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Investigation of the Dyeability Behavior of Banana Fibers with Natural Dye Extract Obtained from Turmeric Plants

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ABSTRACT

In this study, the fibers produced from the banana plants provided from Antalya region were treated with a variety of mordants, and then the fibers were dyed with the natural dye extracted from turmeric plant (Curcuma longa) via ultrasonic and conventional method. Finally, the dye uptake and fastness properties of samples were investigated. The recent studies have demonstrated that the synthetic dyes can be non-biodegradable, allergenic, cytotoxic and partially carcinogenic. Recently demand for eco-friendly, non-carcinogenic and non-toxic products have been gradually increased. Compared to the synthetic dyes, the natural dyes are advantageous in the way of been biodegradable and non-toxic and not causing health problems, produced under temperate conditions. These properties of natural dyes lately result in increasing their usage. Today utilization of many plant extracts as natural dyes has been investigated such as turmeric plant.

Keywords: Banana Fibers, Natural Dyes, Dye Uptakes, Fastness Properties, Ultrasonic Method, Conventional Method.

I. INTRODUCTION

Dyeing of textile materials trace back to ancient times. Through the ages, textile materials have been dyed with the natural dyes provided from the animal and herbal sources [1]. By the use of natural dyes decreased with discovery of synthetic dyes in 1856 [2, 3]. The synthetic dyes are preferable as they provide a wide range of color, being cheap, easier to supply and their fastness properties [4]. The recent studies have demonstrated that the synthetic dyes can be non-biodegradable, allergenic, cytotoxic and partially carcinogenic [5, 6]. Recently demand for eco-friendly, non-carcinogenic and non-toxic products have been gradually increased. Compared to the synthetic dyes, the natural dyes are advantageous in the way of been biodegradable, non-toxic [7, 14] and not causing health problems, produced under temperate conditions. These properties of natural dyes lately result in increasing their usage [8-11]. Today utilization of many plant extracts as natural dyes has been investigated such as turmeric plant. Turmeric which includes yellow pigments is grown in tropical climates and used as spices. Turmeric, which includes yellow pigments is grown in tropical climates and used as spices [12]. Turmeric, the main component of which is curcumin, has the derivatives of dimetoxicurcumin and bis-dimetoxicurcumin (Figure 1). There are several of studies explaining this plant is anti-bacterial, anti-microbial, and anti-oxidant and prevents inflammation [13]. In addition to the eco-friendly nature of the dyes and the auxiliary chemicals used in coloring of textile materials, maintenance of energy consumption at the optimum level is of significance.

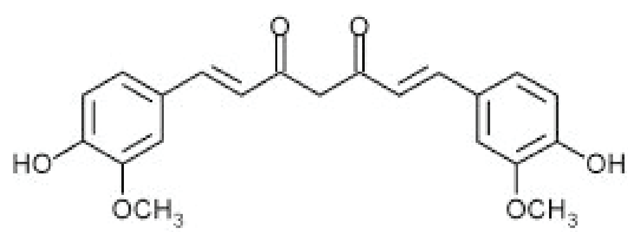

Figure 1. The structure of curcumin [1]

Compared to the ultrasonic process and the conventional process, the ultrasonic energy accelerates the chemical and physical reactions at the dyeing process [15, 18]. This effect results in occurrence of dyeing process at low temperatures, which, in turn, optimizes the use of heat energy. Besides, compared to the fastness of materials which were dyed via conventional method, the colour fastness of materials which were dyed via ultrasonic method is better [16, 17, 20, and 21]. As a result of the above mentioned study, the

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ultrasonic method provides an eco-friendly dyeing process providing low dye bath temperature, shorter dyeing period, low electrolytes as well as low dyestuffs content [18, 19].

In this study, the fibers have been procured from the stem of banana plants. The banana plants used in this study provided in Antalya region. After the banana fibers provided, the fibers mordanted with a variety of mordants and finally the fibers have been dyed with the natural dyestuff which was extracted from turmeric plants by ultrasonic and conventional method. Finally the dye uptakes and the colour fastness behaviour of the samples have been investigated with regards to the mordents and the natural dyes.

Although turmeric plant is quite expensive material, our purpose of using is its colour as well as its healthy properties of which may effect human body through in touch on the human skin.

II. EXPERIMENTAL

2.1. Scouring Process

The banana fibers weighing 5 grams were applied to the scouring process in 3% sodium hydroxide solution (based on the weight of the fiber: o.w.f) at the boil for one hour before have been neutralized with acetic acid and finally the samples dried.

2.2. Mordanting Process

The banana fibers were mordanted with a variety of mordent before the dyeing process. The samples were undergone the mordant process at the boiling temperature for 60 minutes in the mordent liquors prepared in the mordent liquors ratio of 1/20 with a variety of mordent with regard to the material weight. The conditions of the mordanting process are explained in Table 1.

2.3. Preparation of Dyeing Extracts

In this investigation the dyeing solution was prepared by using 1 gram of turmeric and 200 ml of distilled water.

