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DIRECTIONS FOR IMPROVING THE ORGANIZATIONAL AND ECONOMIC MECHANISM OF MEDICINAL PLANT PROCESSING

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Abstract: Medicinal plant processing represents a strategically important sector that contributes to healthcare, economic growth, and rural development through the production of pharmaceuticals, nutraceuticals, cosmetics, and functional foods. The analysis of the current state of the industry shows that, despite its high potential, it faces serious organizational, technological, and institutional challenges. Among the main problems are outdated processing technologies, insufficient investment in modernization, fragmented supply chains, weak quality control mechanisms, and limited access to financing, especially for smallholder farmers and local enterprises. These barriers reduce efficiency, limit competitiveness in international markets, and prevent the sector from realizing its full economic potential.The study emphasizes that improving the organizational and economic mechanism of medicinal plant processing requires an integrated approach, including institutional reforms, technological modernization, financial inclusion, and sustainable resource management. The introduction of digital tools—such as blockchain for traceability, IoT systems for cultivation monitoring, and big data analytics for market forecasting—can ensure transparency, efficiency, and competitiveness. At the same time, strengthening cooperation between farmers, processors,and research institutions, along with the development of human capital, plays a decisive role in accelerating innovation and improving performance. Furthermore, embedding sustainability principles, such as eco-certification and responsible farming practices, is essential for preserving biodiversity and meeting global demand for environmentally friendly products.Overall, the results of the research confirm that the modernization of organizational and economic mechanisms in medicinal plant processing is a key condition for achieving higher efficiency,global competitiveness, and long-term socio-economic benefits.

Key words: medicinal plants, processing industry, organizational and economic mechanism,digital technologies, sustainability,supply chain,

modernization.

Annotatsiya: Dorivor o‘simliklarni qayta ishlash farmatsevtika, nutratsevtika, kosmetika va funktsional oziq-ovqat mahsulotlarini ishlab chiqarish orqali sog‘liqni saqlash, iqtisodiy o‘sish va qishloq taraqqiyotiga hissa qo‘shadigan strategik muhim sohadir. Sohaning hozirgi holati tahlili shuni ko‘rsatadiki, u yuqori salohiyatga ega bo‘lishiga qaramay, jiddiy tashkiliy, texnologik va institutsional muammolarga duch kelmoqda. Asosiy muammolar qatorida qayta ishlash texnologiyalarining eskirganligi, modernizatsiyaga yetarli sarmoya kiritilmagani, ta’minot zanjirlarining tarqoqligi, sifat nazorati mexanizmlarining zaifligi, ayniqsa, kichik fermerlar va mahalliy korxonalarning moliyalashtirish imkoniyatlarining cheklanganligi qayd etilgan. Bu to‘siqlar samaradorlikni pasaytiradi, xalqaro bozorlarda raqobatbardoshlikni cheklaydi va tarmoqning to‘liq iqtisodiy salohiyatini ro‘yobga chiqarishga to‘sqinlik qiladi.Tadqiqotda ta’kidlanishicha, dorivor o‘simliklarni qayta ishlashning tashkiliy-iqtisodiy mexanizmini takomillashtirish kompleks yondashuvni, jumladan, institutsional islohotlarni, texnologik modernizatsiyani, moliyaviy inklyuzivlikni va resurslarni barqaror boshqarishni talab qiladi. Raqamli vositalarni joriy etish, masalan, kuzatuv uchun blokcheyn, yetishtirish monitoringi uchun IoT tizimlari va bozorni prognozlash uchun katta ma'lumotlar tahlili - shaffoflik, samaradorlik va raqobatbardoshlikni ta'minlashi mumkin. Shu bilan birga, fermerlar, qayta ishlash korxonalari va ilmiy-tadqiqot muassasalari o‘rtasidagi hamkorlikni mustahkamlash inson

kapitalini rivojlantirish bilan birga innovatsiyalarni jadallashtirish va samaradorlikni oshirishda hal qiluvchi rol o‘ynaydi. Bundan tashqari, ekologik sertifikatlashtirish va mas’uliyatli dehqonchilik amaliyoti kabi barqarorlik tamoyillarini o‘rnatish bioxilma-xillikni saqlash va ekologik toza mahsulotlarga global talabni qondirish uchun muhim ahamiyatga ega. Umuman olganda, tadqiqot natijalari dorivor o‘simliklarni qayta ishlashda tashkiliy va iqtisodiy mexanizmlarni modernizatsiya qilish yuqori samaradorlik, global uzoq muddatli raqobatbardoshlikka erishishning asosiy sharti ekanligini tasdiqlaydi.

