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ПОСЛЕДНИ ЗНАНИЯ ЗА БАГРЕНЕТО НА ТЕКСТИЛ С БАГРИЛА ОТ ЕСТЕСТВЕН ПРОИЗХОД

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RECENT KNOWLEDGE ABOUT DYEING TEXTILES WITH DYES OF NATURAL ORIGIN

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Abstract:
The textile industry is one of the largest consumers of water, which is especially present in dyehouses where synthetic chemicals and dyes are used. Natural dyes are generally environmentally friendly and have certain advantages over synthetic dyes in terms of production and application. In recent years, there has been interest in the application of these dyes due to their biodegradability and high compatibility with the environment. The paper discusses the review of the work of researchers in 2024. in the field of applying dyes from natural sources that can be used to dye textile material. From an ecological point of view, replacing chemical dyes with "natural products" for dyeing textiles can be convenient and can represent a strategy to reduce risks and pollutants. Also, it is an opportunity for new markets and new businesses that can be developed by including ecology in the market policy.

Keywords: *natural dyes, textile, dyeing, ecology.*

Introduction

Textile dyeing with dyes from natural sources dates back to the past with variable success. Until the end of the nineteenth century, natural dyes were available to textile makers as the main means of dyeing. The development of synthetic dyes, at the beginning of the twentieth century, led to a more complete level of quality and more reproducible dyeing procedures [1].

In recent years, there has been an increasing interest in natural dyes - traditional dyeing techniques are reviving, and natural dyes are increasingly used for handicrafts. According to experts, there is a great potential of using natural dyes, so that in some areas, synthetic dyes could be easily replaced by natural dyes [2,3].

Today, there is a noticeable renewed interest in the use of natural dyes in textile dyeing processes of different origins. It seems to be related to the easier availability of dyeing raw materials and the requirements related to the protection of the environment and the human body. Objects dyed with dyes of natural origin are labeled "ecological dyes" [3].

Natural Dyes

Natural dyes are organic compounds found in the cells of plants, animals and microorganisms. These compounds are usually isolated by extraction, and the choice of solvent depends on their chemical properties. The most commonly used solvents are: water, ethanol, methanol, ether, etc. When dyeing textile material, dye molecules create complexes of the desired tone with metal ions with which the fiber has been pre-mordanted.

Depending on the metal salts used, a wide range of tones is obtained. The following metal salts are most often used as wetting agents: potassium aluminum (III) sulfate or the so-called alum, copper (II) sulfate, potassium bichromate, iron (II) sulfate, tin (II) chloride and others [4, 5].

Natural dyes are classified according to chemical constitution, origin, tone or areas of application. The classification according to the origin or according to the areas of application is not unique, and the most accurate classification is according to the chemical constitution [4].

Dyeing Of Textiles With Natural Dyes?

Although natural dyes cannot be an alternative to synthetic ones, today in recent scientific literature there are more and more works on their application, which is closely related to environmental problems. Accordingly, synthetic dyes with better dyeing properties, better substantivity, and dyeing procedures that require less energy and water consumption were also developed.

Today, there is a conflict between the interests of ecologists and manufacturers of synthetic dyes. The opinion of ecologists is to reject all "chemical" and "synthetic" products and replace them with "bio", "eco" and "natural" products. On the other hand, producers of synthetic dyes say that natural dyes cannot be an alternative due to the lack of natural resources, the depletion of nature, the impossibility of dyeing synthetic fibers, ecologically questionable and demanding dyeing procedures, the impossibility of textile dyeing in industrial processes, weaker color fastness, higher dyeing costs and production etc. [5].

The reality seems to be somewhere between [5, 6]:

- The future of the chemical industry will be based on "soft chemistry" - the processing of chemical substances that are not foreign to nature.
- Frequent energy crises based on the shortage of oil and its derivatives - the basis of chemical production.
- Better biological degradability and generally bet-

ter tolerability of natural dyes in relation to the environment.

• Natural dyes show less toxicity and allergenicity than synthetic ones.

