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Research Article

Dyeing of Cotton Fabrics with Naturally Sourced Dyes (Madder (Rubia tinctorum L.), Turmeric (Curcuma longa) and Walnut Shell (Juglans regia)) and Capsule Collection Applications

Doğal Kaynaklı Boyar Maddelerle (Kök boya (Rubia tinctorum L.), Zerdeçal (Curcuma longa) ve Ceviz kabuğu (Juglans regia)) Pamuklu Kumaşların Boyanması ve Kapsül Koleksiyon Uygulamaları

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Abstract: Natural dyeing, one of the oldest textile coloring methods in human history, has been practiced in various geographies for centuries and has become a cultural heritage. Plant-based dyeing holds a significant place, particularly in Turkish culture and traditional arts. With increasing environmental awareness, these traditional methods have begun to regain value. This study investigated the dyeability of 100% cotton fabrics with dyes obtained from natural sources, using madder (Rubia tinctorum L.), turmeric (Curcuma longa), and walnut shell (Juglans regia). Five separate experimental dyeing processes were conducted for each dye. The effects of Alum [$KAl(SO_4)_212H_2O$], Iron sulfate ($FeSO_4{\cdot}7H_2O$), and Copper sulfate ($CuSO_4{\cdot}5H_2O$), which are mordants commonly used in natural dyeing, on color tone and adhesion were evaluated. As part of the experimental studies, different recipes were tested for different times, temperatures, mordant types, and dye ratios, and the resulting color variations were analyzed visually and technically. The dyeing results revealed that the type of mordant directly impacted both the resulting color tones and the dye's permanence. A design-oriented collection was developed from the colors selected for this purpose and selected for their highest permanence. At the end of the study, dyeing processes were performed on 100% cotton fabrics to be used in the design, based on experimental applications. This framework created a unique textile collection based on natural dyeing. This research also aims to demonstrate the potential of natural dyes for sustainable textile production.

Keywords: Traditional arts, madder (rubia tinctorum l.), turmeric (curcuma longa), walnut shell (juglans regia), mordant, collection design.

Öz: İnsanlık tarihinin en eski tekstil renklendirme yöntemlerinden biri olan doğal boyamacılık, yüzyıllar boyunca farklı coğrafyalarda uygulanmış ve kültürel bir mirasa dönüşmüştür. Özellikle Türk kültüründe ve geleneksel sanatlarında bitkisel boyamacılık önemli bir yer teşkil etmektedir. Günümüzde artan çevresel duyarlılıkla birlikte bu geleneksel yöntemler yeniden değer kazanmaya başlamıştır. Bu çalışmada Kök boya (Rubia tinctorum L.), Zerdeçal (Curcuma longa) ve Ceviz kabuğu (Juglans regia) kullanılarak doğal kaynaklardan elde edilen boyar maddelerle %100 pamuklu kumaşların

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boyanabilirliği incelenmiştir. Bu kapsamda her boyarmaddeden beş ayrı deneysel boyama işlemi gerçekleştirilmiştir. Doğal boyamacılıkta yaygın olarak kullanılan mordan maddelerinden ise şap [$KAl(SO_4)_212H_2O$], demir sülfat ($FeSO_4{\cdot}7H_2O$), ve bakır sülfat ($CuSO_4{\cdot}5H_2O$)'ın renk tonu ve tutunma gücü üzerindeki etkileri değerlendirilmiştir. Deneysel çalışmalar kapsamında farklı süre, sıcaklık, mordan türü ve boya oranları farklı reçetelerle denenmiş; elde edilen renk varyasyonları görsel ve teknik olarak analiz edilmiştir. Boyama sonuçlarına göre mordan türü hem elde edilen renk tonlarını hem de boyanın kalıcılığını doğrudan etkilediği saptanmıştır. Bu çerçevede elde edilen ve kalıcılığı en yüksek olarak seçilen renklerden tasarıma yönelik bir koleksiyon geliştirilmiştir. Çalışmanın sonunda, deneysel uygulamalardan yola çıkılarak tasarımda kullanılacak %100 pamuklu kumaşlara boyama işlemleri yapılmıştır. Bu çerçevede doğal boyamacılığa dayalı özgün bir tekstil koleksiyonu oluşturulmuştur. Bu araştırma aynı zamanda sürdürülebilir tekstil üretimi açısından doğal boyar maddelerin potansiyelini ortaya koymayı hedeflemektedir.
Anahtar Kelimeler: Geleneksel sanatlar, kök boya (rubia tinctorum l.), zerdeçal (curcuma longa), ceviz kabuğu (juglans regia), mordan, koleksiyon tasarımı.

INTRODUCTION

It is known that the use of natural dyes in textile fibers began around 4000 BC in India and Mesopotamia. Dyeing, which had been done with plant and animal-based dyes for centuries, faded into obscurity with the advent of synthetic dyes in the 19th century. Now, with the recognition of the toxic and environmentally harmful effects of synthetic dyes, natural dyeing has begun to gain renewed interest (Karadağ, 2007: 11).