2.4. Dyeing Process

For the dyeing process, 2 grams of materials subjected to the application of pre-mordant process by boiling with the dyeing solution prepared with the liquor ratio of 1:20 for one hour. Then, the dyed samples were removed from the liquor and left to cooling. After this procedure the samples were washed with cool water and they were left to dry. The experimental conditions of the dyeing process with mordant and without mordant take place in Table 2.

The dyeing process was carried out with Maxwell Ultrasound Dyeing device at 70 ºC with the liquor ratio of 1:20 for 15 minutes and the samples were exposed to 20 kHz ultrasonic power. Finally the samples were rinsed with cold water, hot water and again cold water respectively.

Table 1. Mordanting process

Code	The Quantity of Mordant % (o.w.f)	Mordant	pH	Conditions
1	4	Copper Sulphate	5	5 grams of materials were treated in 40 mL liquor (1:20) at the boil and finally for 60 minutes then the samples were cooled and finally squeezed and dried.
2	15	Alum	4	
3	4	Ferrous Sulphate	5	

Table 2. The experimental conditions of the coloring process

The Quantity of material:	2 grams
Liquor :	40 mL (1:20)
Temperature :	Boiling Temperature (around 98°C)
Duration :	60 minutes
Condition :	After the dyeing process was concluded, the samples were left to cool themselves in the liquor. Then the samples were rinsed with running tap water. Finally, the samples were washed with the water at the boiling temperature, rinsed with cold water and left to dry.

2.5. Evaluation of the Colour Properties of the Dyed Samples

Color measurements were performed in the color measuring device, Datacolor SF-600. All samples were measured from ten different regions of the sample and the average curves of wavelength-%reflectance were obtained by the calculation of the arithmetic mean of the reflectance values obtained at the each wavelength. The calculations were performed with respect to D65 light source and 10o standard observer. For measurements, the sample which was not mordanted was accepted as standard and the samples mordanted were compared in terms of the colors. The calorimetric values were measured according to the CIELAB system. Equation 1 was used to determine total color differences [22].

$$\Delta E^{\cdot} = \sqrt{\left(\Delta L^{\cdot}\right)^5 + \left(\Delta a^{\cdot}\right)^5 + \left(\Delta b^{\cdot}\right)^5} \qquad (1)$$

Where ΔE* refers to the total color differences. In commercial regards, if ΔE*< 1, the value of color differences could be accepted in general. The negative value of ΔL* demonstrate that the color of the samples compared is darker than that of the standard whereas the positive value of ΔL* indicates that the color of the samples compared is lighter than that of the standard. Similarly, the positive value of Δa* results in surplus of the red nuance whereas the negative value of Δa* results in surplus of the green nuance. The positive value of Δb* points out that the yellow nuance is much whereas the negative value of Δb* indicates that the blue nuance is much.

2.6. Evaluation of the Colour Properties of the Dyed Samples

The light and washing fastness of the samples were tested according to ISO105-C06 [23] and ISO105-B02 [24] standards. The washing fastness of the samples was performed by using the washing fastness equipment (Gyrowash/James H.HealCo.Ltd 815/20). The light fastness of the samples was performed by using the light fastness equipment with the reference of the blue scale (Atlas Xenotest 150S).

III. RESULTS AND DISCUSSION

3.1. Calculated Values of Color Differences

The colors obtained following the coloring process of the samples mordanted with different mordants were shown in Figure 2. The differences of ΔL*, Δa*, Δb* and ΔC* are demonstrated in Figure 3.

In the spectrophotometric measurements the unmordanted samples accepted as the standard. The total color difference with respect to the ultrasonic and conventional methods (ΔE*) is not among the acceptable values. It is seen from the results that the ultrasonic method gave better dye uptake results than the conventional methods. And the ferrous sulphate gave better colour yield than the cupper sulphate and alum.

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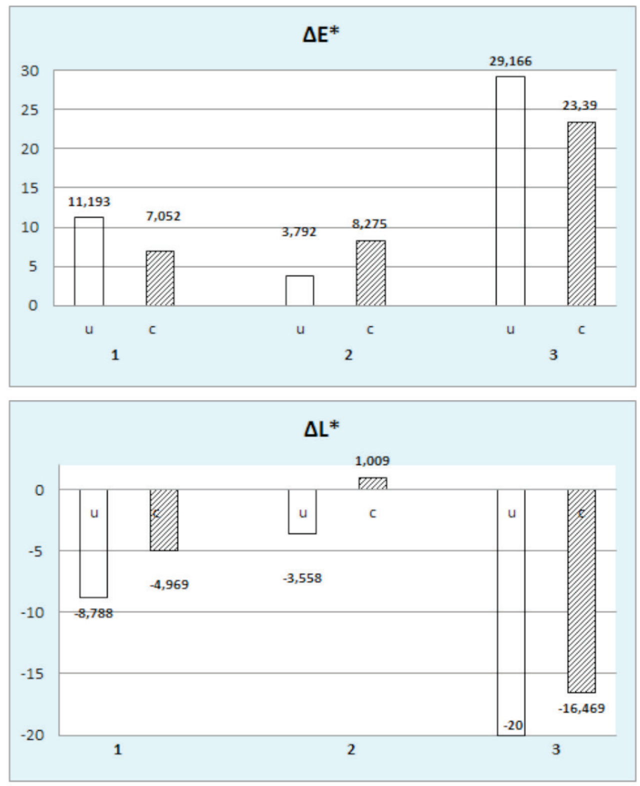
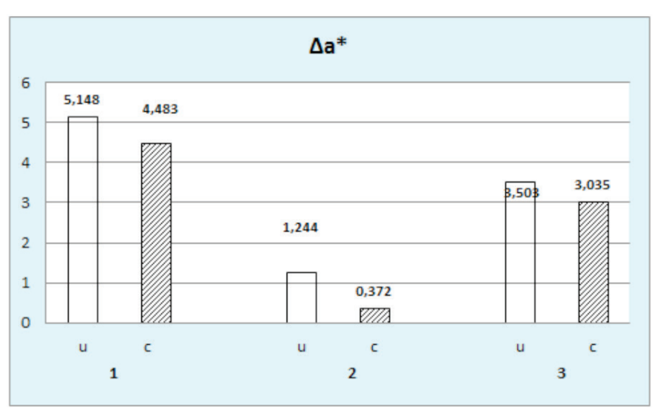