• The harmony achieved by dyeing textile products with natural dyes is also used for therapeutic purposes.

Newer Research On Natural Dyes And Dyeing Possibilities.

In the last decade, various research groups have been conducting research on the possible use of natural dyes in textile dyeing processes. It is very important to find reliable sources of natural dyes.

Research by Prant et al. [7], analyzes the latest developments in natural environmentally friendly dyes and biomordants for textile dyeing, highlighting how they can reduce the sector's environmental impact. Through the analysis of several natural sources, extraction processes and application methodologies, this study clarifies the efficacy, longevity and color fastness of environmentally friendly dyes and biomordantes.

Figure 1 presents the application of natural dyes for ecological dyeing. Natural dyes offer transparency, provide sustainable benefits and a sophisticated look.

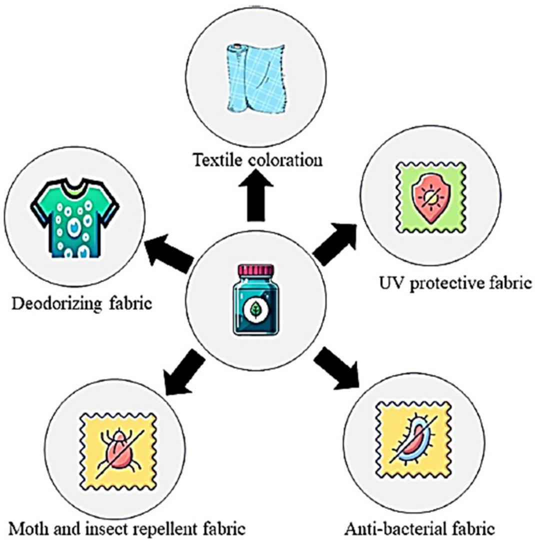


__Figure 1.__ Application of natural dyes in environmentally friendly dyes [7]

Natural dyes used to dye textiles come from a variety of sources, including minerals, plants, animals, and even microbes. Different sources of natural dyes are presented in Figure 2.

Figure 3 presents the mechanism of dyeing natural dyes with biomordants.

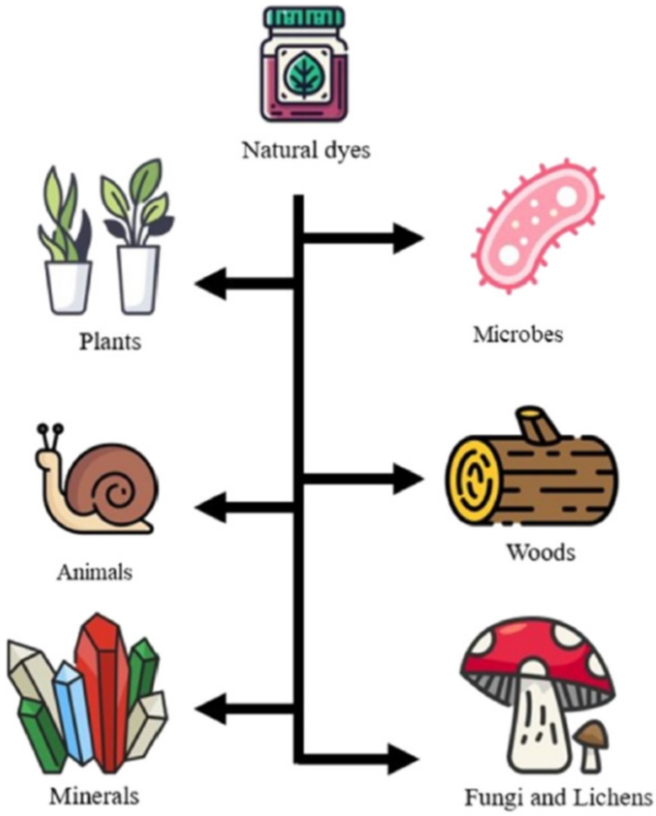


__Figure 2.__ Main sources of natural dyes for textile dyeing [7]

The study by Do et al. [8] provides an analysis of alizarin, a natural dye, in terms of its historical aspects and its potential for functional applications in textiles. The functional properties of natural alizarin were analyzed, including its antimicrobial activity, antioxidant activity, insect repellency and protection against ultraviolet radiation.