Kalit so‘zlar: dorivor o'simliklar, qayta ishlash sanoati, tashkiliy-iqtisodiy mexanizm, raqamli texnologiyalar, barqarorlik, ta'minot zanjiri, modernizatsiya.

Аннотация: Переработка лекарственных растений представляет собой стратегически важный сектор, способствующий здравоохранению, экономическому росту и развитию сельских районов посредством производства фармацевтических препаратов, нутрицевтиков, косметики и функциональных продуктов питания. Анализ текущего состояния отрасли показывает, что, несмотря на свой высокий потенциал, она сталкивается с серьезными организационными, технологическими и институциональными проблемами. К числу основных проблем относятся устаревшие технологии переработки, недостаточные инвестиции в модернизацию, фрагментированные цепочки поставок, слабые механизмы контроля качества и ограниченный доступ к финансированию, особенно для мелких фермеров и местных предприятий. Эти барьеры снижают эффективность, ограничивают конкурентоспособность на международных рынках и не позволяют сектору в полной мере реализовать свой экономический потенциал. В исследовании подчеркивается, что совершенствование организационно-экономического механизма переработки лекарственных растений требует комплексного подхода, включая институциональные реформы, технологическую модернизацию, финансовую доступность и устойчивое управление ресурсами. Внедрение цифровых инструментов, таких как блокчейн для прослеживаемости, системы Интернета вещей для мониторинга выращивания и аналитика больших данных для прогнозирования рынка, может обеспечить прозрачность, эффективность и конкурентоспособность. В то же время укрепление сотрудничества между фермерами, переработчиками и научно-исследовательскими институтами, наряду с развитием человеческого капитала, играет решающую роль в ускорении инноваций и повышении производительности. Более того, внедрение принципов устойчивого развития, таких как экосертификация и ответственное ведение сельского хозяйства, имеет решающее значение для сохранения биоразнообразия и удовлетворения глобального спроса на экологически чистую продукцию. В целом, результаты исследования подтверждают, что модернизация организационно-экономических механизмов в сфере переработки лекарственных растений является ключевым условием для достижения более высокой эффективности, глобальной конкурентоспособности и долгосрочных социально-экономических выгод.

Ключевые слова: лекарственные растения, перерабатывающая промышленность, организационно-экономические механизмы, цифровые технологии, устойчивое развитие, цепочка поставок, модернизация.

INTRODUCTION

Medicinal plants constitute an essential component of both traditional and modern healthcare systems, serving as raw materials for the pharmaceutical, nutraceutical, cosmetic, and functional food industries. The processing of medicinal plants plays a strategic role in ensuring high-quality end products, creating added value, and stimulating economic growth. In many countries, this sector contributes to the development of rural areas by creating employment opportunities for small-scale farmers and processing enterprises. At the same time, the growing global demand for natural and plant-based products has intensified the need for effective organizational and economic mechanisms that can ensure sustainability, competitiveness, and integration into international markets.

However, the current state of medicinal plant processing remains constrained by a number of challenges. These include outdated technologies, insufficient investment in modernization, weak institutional and regulatory mechanisms, fragmented supply chains, and the absence of unified quality standards. In many developing countries, smallholder farms face limited access to financing, infrastructure, and modern processing capacities, which undermines the stability and transparency of the entire value chain. Consequently, despite the abundance of natural resources and increasing demand, the sector fails to fully realize its economic potential.

