ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

EXPERIMENTAL RESEARCH ON OBTAINING A CHROMATIC PALETTE ON HEMP FABRIC BY COMBINING WELD AND MADDER DYES

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Abstract: *In the current world, ecology and sustainability are emerging as a concept. In this context, there is a tendency toward a cleaner industry with better use of energy, replacing synthetic chemicals with raw materials derived from natural and renewable resources, so that they can be preserved in nature. In this regard, the attention of researchers and industry is focused on natural products from nature, such as natural fabrics and natural dyes, which have a remarkable potential. The paper presents the results of an experimental research aimed at developing an ecological process of dyeing hemp fabric and obtaining a chromatic palette with 16 variants by using the natural dyes Weld (Reseda Luteola L.) and Madder (Rubia Tinctorum L.) in different combinations and concentrations. Also, the influence of two types of pre-treatment applied to the samples was analysed, which were applied in order to improve the absorption capacity of the dye, namely scouring with enzyme and scouring and bleaching in one step process. By applying the treatments before the dyeing process and by combining the two natural dyes in different combinations and concentrations, the aim was to obtain a chromatic palette. Wash fastness was evaluated according to ISO 105-C06 standard procedure. The experimental research in this paper is in line with current trends and concepts, offering real solutions in the development of an ecological and sustainable textile finishing process, by using natural hemp fabric and natural dyes in the dyeing process.*

Key words: *ecological textile products, natural dyes, hemp, sustainability, colours*

1. INTRODUCTION

In the current context of globalization, there is a significant worldwide interest in the ecological phenomenon, which point the attention of researchers and industry to the use of materials, processes and technologies in order to ensure the development of organic products. In this context, the ecological phenomenon has a significant importance, as many researchers in various fields of science, and especially in the textile and fashion industry, have turned their attention to products coming from nature [1, 2]. Ecological awareness manifested in all fields, both nationally and internationally, has influenced research, but also the textile industry and the fashion industry.

Hemp is one of the most ecological and versatile natural textile plants [3, 4] and natural dyes considered to be biodegradable, non-allergic and non-toxic, are of remarkable interest.

Against the background of concerns about globalization, natural dyes have become an alternative to synthetic dyes. Natural dyes, obtained from plants, minerals and insects are ecological

and biodegradable, with a minimal impact on the environment, as researchers pay great attention to all areas of application of natural dyes [1, 5, 6].

Natural dyes are not an innovation, but a revival of a rich tradition, and cannot be compared with synthetic dyes only in terms of efficiency for industrial applications. After the current renaissance of dyes coming from nature there is a significant interest in the field of research in relation to everything concerning the pre-treatment process and the process of dyeing with natural dyes. Natural dyes appear to be the most appropriate substitute to the relatively toxic synthetic dyes [2, 3, 4]. They are believed to be safe because of non-toxic, non-carcinogenic and biodegradable nature. Further, natural dyes do not cause pollution and waste water problems.

From literature it is known that Weld and Madder were important sources of colour in textile production from ancient times. The natural dye Madder have been used for dyeing fabrics to the colour red, and the natural dye Weld for yellow colour, and also was usually combined with red dyes to produce different shades of orange.

Weld (Reseda luteola L.) is a perennial plant that produces a yellow dye (luteolin) from its foliage and flowers. This dye is the flavonoid yellow dye source that produces the most stable yellow shades and thus have been widely used for dyeing [7, 8, 9].

Madder (Rubia Tinctorum L.) is a plant anthraquinone red dye contain different anthraquinones, of which the most prominent structures are alizarin and purpurin that are believed to account for the red color [7, 8, 10, 11, 12].

Weld and Madder type dyestuffs belong to the group of mordant dyes which need a pre-treatment with a metal salt, the metal salts most in use are alum compounds [12].

Ecological dyeing with natural dyes is a topical issue. Research in this area focuses on obtaining a wide range of colours, tones and shades, on varying the amount of mordant, on the combination between mordants, on the decrease in the working time and on varying temperature.

Recent developments in the process of finishing of textiles with natural dyes are mainly based on the modification of natural fibres by using different agents before treatment and after treatment. They are used to improve colour, speed and functionality characteristics, and are frequently evaluated in numerous studies carried out.

From an ecological point of view, natural dyes are a viable alternative to synthetic dyes and can be used in the development of ecological textiles, by adapting the dyeing methods of the new systems.

2. EXPERIMENTAL RESEARCH

The experimental research in this paper aimed to develop an ecological process in the field of textile finishing. Pre-treatments of fabrics before the dyeing process with natural dyes aimed at applying two types of treatments, namely scouring with enzyme and scouring and bleaching in one step process. The dyeing process involved the combination of natural dyes Weld (Reseda Luteola L.) and Madder (Rubia Tinctorum L.), in different combinations and concentrations of dye. By applying the pre-treatment procedures of fabric samples and combining Weld and Madder dyes in different combinations and concentrations, the aim was to obtain a chromatic palette.