A diagram of conventional and advanced extraction methods to obtain alizarin from its botanical sources is shown in Figure 4.

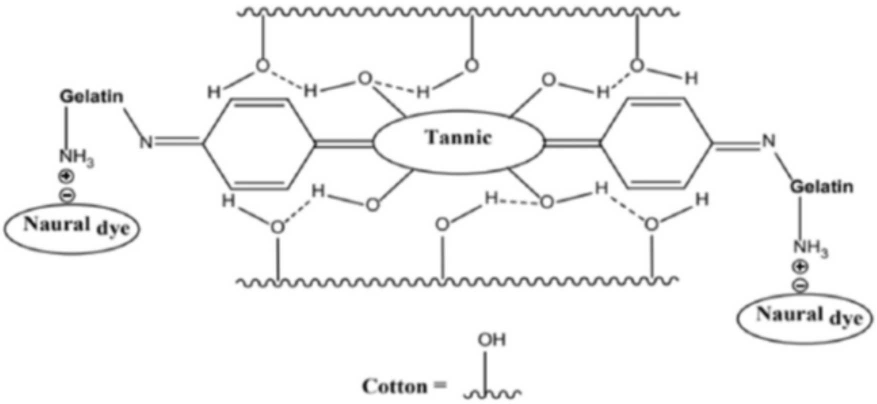


Figure 3. *Mechanism of dyeing natural dyes with biomordants [7]*

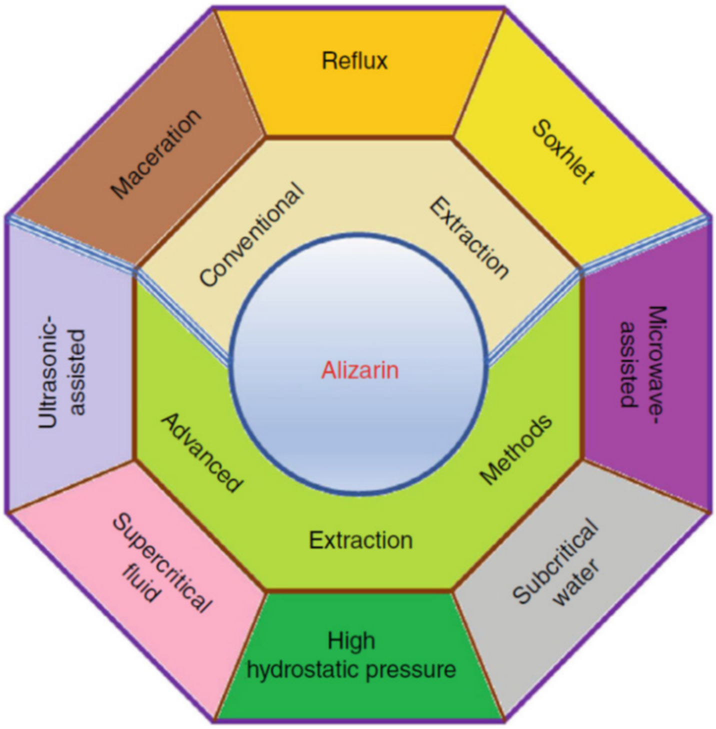


Figure 4. *Diagram of conventional and advanced alizarin extraction methods [8]*

The effect of varying the concentration of alizarin on its antibacterial activity against E. coli and St. aureus is shown in Figure 5A,B. Alizarin inhibited the growth of Candida albicans (Figure 5C). The anti-fungal property of alizarin is attributed to the presence of –OH group which indicates the potential of alizarin as a natural anti-fungal agent.