Improving the organizational and economic mechanism of medicinal plant processing requires a comprehensive approach that integrates innovation, institutional reform, and sustainable resource management. Key directions for enhancement include the use of blockchain technologies to ensure product traceability, the implementation of “smart agriculture” systems to optimize raw material supply, and the application of big data analytics for market forecasting. Furthermore, strengthening collaboration among farmers, processors, and research institutions will accelerate knowledge exchange and innovation diffusion. In addition, public–private partnerships, supportive policies, and the development of international standards are of crucial importance for ensuring competitiveness in global trade.

Therefore, the modernization of the organizational and economic mechanism for medicinal plant processing is not only a matter of improving efficiency but also of fostering sustainability, adaptability, and long-term socio-economic benefits. This study focuses on identifying the necessary directions and strategies for system improvement, with particular attention to the roles of digital transformation, institutional support, and sustainable management practices.

LITERATURE REVIEW

The issue of improving the organizational and economic mechanism of medicinal plant processing has been widely studied at the international level. The World Health Organization (WHO), the Food and Agriculture Organization of the United Nations (FAO), as well as major pharmaceutical and biotechnology research centers, have conducted numerous studies on the significance of medicinal plants, sustainable resource management, quality standards, and international trade. In particular, foreign research emphasizes the integration of digital technologies in medicinal plant processing, the application of sustainability principles, and adaptability to global market demands.

In Uzbekistan and Central Asia, several studies have also been conducted in this field, mainly focusing on the biological characteristics, pharmacological value, and agro-technical aspects of medicinal plants, as well as opportunities for their cultivation and processing. In recent years, economists have paid increasing attention to improving the organizational and economic mechanisms of medicinal plant processing, optimizing supply chains, enhancing export potential, and scientifically substantiating digital transformation processes. However, existing research has largely concentrated on biological and pharmacological aspects, while the economic mechanisms, institutional reforms, and efficiency improvements through digital technologies have not been studied in sufficient depth. This highlights the necessity of re-examining the topic through innovative scientific approaches and developing theoretical as well as practical recommendations.

RESEARCH METHODOLOGY

This study employs a systemic, comparative, and statistical approach to analyze the organizational and economic mechanisms of medicinal plant processing. The current state of the sector was assessed based on scientific literature, reports from international organizations, and empirical data from local practices. Activities of farms and processing enterprises were analyzed to identify existing challenges and inefficiencies. The research also integrates the evaluation of institutional structures, digital transformation trends, and the sustainability of resource use, enabling the formulation of practical strategies for improving the sector's efficiency and competitiveness within both national and global contexts.

ANALYSIS AND RESULTS

Plant cultivation systems provide numerous opportunities and advantages for producers. These include the possibility of year-round crop production, improved growing conditions for ornamental plants and vegetables, and the ability to control micro- and macro-environmental parameters. Such systems have served societies for decades — evolving from simple greenhouse structures used in temperate regions during cold seasons to advanced facilities that now operate even in tropical and desert climates. Protected cultivation systems continue to develop as the global demand for healthy food increases alongside rapid population growth. However, this process faces serious challenges such as the shortage of skilled labor, climate change, and global crises like the COVID-19 pandemic. In many countries, border closures and strict migration regulations resulted in significant losses in agriculture, prompting the search for autonomous plant production systems to address labor shortages and enhance precision management. Yet, poor ventilation, excessive humidity, and high temperatures in these systems can create harmful environments for workers. Moreover, due to the high complexity and cost of advanced production technologies, proper integration and adaptation of both existing and new technologies are essential. Under conditions of rapid technological advancement, producers need decision-support systems that consider key sustainability factors such as capital investment, credit interest rates, market opportunities, and profitability.

To implement new technologies, retrofitting — the modernization of existing facilities — is often used. This process, commonly applied in residential buildings to improve energy efficiency and reduce emissions, is far more complex in plant production systems as it involves not only energy but multiple technological processes. An inappropriate strategy in this context can result in the loss of entire crops and severe economic damage.

