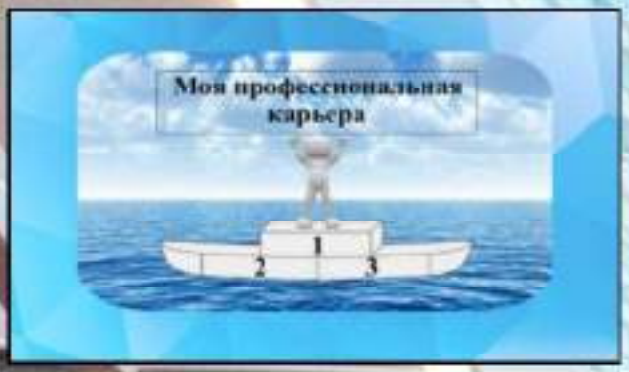

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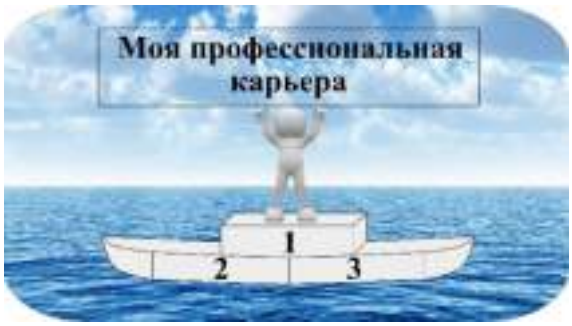

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Целевая аудитория журнала охватывает работников сферы науки и образования (педагоги, учителя, ученые, преподаватели, научные сотрудники, бакалавры, магистранты, аспиранты.

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Abstract

Rutin, a naturally occurring flavonoid glycoside with potent antioxidant, anti-inflammatory, and cardioprotective activities, has gained significant attention for its pharmacological potential. The present study explored the extraction of rutin from *Crataegus turkestanic*, a plant species widely distributed in Central Asia and known for its medicinal value. The extraction process was optimized using various solvents, temperatures, and extraction times to maximize rutin yield. Methanol and ethanol were primarily evaluated due to their efficiency in polyphenol recovery. The extracted compounds were analyzed using UV-Vis spectrophotometry and high-performance liquid chromatography (HPLC) for quantification and purity assessment. The results demonstrated that ethanol at 70% concentration provided the highest rutin yield at moderate temperature conditions. The findings suggested that *Crataegus turkestanic* could serve as an abundant natural source of rutin for pharmaceutical and nutraceutical applications, highlighting its role in developing sustainable bioactive compound extraction technologies.

Methods and Methodology

The study was conducted in a controlled laboratory environment with the primary objective of isolating and quantifying rutin from *Crataegus turkestanic*. The

methodology comprised plant material collection, preparation, solvent extraction, purification, and analytical evaluation. Fresh plant samples of *Crataegus turkestanic* were collected during the flowering season to ensure high flavonoid content. The leaves and flowers were cleaned, air-dried at room temperature, and ground into fine powder using a mechanical grinder. Approximately 10 grams of the powdered plant material were used for each extraction trial.

Solvent extraction was performed using methanol, ethanol, acetone, and water in varying ratios to identify the optimal solvent system for rutin isolation. Each sample was subjected to maceration and Soxhlet extraction techniques under different temperature and time conditions. The filtrates obtained from the extraction were concentrated using a rotary evaporator under reduced pressure at 40°C. The resulting extracts were then subjected to liquid-liquid partitioning with ethyl acetate to enrich the flavonoid fraction. The concentrated extract was stored at 4°C for further analysis.

Quantification of rutin was achieved using UV-Vis spectrophotometry at 356 nm, with calibration curves constructed using pure rutin standards. Further confirmation and purity determination were carried out using HPLC equipped with a C18 column and a mobile phase of acetonitrile and water (40:60 v/v) containing 0.1% formic acid. The detection wavelength was set at 354 nm. Statistical analysis of extraction efficiency was performed using triplicate experiments, and the data were presented as mean ± standard deviation.