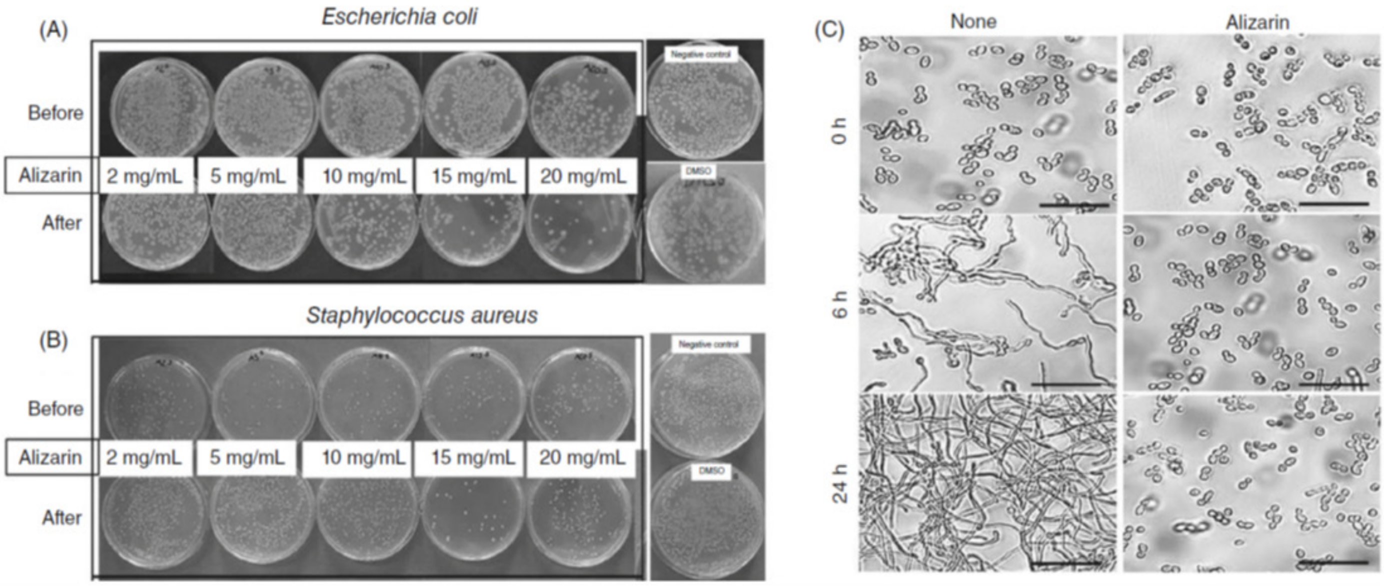


Figure 5. *Antibacterial activity of alizarin against A, Escherichia coli and B, Staphilococcus aureus, C, Effect of alizarin on the growth of Candida albicans [8]*

The aim of the research by Akram et al. [9] is to discover the process of dye extraction using the ultrasonic method and environmentally friendly dyeing of organic cotton knitted fabric. Post-wetting was done using natural lemon juice to improve color fastness.

Figure 6 shows three different shades of dyed cotton, b, c and d. Under a is raw cotton.

Figure 7 shows the dye extraction and dyeing process.