The analysis of the current state of medicinal plant processing shows that the sector holds significant potential for promoting public health, economic development, and rural employment. Nevertheless, the industry still faces numerous structural, technological, and organizational barriers that hinder its full potential. One of the

key problems is the weakness of institutional and organizational frameworks. In many countries, the regulation of medicinal plant processing is fragmented — there is insufficient coordination among government institutions, a lack of unified certification systems, and inadequate mechanisms for quality control. Such shortcomings reduce international competitiveness and limit the ability of small and medium enterprises to meet strict global market requirements. Therefore, strengthening institutional support, harmonizing standards, and improving regulatory mechanisms are essential.

Another major issue is technological backwardness. Many enterprises continue to use outdated methods for cultivation, drying, extraction, and packaging, which leads to low productivity, inconsistent product quality, and higher production costs. The study reveals that enterprises investing in modern processing technologies, digital monitoring systems, and automated quality control achieve greater efficiency, reduce waste, and gain better access to export markets. Hence, technological modernization and innovation occupy a central place in enhancing the organizational and economic mechanism of the industry.

From an economic perspective, limited access to financing remains a critical obstacle, especially for smallholder farms and local processing enterprises. The lack of affordable loans, subsidies, or investment opportunities prevents them from acquiring modern equipment or expanding production capacity. Findings indicate that enterprises benefiting from financial support programs, digital finance platforms, or public–private partnership (PPP) investments demonstrate greater financial stability and competitiveness. Therefore, expanding financial inclusion and creating favorable investment conditions are vital for ensuring the sustainable development of the medicinal plant processing sector.

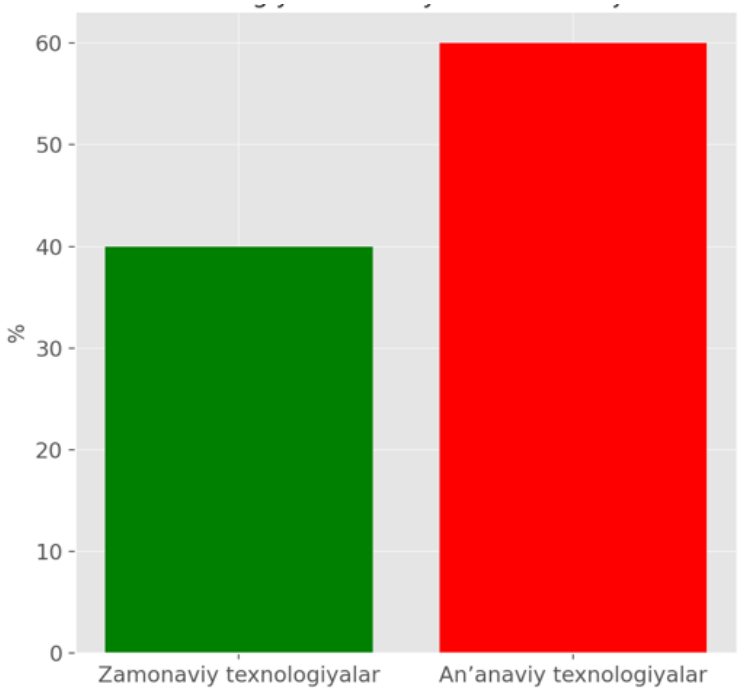

Figure 1. Level of Technology Utilization

The analysis also reveals that there are significant challenges within supply chains. Farmers, collectors, and processors often operate with limited integration or cooperation, which results in inefficiency, weak traceability, and a reduction in product value. This fragmentation undermines consumer confidence and restricts participation in international trade. However, global experience demonstrates that the adoption of traceability technologies such as blockchain, IoT-based monitoring systems for cultivation, and big data analytics for market forecasting can establish transparent, reliable, and efficient supply chains. These technological directions offer substantial potential for improving both organizational and economic efficiency.