Botanical Characteristics and Phytochemical Importance of Crataegus turkestanic

Crataegus turkestanic belonged to the Rosaceae family and was widely distributed in the mountainous regions of Central Asia, particularly in Turkmenistan, Uzbekistan, and Kazakhstan. It was characterized by its thorny branches, white blossoms, and small red fruits rich in bioactive compounds. Historically, the plant was utilized in traditional medicine for cardiovascular disorders, hypertension, and digestive issues. The leaves and flowers were especially known for their high content of flavonoids, phenolic acids, and triterpenoids.

Phytochemical screening of *Crataegus turkestanic* revealed a broad spectrum of secondary metabolites including rutin, quercetin, hyperoside, and chlorogenic acid. Among these compounds, rutin was identified as one of the most pharmacologically valuable constituents due to its antioxidant capacity and vascular protective functions. Previous studies confirmed that rutin contributed to the enhancement of capillary resistance and reduction of inflammation in vascular tissues. The high rutin concentration in the leaves and flowers made *Crataegus turkestanic* a promising candidate for industrial-scale extraction.

Optimization of Extraction Parameters

The efficiency of rutin extraction was strongly influenced by several operational parameters including solvent polarity, extraction time, temperature, and solid-to-liquid ratio. In the present study, these factors were systematically optimized to maximize rutin yield. The initial trials demonstrated that methanol and ethanol exhibited superior extraction capabilities compared to water and acetone due to their intermediate polarity, which matched well with the solubility characteristics of flavonoid glycosides.

Extraction time played a crucial role in rutin recovery. It was observed that extending extraction beyond 90 minutes did not significantly increase yield, as equilibrium between solute and solvent was achieved. Temperature optimization showed that 50–60°C provided optimal conditions without causing degradation of heat-sensitive compounds. The solid-to-liquid ratio of 1:20 (w/v) was determined to be ideal for efficient solvent penetration and rutin solubilization. Through these optimized parameters, a maximum rutin yield of approximately 2.4% (w/w) from dried plant material was obtained.

Solvent Selection and Extraction Efficiency

Solvent selection was a critical step that determined both yield and purity of the extracted compound. Ethanol-water mixtures were preferred due to their safety, cost-effectiveness, and environmental compatibility. Among the tested solvents, 70% ethanol demonstrated the highest extraction efficiency, yielding 15–20% more rutin compared to methanol. The enhanced extraction observed in ethanol-water mixtures

could be attributed to the improved solubility of glycosidic flavonoids in the presence of water, which facilitated cell wall penetration and compound diffusion.

Comparative analyses revealed that pure organic solvents such as acetone and methanol tended to extract other non-polar compounds, reducing rutin purity. Aqueous ethanol thus represented an ideal compromise between selectivity and efficiency. Furthermore, the extraction using ethanol allowed easier downstream processing and was compatible with food-grade applications. This finding suggested that eco-friendly solvent systems could effectively replace toxic organic solvents traditionally used in phytochemical extraction.

Purification and Quantification of Rutin

After extraction, the crude extract contained a mixture of phenolics, flavonoids, and other plant-derived compounds. To isolate rutin, liquid-liquid fractionation with ethyl acetate was employed, followed by purification through column chromatography using silica gel. The eluents were collected in fractions, and each fraction was analyzed spectrophotometrically to detect rutin presence. The fractions containing rutin were pooled and concentrated under reduced pressure.

UV-Vis spectrophotometric analysis confirmed the presence of rutin at 356 nm, corresponding to its maximum absorbance peak. Calibration curves constructed using pure rutin standard solutions (0.5–20 μg/mL) displayed strong linearity ($R^2 = 0.998$). The quantitative determination of rutin in the extracts was subsequently validated using HPLC. The retention time for rutin was observed at approximately 8.6 minutes, confirming its identity. The extracted rutin exhibited a purity level exceeding 90%, suitable for potential pharmaceutical and nutraceutical applications.