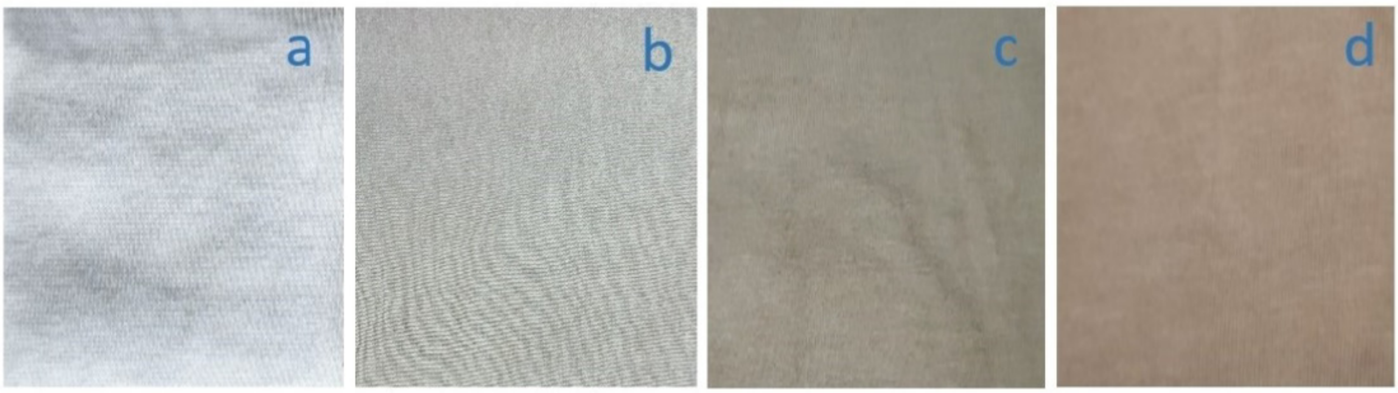


Figure 6. *Shades of the OCS dyed samples [9]*

The study by Taherirad et al. [10] focuses on the sustainable use of quinoa plant components, especially its leaves, as a waste agricultural material for natural dyeing applications. Two different quinoa genotypes, Titicaca and Giza, were selected for their natural coloring properties, Fig. 8. Wool samples dyed with different plant parts such as flowers, leaves and stems showed a distinct yellow tint, with the leaves showing the highest intensity of staining.

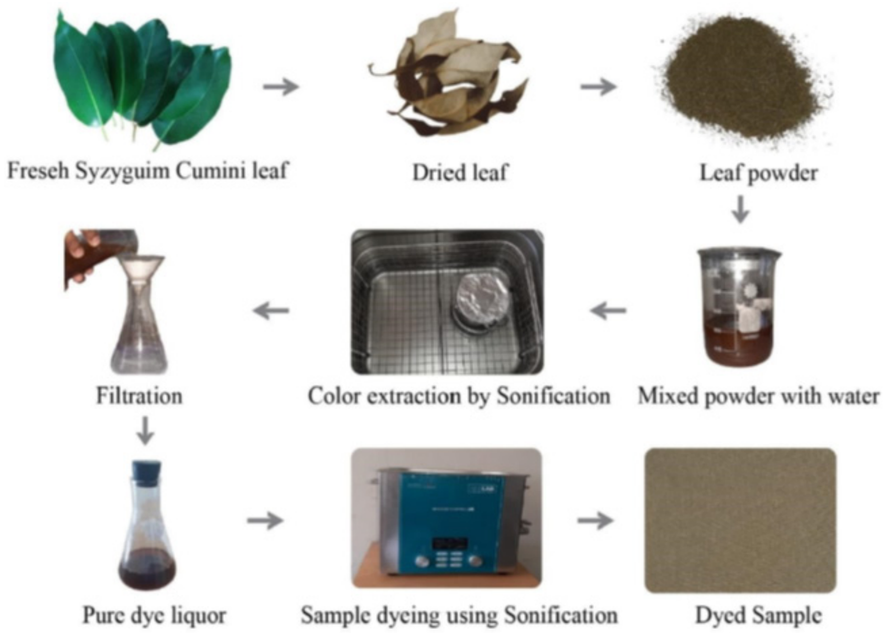


Figure 7. *Dye extraction steps and dyeing of OCS using Syzygium cumini leaf [9]*

Figure 8. *Plant images of Titicaca (left) and Giza (right) quinoa genotypes, performing their flowers, leaves and stalks used as natural dyes for wool dyeing [10]*

Figure 9 shows the antibacterial activity of different parts of the quinoa plant extract against E. coli and S. aureus. The results confirmed that wool samples dyed with the leaves of Giza Quinoa variety showed antibacterial activity against S. aureus, but did not show any zone of inhibition against E. coli.

