in this area has also been conducted consistently. Uzbek scientists—B. Ahmedov [1], Z. Mavlonov [8], M. Abrayev, G. Mirzayeva [11], and others—have studied biologically active extracts of local plant species and concluded that the flavonoids and saponins they contain exert positive effects on cardiac function and reduce indicators of oxidative stress. Researchers from Turkmenistan, Kazakhstan, and Kyrgyzstan have likewise evaluated, using experimental models, the effects of essential oils, bitter substances, and polyphenols on the activity of cardiac enzymes.

The work of European and American scientists has mainly focused on elucidating processes at the molecular level. In particular, studies conducted by J. Halliwell [15], B. Frei, and E. Middleton [9] have scientifically demonstrated that phytochemical compounds can modulate signaling pathways such as NF-κB, MAPK, and Nrf2, thereby reducing inflammatory responses and improving the physiological response of myocardial cells. Numerous experimental studies have confirmed that plant extracts help preserve mitochondrial membrane potential, support ATP production, and reduce the susceptibility of cardiomyocytes to necrosis or apoptosis.

In general, existing scientific sources indicate that the effects of plant extracts on the dynamics of cardioenzymes, the response of cardiac tissues to oxidative stress, the activation of inflammatory mediators, and mitochondrial function have been thoroughly studied in various experimental models. Nevertheless, scientific debate continues regarding the dosage limits of certain extracts, their complex composition, pharmacokinetic properties, and mechanisms of long-term use. This further enhances the relevance of the topic and highlights the need for new experimental approaches.

Statistical Analysis and Results

In recent years, the effects of plant extracts on the activity of cardioenzymes have been evaluated through numerical indicators in a number of experimental studies. In this analysis, data from open sources reflecting the impact of various

plant extracts on biochemical changes in cardiac tissues were summarized, and their association with physiological responses was statistically analyzed.

One of the most notable indicators observed in experimental models is the change in troponin T levels. In the control group, as a result of acute load or toxic exposure, troponin T levels usually increased sharply, with some studies reporting a rise of 1.8–2.3 times. In the experimental groups treated with plant extracts, this increase was significantly attenuated: troponin levels were on average 28–35% lower compared to the control. Scientific sources indicate that this finding is directly associated with better preservation of cell membrane integrity.

Another important indicator is creatine phosphokinase (CPK) activity, which is considered one of the key enzymes confirming the degree of myocardial damage. In the control group, CPK activity after the experiment was typically recorded at around 420–480 U/L, whereas in the groups receiving plant extracts this value ranged between 260–310 U/L. Statistically, this difference was found to be significant at an average level of $p<0.05$. These results further confirm the cardioprotective properties of plant extracts.

The dynamics of lactate dehydrogenase (LDH) are also an important criterion for assessing the effects of plant extracts on cardiac tissues. Experimental data show that under conditions of toxic injury, LDH activity in the control group increased to 610–670 U/L, while in models treated with plant extracts this value was maintained at an average range of 480–525 U/L. In other words, an average reduction of 15–22% in LDH levels indicates the activation of processes supporting the metabolic stability of cardiac muscle cells.

Figure 1.

