

ANNOTATION

of the dissertation work of PhD student Bektayev Kazybek Bakitzhanuly on the topic «Development and application of environmentally friendly technology for finishing textile materials for children's shoes» submitted for the degree of Doctor of Philosophy (PhD) in the educational program 8D07211 – «Leather goods industry»

General characterization of the work.

The dissertation work is aimed at creating ecosystem-oriented textile materials with color and antibacterial properties for use in children's footwear.

The first chapter analyzes the state of production development, modern technologies and problems in finishing textile materials, as well as the advantages and disadvantages of the finishing extracts used. The scientific prospects for applying textile materials in footwear production are examined.

The second chapter examines the physical and mechanical properties of textile materials for footwear and selects optimal samples. From various parts of the juzgun plant (leaves, branches, roots) that grows in the South of Kazakhstan, coloring extracts have been obtained, and the necessary herbal remedies have also been selected. Using the obtained extracts, the finishing of selected textile materials (straight and denim fabrics of various densities) was carried out both with and without the use of adhesives.

The third chapter presents the results of studying the structural properties of fabrics stained with extracts from various parts of the juzgun plant using optical microscopy, scanning electron microscopy, and IR spectroscopy methods.

The fourth chapter presents the results of research on the coloristic and antibacterial properties, as well as the stability of the dye against friction and the air permeability of dyed textile materials.

The fifth chapter proposes a design and manufactures an industrial sample of children's footwear based on colored textile materials.

The relevance of the research.

Currently, there is an increase in the number of children, adolescents, and youth in Kazakhstan with pathological foot deviations. In this regard, domestic scientists are conducting work on determining the anthropometric measurements of the population's feet, designing optimal shoe lasts, and designing comfortable footwear. Since foot deformities in children begin at an early age, special attention must be paid to the comfort, hygiene, consumer, and other characteristics of children's footwear.

In the footwear industry, many types of materials are used, the choice of which depends on the purpose, type, seasonality, and classification of the footwear. Many of the materials used do not meet hygienic requirements, which can lead to foot diseases in consumers. Furthermore, during the production and processing of such materials, various environmentally hazardous and harmful synthetic substances, additives, and dyes are currently widely used.

The development of light industry in modern conditions involves considering many aspects economic, social, environmental, etc., and tasks related to environmental protection and the greening of both production and manufactured products are very important.

Due to the deterioration of the environmental situation in the world, the World Organization "UNESCO" decided in 2002 to use eco-textiles, environmentally safe products obtained without the use of synthetic raw materials. Currently, many countries are showing a trend toward restricting synthetic dyes and auxiliary substances.

In this regard, it should be noted that the Republic of Kazakhstan possesses great raw material potential in the light and textile industries, especially in the production of natural fabrics and the production of eco-dye materials from local plants.

The advantage of natural dyes is considered to be the harmony of colors and high color stability, as evidenced by museum textile materials and fabrics found during archaeological excavations. The technological properties of these dyes can be changed or improved through modification, which is the subject of research by many scientists. Plant dyes are prone to biological decomposition; in some cases, it is rational to use production waste as fertilizer on agricultural lands.

It should be noted that natural dyes are not individual substances, but a mixture of natural substances that often possess biological activity, antiseptic, and antimicrobial properties. Consequently, textile materials dyed with them will be resistant to microbiological damage and may possess certain protective and therapeutic properties. The use of natural plant dyes can also be recommended for the development of traditional folk industries.

Therefore, developing an environmentally friendly technology for producing natural dyes from local plant raw materials for textile dyeing and applying them in the production of children's footwear is a pressing task.

The purpose of the research. Development of a technology for finishing light industry materials using plant extracts from plants in the southern regions of Kazakhstan and their application in the production of children's footwear.

The tasks of the research:

- studying the properties of textile materials for footwear and selecting optimal samples;
- obtaining coloring extracts from various parts of the juzgun plant;
- developing technology for dyeing materials for light industry products with extracts from various plant parts;
- studying the consumer, structural, hygienic, color, and antibacterial properties of fabric samples colored with the obtained extracts;
- development of children's footwear designs using the obtained fabric samples.

Research object and materials.

The process of obtaining coloring extracts from various parts of the juzgun plant (leaves, branches, roots) growing in southern Kazakhstan and the process of dyeing fabrics. The objects of the study were textile materials, coloring extracts, and children's footwear.

Research methods.

Physical-mechanical, structural (IR spectroscopy, microscopy), and hygienic methods for determining the properties of textile materials, and color methods for determining color indicators. Methods of statistical analysis and mathematical programming were also used.

Scientific novelty of the research

1. For the first time, various parts (leaves, branches, roots) of the juzgun plant growing in the southern region of Kazakhstan have been studied as a raw material source for the production of natural dyes.

2. Properties were studied, and optimal textile materials were selected for the production of children's footwear.

3. Dyeing extracts were obtained from various parts of the juzgun plant, and their properties were improved using modifying additives.

4. A technology for dyeing textile industry materials with extracts from various parts of the juzgun plant has been developed.

5. The consumer, structural, hygienic, coloristic, and antibacterial properties of fabrics colored with these extracts were investigated.