Figure 9. *Antibacterial activity of wool dyed with leaves of Giza Quinoa variety using various metal mordants against E. coli (left) and S. aureus (right), highlighting its potential for textile applications [10]*

Yameen et al.'s [11] research aims to optimize the silk and wool dyeing process using natural dyes from Bika orellana (annatto). This research aims to optimize the silk and wool dyeing process using natural dyes from Bika orellana (annatto).
New shades were achieved on silk fabric and woolen yarn during dyeing process with annatto seed powder extract under selected conditions. A schematic representation of the dyeing and bio-mording process using microwave processing is shown in Figure 10.

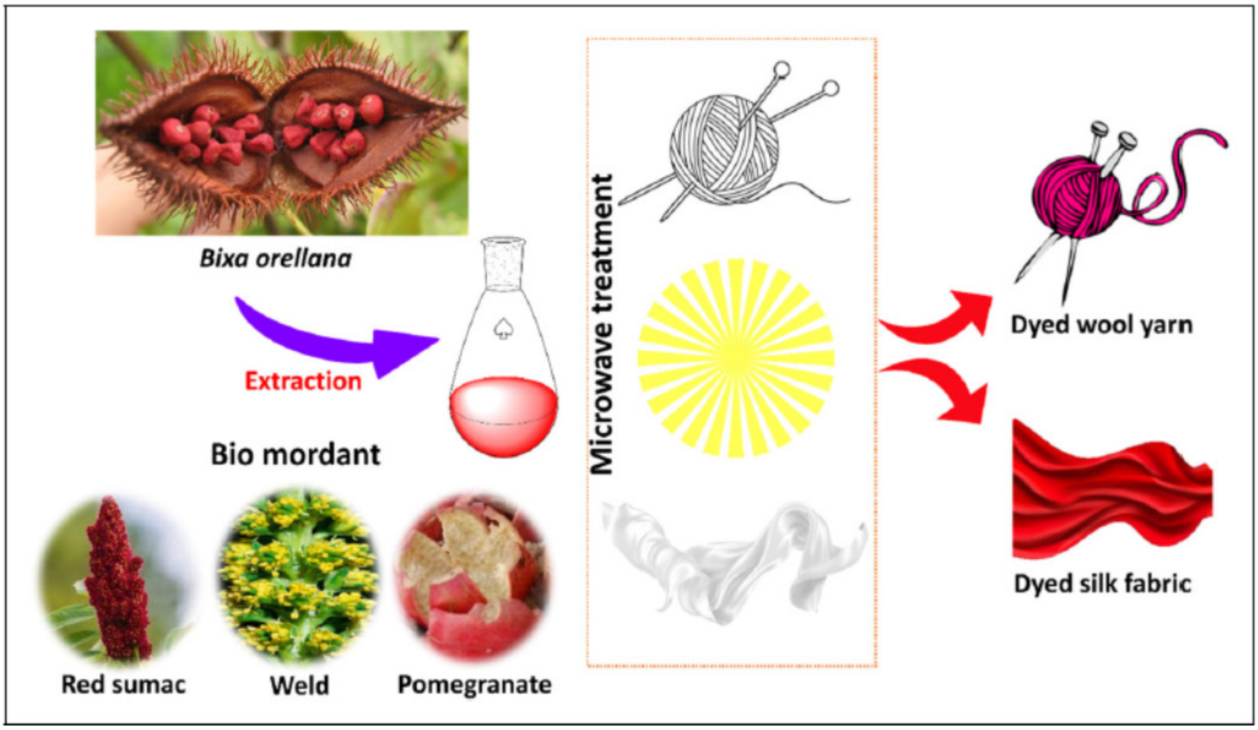


Figure 10. *Schematic representation of natural dyeing of silk fabric and woolen yarn with the help of microwave oven using bio-mordant [11]*

The color and shade coordinates of the dyed silk fabric using the selected high yield wetted material are shown in Table 1.

