IMPROVING THE TECHNOLOGY OF FIBER PRODUCTION BASED ON HEMP GROWN IN SURKHANDARYA REGION

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Abstract. This study focuses on improving the fiber extraction technology from hemp (Cannabis sativa L.) cultivated in the Surkhandarya region of Uzbekistan. Hemp is recognized as an eco-friendly, fast-growing, and high-yield plant with significant potential in the production of natural fibers for the textile and composite material industries. However, traditional retting and fiber separation methods used in the region often lead to quality loss, low efficiency, and environmental concerns.

The research involved field cultivation of local hemp varieties, characterization of stem morphology, and testing of advanced retting techniques, including enzyme-assisted and water-retting methods. Comparative analysis of mechanical and biochemical parameters demonstrated that enzyme-assisted retting significantly improved fiber quality, reduced processing time, and preserved tensile properties of the extracted fiber. The optimized process showed a 27% increase in clean fiber yield and enhanced uniformity compared to traditional methods.

This work proposes a practical and scalable model for modernizing hemp fiber production in arid regions, contributing to the development of sustainable raw material supply chains for green industries in Central Asia.

Keywords: hemp fiber; Surkhandarya; retting technology; enzyme retting; natural textile fibers; sustainable agriculture; fiber extraction

Аннотация. В этом исследовании основное внимание уделяется совершенствованию технологии извлечения волокон из конопли (Cannabis sativa L.), выращиваемой в Сурхандарьинской области Узбекистана. Конопля признана экологически чистым, быстрорастущим и высокоурожайным растением со значительным потенциалом в производстве натуральных волокон для текстильной промышленности и производства композитных материалов. Однако традиционные методы мочки и разделения волокон, используемые в регионе, часто приводят к потере качества, низкой эффективности и экологическим проблемам.

ISSN 3030-3907

Исследование включало выращивание в полевых условиях местных сортов конопли, характеристику морфологии стебля и тестирование передовых методов мочки, включая методы с использованием ферментов и водной мочки. Сравнительный анализ механических и биохимических параметров показал, что мочка с использованием ферментов значительно улучшает качество волокна, сокращает время обработки и сохраняет растяжимые свойства извлеченного волокна. Оптимизированный процесс показал 27%-ное увеличение выхода чистого волокна и улучшенную однородность по сравнению с традиционными методами.

В данной работе предлагается практичная и масштабируемая модель модернизации производства конопляного волокна в засушливых регионах, способствующая развитию устойчивых цепочек поставок сырья для зеленой промышленности в Центральной Азии. Ключевые слова: конопляное волокно; Сурхандарья; технология мочки; ферментная мочка; натуральные текстильные волокна; устойчивое сельское хозяйство; извлечение волокна

Annotatsiya. Ushbu maqola O‘zbekistonning Surxondaryo viloyatida yetishtiriladigan kanopdan (Cannabis sativa L.) tola olish texnologiyasini takomillashtirishga qaratilgan. Kenevir to‘qimachilik va kompozit materiallar sanoati uchun tabiiy tolalar ishlab chiqarishda katta salohiyatga ega bo‘lgan ekologik toza, tez o‘sadigan va yuqori hosildor o‘simlik sifatida tan olingan. Biroq, mintaqada qo‘llaniladigan an'anaviy retting va tolalarni ajratish usullari ko‘pincha sifatni yo‘qotish, past samaradorlik va atrof-muhit muammolariga olib keladi.

Tadqiqot mahalliy kanop navlarini dalada etishtirish, poya morfologiyasini tavsiflash va ilg'or qayta ishlash usullarini, shu jumladan fermentlar yordamida va suvni qayta ishlash usullarini sinab ko‘rishni o‘z ichiga oldi. Mexanik va biokimyoviy ko‘rsatkichlarning qiyosiy tahlili shuni ko‘rsatdiki, ferment yordamida qayta ishlash tola sifatini sezilarli darajada yaxshilagan, ishlov berish vaqtini qisqartirgan va olingan tolaning cho‘zilish xususiyatlarini saqlab qolgan. Optimallashtirilgan jarayon an'anaviy usullar bilan solishtirganda toza tola hosildorligining 27% ga oshganini va bir xillikning yaxshilanganligini ko‘rsatdi.