The hemp fabric (hemp 100%, fineness of warp yarn: Nm=10/2 and fineness of weft yarn: Nm=10/1 with specific weight: 276 g/m2) realised in Romania was used.

In this experimental study were used following: enzyme pectinase BioPrep 3000L (Novoyzmes), non-ionic surfactant Triton X-100 (Sigma-Aldrich), NaOH 38°BE, 33%, Hidrogen peroxide 35% and aluminium sulphate $Al_2(SO_4)_3$ (Acros Organics), Tannex CB and Tanaterge Advance (Tanatex Chemicals B.V.).

Natural dyes Weld and Madder were supplied from Couleurs de Plantes (France).

All experiments were performed with demineralized water and the 5 grams textile material was used as sample.

2.1. The pre-treatments process of samples

Pre-treatments of fabric samples before the dyeing process with natural dyes aimed to applying two types of treatments, namely scouring with enzyme to obtain a ecological textile finishing, and scouring and bleaching in one step process to obtain a high degree of white necessary for dyeing in light colors. By applying both pre-treatments, the aim was to improve the absorption capacity for subsequent dyeing with natural dyes.

2.1.1. Pre-treatment with enzyme

Enzyme pre-treatment is an ecological and sustainable treatment that can thus avoid chemical bleaching and has been applied in order to improve the absorption capacity of the dye.

The experiments were performed in the Zeltex VISTA COLOR equipment, where the samples were introduced, at a temperature of 50°C for 1 h. The experimental study aimed to applying the pre-treatment with 2 ml enzyme pectinase BioPrep 3000L and non-ionic surfactant Triton X-100. The role of the surfactant is to facilitate the absorption capacity of the enzyme, greatly improving the water absorption capacity, thus obtaining a high degree of hydrophilicity necessary for dyeing. The concentration of the buffer solution was constant, at 0.5 M for a pH of 8.0.

After pre-treatment, the samples were washed in cold water and dried in a drying machine for 50 minutes at 50°C.

2.1.2. Pre-treatment scouring and bleaching in one step

In order to improve the absorption capacity of the dye and to obtain a soft touch with hygienic-physiological performance properties, with a high degree of white necessary for dyeing in light colors, the samples were subjected to a process of scouring and bleaching in one step process.

The experiments were performed in the Zeltex VISTA COLOR equipment, where the samples were introduced, at a temperature of 98°C for 1 h. A concentration of 5 ml of H_2O_2 was used, because it offers both an optimal absorption capacity and a high degree of white.

In the pre-treatment scouring and bleaching in one step, the receipe includes: 5 g/L NaOH 38°BE, 33%; 1 ml/L Tannex CB; 5 ml/L H_2O_2; 2 ml/L Tanaterge Advance.

Optimal conditions for this experiment are a temperature of 98°C, a duration of 1 h and 5 ml of H_2O_2. After the bleaching process, the fabrics were washed with water at 90°C, for 1 h, in the Linitester equipment, after which they were washed with cold water and dried in a drying machine, for 1 h at 50°C.

2.1.3. Testing the samples after applying the two pre-treatments

The influence of the two types of finishing treatments applied to the samples was analysed by determining the water absorption capacity of the fabric samples, obtaining values of 1 sec. in the case of bleaching, respectively 2 sec. in case of the enzymatic treatment, which reflect, in both cases, a very good water absorption capacity. The properties of textiles after the application of treatments were determined by measuring the water absorption rate. The measurements were performed on different surfaces of the sample. The water absorption rate was determined by means of the pipetting method (AATCC Test Method 39-1980), which is a method of analysis from this point of view.

Figure 1 presents the untreated sample of hemp fabric, and also the results obtained after the two pre-treatments process applicated.

Fig. 1. *Untreated samples; Scouring with enzymes; Scouring and bleaching in one step*

2.2. The process of dyeing with natural dyes

Dyeing is a method which imparts beauty to the textile by applying various colours and their shades on to a fabric. In the dyeing process with natural dyes Weld and Madder were used two procedures: mordanting and dyeing procedure.

2.2.1. Mordanting procedure

The mordanting procedure was achieved with 16% $Al_2(SO_4)_3$; fabric: liquor ratio 1:30; duration 1 h; temperature 98°C. The mordanting process was carried out in the laboratory, with the Zeltex VISTA COLOR equipment, using 150 ml of demineralized water, 0.8 grams of aluminium sulphate $Al_2(SO_4)_3$. The 5 grams textile material was treated with mordant for 1 h at 98°C. After the mordanting stage, the fabrics were washed thoroughly with cold water.