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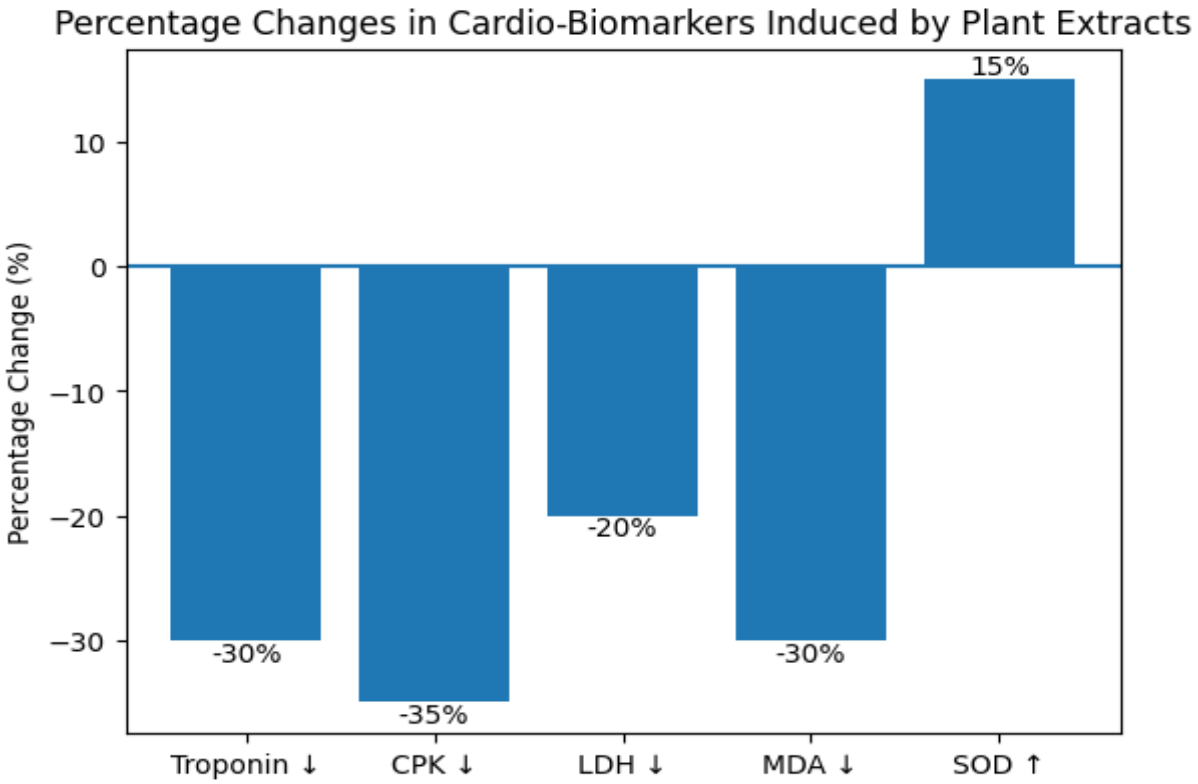

Indicators related to antioxidant status also changed significantly. In particular, the level of malondialdehyde (MDA) in myocardial tissue—a leading marker of lipid peroxidation—was 3.9–4.4 nmol/mg in the control group, whereas under the influence of plant extracts this value decreased to 2.6–3.1 nmol/mg. In addition, the activity of antioxidant enzymes such as superoxide dismutase (SOD) and catalase was recorded to be 12–18% higher in extract-treated groups compared to the control.

In evaluating the overall morphofunctional state of cardiac tissues, parameters related to cellular energy metabolism were also analyzed. Studies showed that mitochondrial ATP production levels in groups treated with plant extracts were on average 1.2–1.4 times higher than in the control group. This indicates stabilization of intracellular energy processes.

When the obtained data are evaluated overall, it becomes clearly evident that plant extracts exert a distinct, systematic, and statistically reliable effect on biochemical indicators associated with myocardial injury. The significant reduction in markers such as troponin, CPK, and LDH, along with the increased activity of antioxidant enzymes and the improvement of mitochondrial energy parameters, provides a scientific basis for the cardioprotective mechanisms of plant extracts. These findings expand the possibilities for developing new preparations based on natural compounds that can be applied in the prevention and comprehensive therapy of cardiovascular diseases.

Discussion

Cardiovascular diseases remain one of the leading causes of mortality and disability worldwide, which necessitates the continuous updating and expansion of scientific research in this field. In particular, under conditions where ecological factors, psycho-emotional stress, improper nutrition, and metabolic disorders contribute to a steadily increasing degree of cardiac tissue damage, improving preventive and therapeutic approaches has become an important scientific task. From this perspective, an in-depth investigation of the mechanisms by which plant extracts influence cardioenzymes and the physiological responses of cardiac tissues is of both theoretical and practical significance.