Ushbu ish qurg'oqchil hududlarda kanop tolasi ishlab chiqarishni modernizatsiya qilishning amaliy va kengaytiriladigan modelini taklif qiladi, bu Markaziy Osiyodagi yashil sanoat uchun barqaror xom ashyo yetkazib berish zanjirlarini rivojlantirishga yordam beradi.

Kalit so‘zlar. kanop tolasi; Surxondaryo; qayta ishlash texnologiyasi; fermentlarni qayta tiklash; tabiiy to‘qimachilik tolalari; barqaror qishloq xo‘jaligi; tolalarni olish

Introduction

ISSN 3030-3907

Hemp (Cannabis sativa L.) has long been recognized as a fast-growing, renewable, and multipurpose crop used for food, textiles, bio-composites, and green construction materials. In recent decades, the demand for natural plant-based fibers has increased due to rising environmental awareness and the need to replace petroleum-based synthetics. Among fiber crops, hemp offers particular advantages including low water consumption, high biomass yield, and strong, durable bast fibers suitable for technical textiles.

The Surkhandarya region of Uzbekistan, characterized by its arid climate and long growing season, provides favorable agro-ecological conditions for hemp cultivation. However, the regional fiber extraction practices still rely largely on traditional retting methods, which are labor-intensive, time-consuming, and often environmentally damaging due to uncontrolled microbial decomposition. These limitations affect the quality, uniformity, and market competitiveness of the final fiber products.

Recent studies on local hemp varieties cultivated in the Termiz district, including those from the experimental field of the Termiz Engineering and Agro-Technological University, have revealed promising physical and chemical properties in terms of stem strength, fiber length, and lignocellulosic composition. These findings highlight the potential for improving fiber production through innovative, sustainable technologies.

The main objective of this study is to develop and optimize a modernized fiber extraction technology based on enzyme-assisted and controlled retting techniques that are applicable to Surkhandarya-grown hemp. The paper also analyzes the physicochemical characteristics of the resulting fibers, evaluates their suitability for industrial use, and proposes a scalable model for the implementation of eco-efficient processing in dryland agricultural systems.

Plant Material and Study Area

The hemp (Cannabis sativa L.) varieties used in this study were cultivated during the 2023–2024 growing season at the experimental field of Termiz Engineering and Agro-Technological University, located in the Termiz district of the Surkhandarya region, Uzbekistan. This area is characterized by a dry, continental climate, with average summer temperatures ranging from 30 to 40°C and annual precipitation of less than 300 mm. These conditions make the region favorable for cultivating drought-tolerant crops such as hemp.Two local hemp cultivars with high fiber-yield potential were selected based on prior agronomic performance, biomass productivity, and stem structure.

Fiber Extraction Methods

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To investigate the impact of different retting techniques on fiber yield and quality, three processing methods were applied:

1. Traditional Water Retting (Control Group)

Bundles of hemp stems were submerged in water tanks for 10–12 days under ambient outdoor conditions.

Retting completion was determined visually and by tactile softness of the stem bark.

2. Enzyme-Assisted Retting

A commercial pectinase-enzyme blend (3% concentration) was applied in a controlled water bath (temperature: 35°C).

Retting duration: 48–72 hours depending on stem thickness.

The process was optimized for minimal degradation of fiber strength.

3. Alkaline Chemical Retting (Comparative Reference)

Stems were treated with 1% NaOH solution for 3 hours at 80°C to accelerate fiber separation.

Residues were washed and neutralized with acetic acid before drying.

Fiber Processing and Cleaning

After retting, fibers were manually stripped and washed thoroughly. They were then dried under ambient conditions for 24–48 hours. Mechanical combing and softening were performed to remove shives and align fiber bundles.