Figure 2. The colors obtained in the dyeing process. (1.Copper Sulphate (Ultrasonic Method), 2.Copper Sulphate (Conventional Method), 3. Alum (Ultrasonic Method), 4. Alum (Conventional Method), 5. Ferrous Sulphate (Ultrasonic Method), 6 Ferrous Sulphate (Conventional Method))



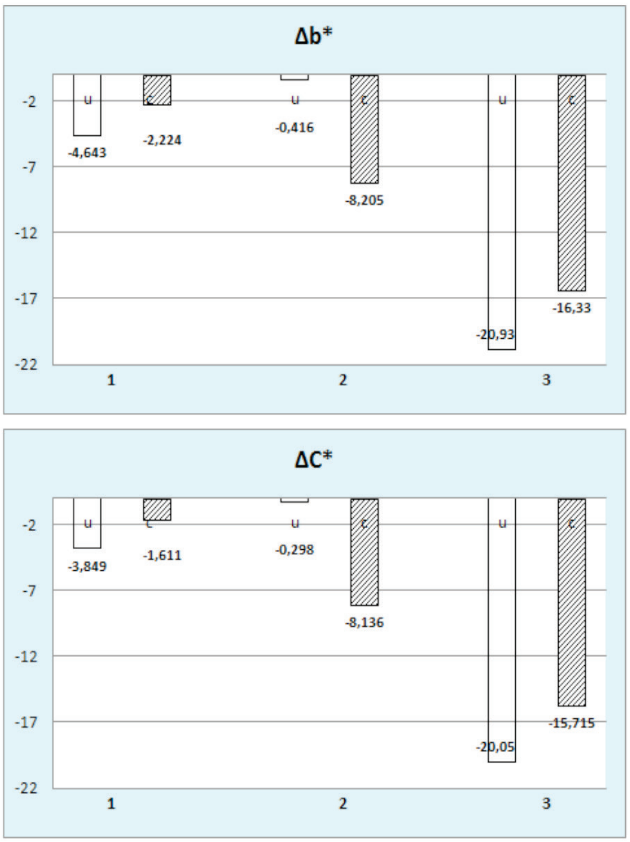


Figure 3. The color measurement values of the cotton samples. (1: Copper Sulphate, 2: Alum, 3: Ferrous Sulphate, u:ultrasonic, c:conventional)

3.2. Results of the Color Fastness Test

The results of the light and washing fastness tests applied to the samples are shown in Table 3.

It is seen from the colour change result that the conventional method was slightly better than the ultrasonic method for copper sulphate and alum whereas the ferrous sulphate gave better results on ultrasonic method. The staining result for all three mordants was high and almost similar colour change and light fastness at moderate level. The light fastness value was low for almost all the mordants, whereas known the light fastness of the most natural dyes is low.

IV. CONCLUSION AND ASSESSMENT

The colours obtained by use of curcuma plants were slightly lower than the industrial requirements for the three used on this study. It is recommended to try different mordants as well as different dyeing conditions in order to improve the dyeing behavior.

Table 3. The results of washing and light fastness

Code	Washing Fastness							Light Fastness
	Colour Change	Staining						
		Acetate	Cotton	Polyamide	Polyester	Acrylic	Wool	
1	1-2	5	4-5	4	5	4-5	4-5	2
2	2	5	4	4-5	5	4-5	4-5	2
3	1-2	5	4-5	4	5	5	5	2
4	2	5	4	4-5	5	5	4-5	1-2
5	2-3	4	4-5	4	5	4-5	4-5	1-2
6	2	4	5	4	5	4-5	4-5	2

1. Copper Sulphate (Ultrasonic Method), 2.Copper Sulphate (Conventional Method), 3. Alum (Ultrasonic Method), 4. Alum (Conventional Method), 5. Ferrous Sulphate (Ultrasonic Method), 6 Ferrous Sulphate (Conventional Method)

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