2.2.2. Dyeing procedure

The dyeing procedure was achieved in the Zeltex VISTA COLOR equipment, also used in the mordanting procedure, at a temperature of 98°C, for 1 h with following dye concentrations for:

1. The combination of Weld and Madder dyes: 5% concentration of dye (0,50 gr. Weld with 0,25 gr. Madder) and 10% concentration of dye (1 gr. Weld with 0,50 gr. Madder)
2. The combination of Madder and Weld dyes: 5% concentration of dye (0,50 gr. Madder with 0,25 gr. Weld) and 10% concentration of dye (1 gr. Madder with 0,50 gr. Weld)

After being dyed, the samples were rinsed intensively with hot water at 80°C, followed by rinsing with cold water. Finally, the dyed samples were dried in the drying machine for 50 minutes, at a temperature of 50°C.

2.2.3. Colour Fastness tests

The colour fastness tests was achieved in the Linitester equipment, at the temperature of 40°C, for 30 min, with colour testing detergent: ECE - Color Detergent, according to the Fastness Test ACC. ISO 105-C06 (Gewebe GmbH Test, Germany). The solution was prepared by dissolving 4 grams of detergent and 1 gram of sodium carbonate /1L of water.

3. RESULTS AND DISCUSSION

The experimental research in this paper aimed to obtain a chromatic palette by using and combining Weld and Madder dyes in different combinations and concentrations.

Figure 2 presents the results of dyeing for the combination of Weld and Madder dyes.

Figure 3 presents the results of dyeing for the combination of Madder and Weld dyes.

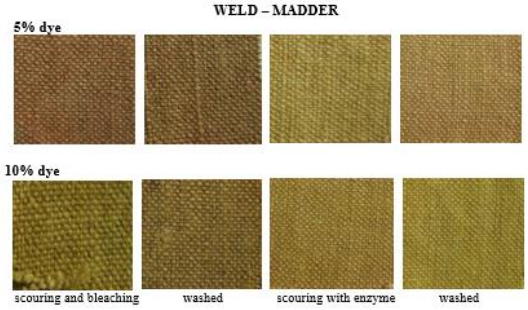

Fig. 2. *The results for combination Weld and Madder (5% and 10% concentration of dye)*

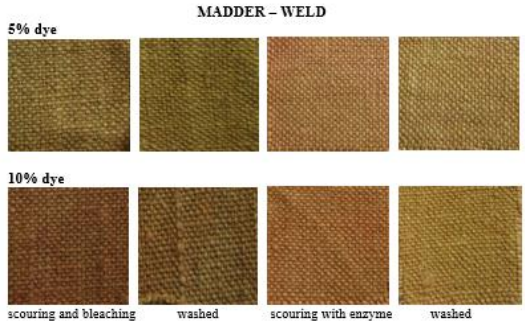

Fig. 3. *The results for combination Madder and Weld (5% and 10% concentration of dye)*

The experimental research carried out in this paper demonstrates the obtaining of both an ecological dyeing process, and also a chromatic palette following the application of the two types of pre-treatment and the combination of dyes using different combinations and concentrations.

Absorption time values obtained from enzyme treatments are comparable to those obtained from the scouring and bleaching treatment. Therefore, enzyme treatment is preferable, when the colour variant does not impose light colours and shades because it is an ecological treatment.

From the strict point of view of obtaining a higher degree of whiteness, the use of hydrogen peroxide H_2O_2 is necessary for the possibility of dyeing in light and pastel colours or for obtaining a soft touch, with hygienic-physiological properties of performance regarding the moisture absorption capacity, and the ability to sterilize the textile substrate due to the biocidal effect of eliminating streptococcal pathogens, viruses or bacteria.

The utility of the experimental process used has a special applicative character, by avoiding the classic dyeing using chemical reagents with potential pollutant and by using aluminium sulphate, the volume of wastewater and their degree of loading is considerably reduced. The use of this process has an immediate applicative character, in conditions of industrial processing.

4. CONCLUSION

As it can be seen, this paper is an experimental research that meets the current and prospective requirements of the textile industry on the use of natural dyes extracted from nature in the dyeing process. It can be concluded that through the process of dyeing with natural dyes and the use of natural fabrics, such as hemp, ecological textile products can be made, and by combining the dyes a chromatic palette can be obtained. The sustainable and diverse using of natural resources is significant in the development of environmentally beginning processes and products in the future.

ACKNOWLEDGEMENTS

The author would like to express her content to the staff of the "Research Centre for Design &Technology", Saxion University of Applied Science, namely to Pramod Agrawal, Ger Brinks and Henk Goijer for their support during the research internship in Enschede, the Netherlands, and last but not least for completing this research.

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