Human capital also plays a decisive role in the efficiency of medicinal plant processing. The sector faces a shortage of qualified specialists in biotechnology, processing technologies, quality assurance, and digital management. Empirical evidence indicates that investments in education, vocational training programs, and collaboration with research institutions significantly enhance knowledge exchange, accelerate innovation implementation, and improve sectoral performance. Therefore, the development of human capital should be regarded as a priority direction in reforming and strengthening the organizational and economic mechanism of medicinal plant processing.

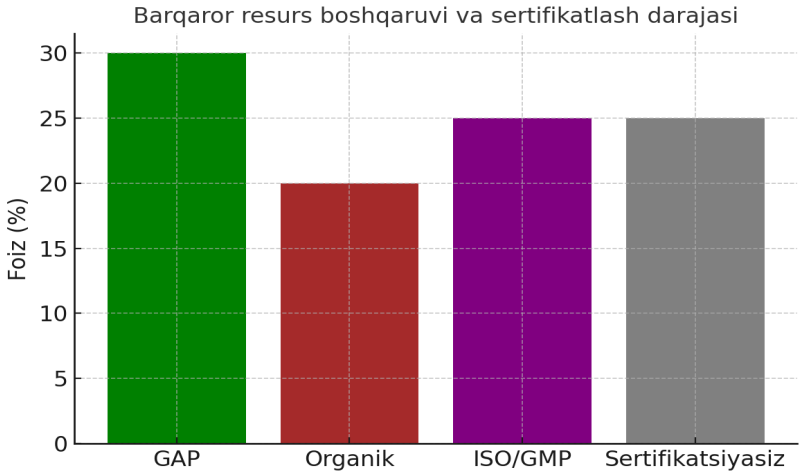

Figure 2. Level of Sustainable Resource Management and Certification

Finally, the sustainability of natural resources remains a critical issue. The overharvesting of wild medicinal plants and the absence of sustainable cultivation practices threaten biodiversity and the long-term stability of the sector. The analysis confirms that companies implementing sustainable farming practices, utilizing certification systems, and adopting eco-labeling standards not only help preserve biodiversity but also gain significant economic advantages by meeting the growing consumer demand for environmentally responsible products. Therefore, sustainability must be established as a core principle in the modernization process of the sector.

Overall, the analytical results indicate that improving the organizational and economic mechanism of medicinal plant processing requires a comprehensive and multidimensional approach. This approach should integrate institutional support and standardization reforms, technological modernization, expansion of financial accessibility, the creation of transparent and digitized supply chains, the development of human capital, and the implementation of sustainable resource management practices. Only through the combined implementation of these measures can the sector achieve high efficiency, competitiveness, and sustainability—making a significant contribution not only to public health but also to sustainable economic growth and rural development.

CONCLUSION AND RECOMMENDATIONS

Despite its vast potential, the medicinal plant processing industry remains constrained by several organizational, technological, and institutional challenges that prevent it from fully realizing its capabilities. The analysis shows that weak coordination among government institutions, the absence of unified quality and certification systems, and insufficient regulatory mechanisms significantly reduce the sector's competitiveness in international markets. Furthermore, reliance on outdated processing technologies leads to inconsistent product quality and low production efficiency. Limited access to financing—especially for small farmers and local processors—has severely hindered modernization initiatives.

In addition, poor collaboration among farmers, collectors, and processors in the supply chain decreases efficiency, undermines transparency, and erodes consumer trust. The shortage of qualified personnel, particularly specialists in biotechnology, quality control, and digital management, also constrains innovation and operational excellence.

To address these challenges, it is recommended to:

Strengthen institutional coordination and develop a unified national certification and quality assurance system aligned with international standards;

Promote technological modernization and digital transformation, including the use of IoT, AI, and blockchain technologies for monitoring and traceability;

Expand financial inclusion through low-interest credit lines, grants, and PPP-based investment programs to support modernization;

Enhance capacity-building programs to train specialists in biotechnology, processing, and digital management;

Integrate sustainability principles and certification mechanisms to ensure environmental protection and long-term sectoral viability.

Implementing these comprehensive measures will help build an innovative, competitive, and sustainable medicinal plant processing industry capable of supporting both national economic resilience and global market integration.

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