Table 1. Selected dyed silk fabric darkening quality parameters with annatto seed powder extract before and after chemical and bio mordanting [11]

Mordant	Conc. (g/ 100 mL)	*K/S*	*L**	*a**	*b**	*c**	*h*	Dyed silk fabric
Fe	2% pre	5.3125	56.73	34.99	56.53	66.48	58.25	
Fe	2.5% post	27.1642	52.75	39.78	54.69	67.63	53.97	
Al	1.5% pre	25.8546	53.88	36.77	57.56	68.3	57.44	
Al	2.5% post	17.4695	63.36	42.87	60.81	74.41	54.82	
TA	1.5% pre	30.4102	55.45	36.69	63.24	73.11	59.89	
TA	1% post	31.1503	54.71	37.57	61.76	72.29	58.69	
Red sumac	2% pre	16.4063	58.5	36.13	60.03	70.06	58.96	
Red sumac	2% post	40.1178	52.17	47.57	54.56	72.39	48.92	
Pomegranate peel	1.5% pre	16.3784	54.16	36.23	51.35	62.85	54.8	
Pomegranate peel	2.5% post	17.4779	59.57	33.37	64.96	73.03	62.82	
Weld flower	1.5% pre	12.1658	64.7	31.16	68.64	75.38	65.59	
Weld flower	2.5% post	21.6494	66.31	33.59	78.31	85.21	66.79	

The research of Batool et al. [12] is aimed at investigating the possibility of using sugar beet leaves as a natural dye source for dyeing cotton fabrics. Sugar beet leaves were collected from vegetable fields and the freshly obtained leaves were cleaned and properly dried before being crushed into powder.

The dye filtrates obtained by the extraction process were used for dyeing cotton fabric (Figure 11).

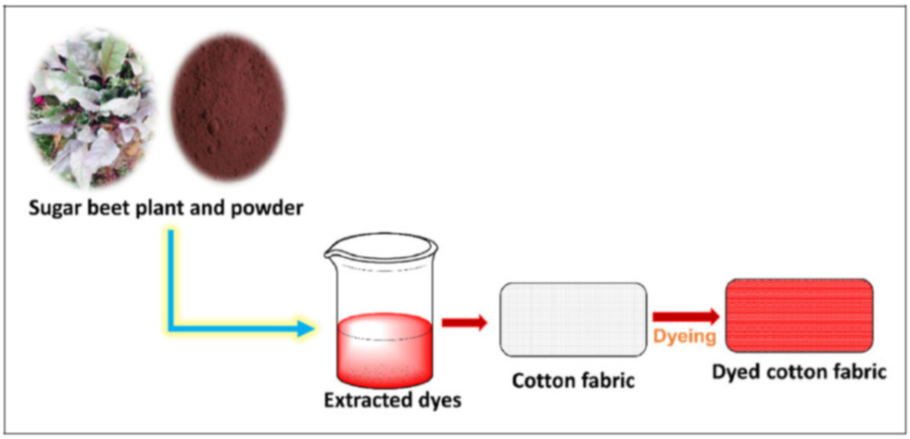


Figure 11. Demonstration of dyeing process on cotton fabric using natural dye obtained from sugar beet leaves [12]

The use of bio-mordants showed a more sustainable approach in achieving a darker shade, as shown in Table 2.

Table 2. Color and shade characteristics of ribbed cotton fabrics dyed with sugar beet leaf dye extract [12]