Laboratory Analysis

To assess the quality of the extracted hemp fibers, the following parameters were measured:

Property	**Method / Standard Applied**
Fiber Yield (%)	Gravimetric analysis
Fiber Length (mm)	Manual measurement, n = 50
Tensile Strength (MPa)	ISO 5079:2017
Moisture Content (%)	Oven-drying method at 105°C
Lignin and Cellulose Content (%)	TAPPI standard chemical analysis
Microscopic Structure	Optical microscopy at 100× magnification

All analyses were conducted in triplicate to ensure data accuracy and repeatability. Statistical analysis (ANOVA) was performed using SPSS software to compare mean differences among treatment groups at a 95% confidence level ($p < 0.05$).

Results

The study compared the performance of three retting techniques—traditional water retting, enzyme-assisted retting, and alkaline chemical retting—in terms of

ISSN 3030-3907

fiber yield, mechanical strength, and structural quality. Hemp stems harvested from the Termiz district exhibited noticeable differences in response to each treatment method.

1. Fiber Yield

Retting Method	Fiber Yield (%)
Traditional Water Retting	18.6%
Enzyme-Assisted Retting	23.7%
Alkaline Chemical Retting	20.1%

Enzyme-assisted retting resulted in the highest fiber yield, showing a 27% increase over the traditional method. This indicates improved separation efficiency and less material loss.

2. Fiber Length and Uniformity

Average fiber length for enzyme-retted samples was 73 mm, compared to 64 mm in water-retted and 68 mm in chemically treated fibers.

Enzyme retting also produced fibers with more consistent diameter and smoother surfaces, as observed under 100× magnification optical microscopy.

3. Mechanical Properties

Property	Water Retting	Enzyme Retting	Chemical Retting
Tensile Strength (MPa)	248.5	281.2	265.4
Elongation (%)	1.9	2.3	2.1

Enzyme retting enhanced the tensile strength by 13% compared to water retting, indicating better preservation of fiber integrity.

4. Moisture Content and Chemical Composition

Parameter	Water Retting	Enzyme Retting	Chemical Retting
Moisture Content (%)	10.7	9.3	8.9
Cellulose Content (%)	63.2	68.5	65.7
Lignin Content (%)	14.9	11.3	10.8

Enzyme retting preserved a higher cellulose-to-lignin ratio, which contributes to stronger and more flexible fibers.

5. Visual and Structural Observations

1. Microscopic analysis revealed that enzyme-treated fibers had cleaner surfaces, fewer impurities, and well-separated bundles.

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2. Traditional retting resulted in partially degraded fibers with noticeable surface pitting and irregularity.

3. Summary of Findings

4. Enzyme-assisted retting proved to be the most effective method overall.

5. It improved fiber yield, tensile strength, and structural cleanliness.

6. The method is environmentally friendly, requires shorter processing time, and is adaptable to small-scale rural operations in Surkhandarya's dry climate.

Discussion

The results of this study clearly demonstrate that the method of retting significantly affects the quality, yield, and mechanical properties of hemp fibers cultivated in the arid agro-climatic conditions of Surkhandarya, Uzbekistan. Among the three retting techniques evaluated, enzyme-assisted retting proved to be the most effective, offering higher fiber yield, improved tensile strength, and better preservation of the cellulose structure.

The 27% increase in fiber yield observed with enzyme retting over traditional water retting aligns with findings from previous research, such as those by Sharma et al. (2019), who also reported enhanced fiber recovery using bio-enzymatic approaches. The cleaner surface and more uniform fiber diameter observed under microscopic analysis support the conclusion that enzyme action facilitates controlled degradation of pectin and hemicellulose without compromising the structural integrity of the bast fibers.

Moreover, the increase in cellulose content and the reduction in lignin percentage in enzyme-treated fibers suggest a more efficient separation of useful fiber components from woody core tissues. These changes contribute to higher tensile strength and greater flexibility, making the fibers more suitable for spinning and technical textile applications.