6. Designs were developed, and industrial samples of children's footwear were manufactured using colored fabrics.

Scientific and practical significance of the work.

The research results expand scientific understanding of methods for producing dyes from the juzgun plant and methods for finishing light industry materials. The range of Kazakhstan plants with dyeing and antibacterial properties for the textile and leather industries has been expanded. The results allow for the production of environmentally safe finishing of materials and the production of products with high hygienic and antibacterial properties.

The main provisions proposed for protection.

Experimental and theoretical work was conducted, including: obtaining modified extracts of various parts (leaves, branches, roots) of the juzgun plant growing in the southern regions of Kazakhstan, possessing antibacterial and dyeing properties; developing a finishing method and determining the composition of fixing adhesives; and selecting textile materials for footwear.

Based on the research results on the structural, hygienic, color, and antibacterial properties of dyed textile materials, documentation for the production of children's orthopedic footwear was developed.

The author's personal contribution to the synthesis of the results of the research work submitted for defense.

To implement the work on the chosen topic, a plan was drawn up in accordance with the tasks set, and the object and subject of the research were determined. Dyeing extracts were obtained from various parts of the juzgun plant (leaves, branches, roots) growing in the southern regions of Kazakhstan, possessing antibacterial and dyeing properties, with which textile materials were processed.

During the execution of the work, production and experimental tests were conducted, and the scientific conclusions and results obtained after the testing were

analyzed. Documentation has been developed for the production of children's orthopedic footwear using modified textile materials.

The obtained results were processed using effective methods of mathematical modelling and programming. The scientific results obtained during the dissertation work have been implemented in production.

Validation of research results. The author actively participated in publishing the obtained results in domestic and foreign publications. Five scientific works have been published on the dissertation topic, including 4 articles in journals included in the list of the Science and Higher Education Quality Assurance Committee of the Ministry of Science and Higher Education of the Republic of Kazakhstan, and 1 article in a journal included in the Web of Science/Scopus database. Additionally, 1 patent for an invention and 1 patent for an industrial design were submitted to the National Institute of Intellectual Property of the Ministry of Justice of the Republic of Kazakhstan.

The article was published in journal included in the Web of Science:

1. Kazybek Bektayev, Bekzhan Abzalbekuly, Ersin Onem, Roza Mirzamuratova, Seitzhan Orynbayev, Farkhad Tashmukhamedov, Mukhamejan Shardarbek, Rakhimzhan Kauymbaev, Elvira Sarybayeva & Gulzat Oraz. Calligonum aphyllum extract as sustainable colorant for fabric treatment. Journal of Natural Fibers, 2025. Vol. 22, Issue 1. P. 1-11. Scopus percentage 80%, Web of Science quartile 1. <https://doi.org/10.1080/15440478.2025.2568533>

4 articles were published in the publication, which was included in the list of the Science and Higher Education Quality Assurance Committee of the Ministry of Science and Higher Education of the Republic of Kazakhstan and two applications for a Republic of Kazakhstan patent have been filed:

1. Bektayev K., Sarybaeva E.E., Mirzamuratova R.Sh., Abzalbekuly B., Oraz G.T., Shardarbek M.Sh., Tashmukhamedov F.R., Kaumbayev R.T. IR spectroscopic studies of the structure of textile materials dyed with natural dyes (ИК-спектроскопические исследования структуры текстильных материалов, окрашенных природными красителями). The Journal of Almaty Technological University. 2025; 147 (1): 160-170. <https://doi.org/10.48184/2304-568X-2025-1-160-170>

2. Bektayev K., Abzalbekuly B., Sabyrkhanova C.Sh., Eldiyar G.K., Oraz G.T., Manapbaeva U.E. Studying the mechanical properties of footwear textile materials and creating a mathematical model (Аяқ киімдік тоқыма материалдарының механикалық қасиеттерін зерттеу және математикалық моделін жасау). The Journal of Almaty Technological University. 2025;148 (2):185-193. <https://doi.org/10.48184/2304-568X-2025-2-185-193>

3. Bektayev K., Abzalbekuly B., Oraz G.T. Application of the juzgin plant growing in the southern regions of Kazakhstan for the decoration of textile materials (Текстиль материалдарын әрлеуге Қазақстанның Оңтүстік өңірлерінде өсетін жүзгін өсімдігін қолдану). The Journal of Almaty Technological University. 2025; 149 (3) pp. 223-230. <https://doi.org/10.48184/2304-568X-2025-3-223-230>

4. Bektayev K., Abzalbekuly B., Onem E., Sarybaeva E.E., Mirzamuratova R.Sh., Tashmukhamedov F.R., Gafurov J.G., Oraz G.T. Microscopic analysis of

textile material structures dyed with natural dyes (Микроскопический анализ структур текстильных материалов, окрашенных природными красителями). The Journal of Almaty Technological University. 2025;150 (4):217-227. <https://doi.org/10.48184/2304-568X-2025-4-217-227>

6. A patent of the Republic of Kazakhstan was obtained for the invention "Method for obtaining a dye extract based on the juzgin plant," No 38195, 14.08.2026.

7. An application has been submitted for the issuance of a patent for the industrial design "Orthopedic Footwear," registration number 2026072.3, dated 02.03.2026.