Mordanted sample	L^*	a^*	b^*	Color shade
Chemical pre-mordanted 1% TA	50.83	15.32	22.94	
Chemical pre-mordanted 4% $FeSO_4$	66.12	8.76	30.22	
Chemical pre-mordanted 4% K2Cr2O7	83.47	−1.10	13.17	
Chemical pre-mordanted 6% CuSO4	80.01	−8.19	9.91	
Chemical post-mordanted 6% $FeSO_4$	62.78	8.21	27.11	
Chemical post-mordanted 6% TA	57.66	11.65	18.14	
Chemical post-mordanted 6% K2Cr2O7	85.44	−0.05	7.61	
Chemical post-mordanted 4% CuSO4	75.60	−12.20	7.72	
Bio–pre-mordanted 8% pomegranate	70.32	−1.46	39.27	
Bio–pre-mordanted 6% onion	68.33	5.89	19.67	
Bio–pre-mordanted 6% henna	75.08	0.94	18.36	
Bio–pre-mordanted 6% turmeric	68.24	5.33	23.49	
Bio–pre-mordanted 6% golden shower bark	70.89	9.41	23.21	
Bio–post-mordanted 6% onion	65.06	9.21	19.14	
Bio–post-mordanted 6% henna	61.71	3.57	22.78	
Bio–post-mordanted 4% turmeric	65.74	11.42	28.66	
Bio–post-mordanted 4% pomegranate	66.64	−5.80	17.99	
Bio–post-mordanted 6% golden shower bark	63.92	9.96	25.17	

The research [13] deals with the optimization of the woolen fabric finishing process using certain plant extracts in order to obtain textiles with improved performance. It strives for multifunctionality, i.e. achieve multiple effects on the textile material with one functional treatment. Aqueous and ethanolic extracts of the flowers of the medicinal plants Marigold, St. John's wort and Roselle were used in these processes of refining woolen textile materials, when, in addition to coloring, antimicrobial and UV protection is achieved.

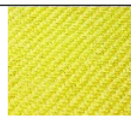
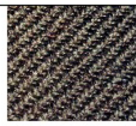
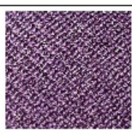
Procedures with best results:

- The best results of dyeing wool fabric with extracts of calendula, St. John's wort and hibiscus were achieved by processing in one bath, at a concentration of plant extract 100%, regardless of the extraction solvent (aqueous or alcoholic), bath ratio 1:30, at a pH of 3.5 (wine acid), processing time 60 min and temperature 60 °C.
- The mordant samples were checked, preference was given to potassium-sodium-tartrate and alum (3%), because they are the least ecologically undesirable compounds, with solid achieved effects.
- Part of the research was done with the use of ultrasonic waves, i.e. with the help of an ultrasonic device ELAC Nautik GmbH, bath ratio 1:200, pH

3, 50 °C, for 60 min. The following parameters of the ultrasound machine were used: power 50 W, frequency 2.1 MHz, reflected power 7.

Table 3 shows the appearance of dyed samples of wool fabric, dyed with varying origin of extract, method of extraction, type of mordant. Depending on these factors, different shades of color appear from gray to purple. The shade of the dyed samples is mostly influenced by the type of mordant.

Table 3. Appearance of dyed fabric samples after dyeing with plant extracts

Content of the recipe	A dyed sample	Content of the recipe	A dyed sample
unprocessed		unprocessed	
H_2O, calendula, aluminum potassium sulfate		ethanol, calendula, aluminum potassium sulfate	
H_2O, calendula, potassium sodium tartrate		ethanol, calendula, potassium sodium tartrate	
H_2O, St. John's wort, aluminum potassium sulfate		ethanol, St. John's wort, aluminum potassium sulfate	
H_2O, St. John's wort, potassium sodium tartrate		ethanol, St. John's wort, potassium sodium tartrate	
H_2O, Roselle, aluminum potassium sulfate		ethanol, Roselle, aluminum potassium sulfate	
H_2O, Roselle, potassium sodium tartrate		ethanol, Roselle, potassium sodium tartrate	

Conclusion

Dyes that come from natural sources and can be used in textile dyeing will represent an important factor in the future, as a competitor to conventional dyeing procedures with synthetic dyes. The reasons are very significant, and they primarily concern ecology and health.

Namely, textiles, as an object with a greater or lesser degree of "closeness to the skin", can be risky (allergies), while on the other hand, the classic dyeing of textiles with synthetic dyes is characterized by high environmental pollution and a high health risk for people who handle harmful substances.

In order to reduce the high pollution that characterizes modern textile dyeing processes, the partial replacement of synthetic dyes with natural dyes in textile production can represent a risk and pollutant reduction strategy.

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