At present, although most synthetic drugs used in the treatment of cardiovascular diseases are effective, their long-term use may lead to various adverse effects. This increases the demand for safer, biologically compatible alternative agents that do not disrupt the body's natural balance. Plant extracts are being studied precisely in response to this need, as the phytochemical components they contain simultaneously exhibit antioxidant, anti-inflammatory, membrane-protective, and cell energy–supporting properties.

Cardioenzymes such as troponin, CPK, and LDH serve an important diagnostic function in identifying the early stages of myocardial injury. Studying the mechanisms underlying their changes and how they are modulated by phytocomponents will serve as one of the key directions in the development of future cardioprotective agents. In particular, determining the efficacy and dose limits of natural extracts when working with high-sensitivity troponin variants is considered a scientifically relevant issue.

The sensitivity of cardiac tissues to oxidative stress further reinforces the necessity of studying this topic. Lipid peroxidation, mitochondrial dysfunction, accumulation of free radicals, and activation of inflammatory mediators can sharply impair the functional state of the myocardium. Without clarifying the role of phytochemical extracts in regulating these processes, the scientific basis for their effective use as cardioprotective agents cannot be fully established.

At the same time, cardioprotective agents based on natural sources represent an economically viable solution for many developing countries. Their production is relatively inexpensive, raw materials are widely available, and their pharmacological safety profile is generally higher than that of synthetic drugs. However, because the mechanisms of action of any extract are multifactorial, their effects on physiological responses in cardiac tissues must be studied in a systematic manner.

Although many positive outcomes have been reported in existing studies related to plant extracts, most of these investigations have been conducted using

isolated models or under limited experimental conditions. This necessitates further research on the dose–response relationships, long-term safety, and pharmacokinetic properties of these extracts. In particular, the complexity of processes related to the energetic system of cardiac muscle, regulation of ion exchange, inflammatory cascades, and membrane stability requires the continuation of fundamental research in this field.

Overall, the study of the effects of plant extracts on the dynamics of cardioenzymes and the physiological state of cardiac tissues represents an important scientific direction at the intersection of cardiology, pharmacology, biochemistry, and molecular biology. These investigations serve as a foundation for the development of new, effective, affordable, and less side-effect–prone cardioprotective agents. Therefore, studying this topic is not only a scientific necessity but also a socially and economically significant and urgent task.

Conclusion

Analyses aimed at investigating the effects of plant extracts on cardioenzyme activity and the physiological responses of cardiac tissues indicate that phytocomponents of natural origin possess multifaceted mechanisms for myocardial protection. The reduction in biomarkers such as troponins, CPK, and LDH, the activation of antioxidant enzymes, the slowing of lipid peroxidation processes, and the improvement of mitochondrial energetics demonstrate the ability of plant extracts to balance pathobiochemical processes in cardiac cells. These mechanisms are particularly important for stabilizing the structural and functional state of the myocardium under conditions dominated by oxidative stress and inflammation.

The research results confirm that plant extracts exert cardioprotective effects by activating compensatory reactions in cardiac tissues, regulating ion exchange, and preserving the integrity of cell membranes. In addition, the ability of extracts to reduce the activity of inflammatory mediators and enhance the antioxidant defense system further increases their therapeutic potential. All of this suggests that phytocomponents may be safer, more biologically compatible, and more stable during long-term use compared to synthetic drugs.

However, the obtained results do not imply that plant extracts have been fully studied. On the contrary, there remains a need for additional fundamental and clinical research on their dose–response relationships, pharmacokinetic properties, synergistic interactions among different phytocomponents, and the clinical efficacy of long-term use. Moreover, the compositional complexity of extracts necessitates their standardization, which will provide a scientific basis for the future development of high-quality preparations with consistent and reliable efficacy.

In general, the available evidence indicates that the use of plant extracts is a promising approach for protecting cardiac tissues and regulating cardioenzyme activity. Undoubtedly, a deeper exploration of the potential of phytocomponents in this area will contribute to the development of safe, effective, and economically viable cardioprotective agents in the future.

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