In contrast, traditional water retting, while simple and low-cost, exhibited inconsistencies in fiber separation, longer processing times, and partial microbial degradation of the fibers. Chemical retting, though faster, posed environmental challenges and yielded stiffer fibers with lower elongation properties—limiting their usability in soft textile products.

Importantly, the Surkhandarya region's hot and dry climate supports rapid drying and natural enzyme activation during retting, creating an opportunity for scalable, eco-friendly fiber production systems. The enzyme retting process can be adapted by local farmers and small enterprises, contributing to the regional economy and enabling sustainable raw material supply chains.

Overall, the findings highlight the practical potential of modernizing hemp fiber extraction in Central Asia by incorporating enzyme-based biotechnologies.

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This could improve the market competitiveness of domestically produced fibers while addressing both environmental and economic sustainability goals.

Conclusion

This study investigated the potential of improving hemp fiber extraction methods using local Cannabis sativa varieties cultivated in the Surkhandarya region of Uzbekistan. Through comparative analysis of three retting techniques—traditional water retting, enzyme-assisted retting, and alkaline chemical retting—it was found that enzyme-assisted retting provided the best overall performance.

Key findings include:

1. A 27% increase in fiber yield was achieved with enzyme retting compared to traditional methods.

2. Tensile strength and fiber flexibility were significantly enhanced, making the fibers suitable for textile and technical applications.

3. Microscopic analysis confirmed cleaner, more uniform fibers with minimal structural degradation.

4. Environmental impact was reduced, as enzyme retting avoids chemical pollution and requires less water than conventional retting.

5. The optimized process is scalable and adaptable to small and medium agricultural operations in dryland regions like Surkhandarya.

These results indicate that enzyme-assisted retting is a sustainable, efficient, and regionally appropriate method for modernizing hemp fiber production. Implementation of this technology could strengthen Uzbekistan's position in the natural fiber industry and contribute to the development of green, bio-based economies in Central Asia.

REFERENCES

1. Sharma, H. S. S., Van Sumere, C. F., & Kahlon, R. S. (2019). Hemp retting: Principles and recent developments. Journal of Natural Fibers, 16(3), 321–334. https://doi.org/10.1080/15440478.2018.1535893

2. Liu, M., Zhang, C., & Huang, T. (2021). Enzymatic retting of bast fibers: A sustainable approach. Industrial Crops and Products, 164, 113375. https://doi.org/10.1016/j.indcrop.2021.113375

3. Müssig, J., & Stevens, C. V. (2020). Hemp fibers: Processing, properties, and applications. In Handbook of Natural Fibres (Vol. 1). Woodhead Publishing.

4. FAO. (2022). Hemp: A sustainable crop for the future. Food and Agriculture Organization of the United Nations. https://www.fao.org

5. Kirchoff, N., & Schlegel, P. (2018). Hemp fiber retting and the impact on quality parameters. Textile Research Journal, 88(7), 801–812. https://doi.org/10.1177/0040517517697649

ISSN 3030-3907

6. Kozlowski, R. M. (Ed.). (2012). Handbook of natural fibers. Elsevier.

Scientific Websites Used

1. https://www.fao.org – Food and Agriculture Organization of the United Nations (FAO): Global insights on sustainable agriculture and hemp development.
2. https://www.sciencedirect.com – ScienceDirect: Peer-reviewed articles on fiber extraction, retting technology, and sustainable materials.
3. https://www.springer.com – SpringerLink: Scientific publications on natural fiber innovation and bioprocessing.
4. https://www.mdpi.com – MDPI Open Access Journals: Articles related to biomass, agrotechnology, and green processing.
5. https://www.researchgate.net – ResearchGate: Access to preprints, datasets, and research publications.
6. https://www.textilelearner.net – Textile Learner: Technical explanations of fiber processing and retting methods.
7. https://www.frontiersin.org – Frontiers in Plant Science: Updated research on sustainable fiber crops and biotechnology.
8. https://www.woolmark.com – The Woolmark Company: Though wool-focused, contains relevant knowledge on fiber testing and nonwoven applications.

ISSN 3030-3907