Pharmacological and Industrial Relevance of Rutin

Rutin exhibited a broad range of pharmacological activities, making its extraction from natural sources a matter of growing industrial interest. Its strong antioxidant activity enabled it to neutralize reactive oxygen species, thereby reducing oxidative stress and preventing cellular damage. Moreover, rutin demonstrated significant anti-inflammatory and anti-carcinogenic properties. It was particularly noted for its

beneficial effects on the cardiovascular system, including strengthening capillary walls, reducing vascular permeability, and improving circulation.

Industrially, rutin was utilized as a raw material for synthesizing derivatives with improved solubility and bioavailability. Its applications extended into the cosmetic and nutraceutical industries, where it was employed as an active ingredient in anti-aging and skin-protective formulations. The sustainable extraction of rutin from *Crataegus turkestanic* provided an economically viable and environmentally friendly alternative to synthetic production, aligning with modern trends in green chemistry and bioproduct development.

Comparative Evaluation with Other Crataegus Species

Comparative analysis of rutin content across various *Crataegus* species revealed that *Crataegus turkestanic* possessed a relatively high concentration of rutin compared to other species such as *Crataegus monogyna* and *Crataegus oxyacantha*. This difference could be attributed to environmental conditions, genetic factors, and phenological stages. Samples collected during the flowering period exhibited the highest rutin concentration due to increased biosynthesis of flavonoids under sunlight exposure.

In addition, soil mineral content and altitude were observed to influence secondary metabolite accumulation. Plants grown in higher altitudes exhibited higher rutin levels, possibly as a natural defense mechanism against UV radiation. This variability highlighted the importance of selecting optimal cultivation conditions for maximizing bioactive compound production in *Crataegus* species.

Challenges and Limitations in Extraction Process

Despite the promising results, several challenges were encountered during rutin extraction. The sensitivity of flavonoid compounds to light, temperature, and pH required careful control of experimental conditions. Degradation of rutin could occur during solvent evaporation or prolonged exposure to high temperatures. Moreover, the co-extraction of other polyphenols complicated purification, requiring multiple chromatographic steps. These challenges increased operational costs and processing time.

Another limitation was the variability in plant composition due to environmental and seasonal factors, which affected rutin yield and consistency. Standardization of raw material through controlled cultivation and harvesting practices was therefore necessary to ensure reproducibility. Future research could explore the integration of novel extraction techniques such as ultrasound-assisted or microwave-assisted extraction to enhance efficiency while minimizing solvent consumption and thermal degradation.

Potential for Commercial and Pharmaceutical Applications

The extraction of rutin from *Crataegus turkestanic* demonstrated significant potential for commercial exploitation. Given the global demand for natural antioxidants, rutin could be marketed as a high-value bioactive compound for pharmaceutical, nutraceutical, and cosmetic industries. Its proven biological activities provided the scientific basis for its inclusion in functional foods and dietary supplements targeting cardiovascular health and oxidative stress management.

The eco-friendly extraction approach developed in this study aligned with sustainable development principles, offering an economically feasible process suitable for industrial scaling. Moreover, local cultivation of *Crataegus turkestanic* in Central Asia could support rural economic development through value-added production chains, transforming traditional medicinal resources into globally competitive bioproducts.

Conclusion

The present study successfully established an effective method for extracting rutin from *Crataegus turkestanic*. Through systematic optimization of solvent composition, temperature, and extraction time, ethanol-water mixtures were identified as the most efficient solvent system. The purified rutin demonstrated high yield and purity, validating *Crataegus turkestanic* as a rich natural source of this bioactive compound. Beyond its pharmacological benefits, the study emphasized the significance of sustainable extraction practices in developing natural products. The findings provided valuable insights for future research aimed at industrial application, standardization, and enhancement of rutin production from medicinal plants.

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