With the rapid spread of industrialization, the use of synthetic dyes in the textile sector has increased, but this has brought about serious environmental and health problems. The negative impacts of chemical dyes on water resources and human health, in particular, have brought natural dyeing back to the forefront. Natural dyeing is a textile coloring method dating back thousands of years and using dyes derived from plant or animal sources (Tüm Cebeci, 2020: 658). In this context, the study used dyes derived from natural sources such as madder *(Rubia tinctorum L.*), turmeric (*Curcuma longa*), and walnut shell (*Juglans regia*) to dye cotton fabrics. An examination of the dyes used reveals that madder (Rubia tinctorum L.) has been used to dye textiles in many regions of the world since ancient times. One of the oldest textiles known to have been dyed with madder in archaeological excavations is a belt found in Tutankhamun's tomb, dating back to 1350 BC (Guangguo et al., 2023: 2). Throughout history, it has been the most widely used natural red dye source in and around Anatolia. In the 1700s, approximately two-thirds of the world's need for madder was supplied by the Ottoman Empire (Özdemir and Karadağ, 2023: 3). The unique red tone obtained from madder produced in Edirne, in particular, was referred to as "Edirne Red" (Rouge d'Andrinople) or "Turkish Red" in the international literature and gained great fame. The dye concentrates in the root of the plant, and analyses have determined that alizarin is the most dominant compound (Tüm Cebeci, 2023: 74). In a recent study (Karadağ, 2025) the Turkish red recipe was revealed again in 2017 through various academic and scientific research and analysis. It was determined that the application could

be used in sustainable and industrial dyeing processes in addition to traditional dyeing methods.

Turmeric (*Curcuma longa*), commonly known as curcuma, is a perennial herbaceous plant belonging to the Zingiberaceae family that grows in tropical climates. Botanically related to ginger, this plant is widely cultivated in various regions of Asia, primarily India, and Africa. Turmeric is used primarily as a spice and natural food coloring; its processing produces a bright yellow, highly colored powder (Bassey, Oremosu & Osinubi, 2011: 2). In Turkish culture, colors are imbued with many mythological meanings. Yellow, in particular, has been characterized as the color of light, gold, the color of the earth, or a symbol of the sun (Çoruhlu, 2020: 341).

Walnut shells (Juglans regia) are an important plant source with both natural dye and antimicrobial properties. The dye obtained from the outer shells of the walnut fruit is juglone, a compound particularly effective in achieving brown tones (Enez, 1987: 59). One of the key advantages of walnut shells is that they do not require a mordant; in other words, they can be applied directly to fibers. The resulting colors are brown and its shades, and their light and washing fastnesses are quite high (Genç, 2017: 106-107).

Mordanting Process

Most natural dyes do not form permanent bonds directly with the fibers; therefore, auxiliary substances called mordants are required to fix the dye to the fibers and increase color and lightfastness. The word "mordant" derives from the Latin root mordere, meaning "to bite." In the dyeing process, the mordant forms a bridge between the fiber and the dye, allowing the dye to adhere better to the fabric (Ado et al., 2014: 77). In natural dyeing, mordants can be used as water-soluble metal salts, as well as some weakly acidic or alkaline substances. The most commonly used mordant substances include Alum [$KAl(SO_4)_2 12H_2O$], Iron sulfate ($FeSO_4 \cdot 7H_2O$), Copper sulfate ($CuSO_4 \cdot 5H_2O$), Tin chloride ($SnCl_2 \cdot 2H_2O$) and Tartaric acid. The majority of natural dyes are classified as mordant dyes (Karadağ, 2007: 11-12).

In natural dyeing, the mordant used not only ensures the dye adheres to the fibers but also directly affects the resulting color tone. Within the same dye, quite different color tones can be achieved by using different mordants. For example, iron sulfate, due to its "darkening" effect, darkens colors and creates more muted tones. Copper sulfate, while similarly darkening colors, allows for the creation of unique tones that are difficult to achieve under normal conditions. Stannous chloride highlights colors with its brightening properties. Tannic acid, often used in conjunction with other mordants, increases color saturation and brightness. Chromium salts are known as mordants, particularly effective in

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achieving yellow hues. Oxalic acid helps to more effectively extract blue tones from some plants (Ado et al., 2014: 78).

The main purpose of the study is to observe how cotton fabrics respond to different natural dyes, compare the effects of different mordant types and application methods on color tone and permanence, and create a collection of these dyed fabrics with aesthetic value. This research, conducted in line with sustainable production principles, both raises environmental awareness and paves the way for the integration of traditional techniques with contemporary design.

MATERIALS AND METHODS

Materials

In this study, three different mordants were applied to 100% cotton fabrics before the natural dyeing process. The mordant types applied were Alum ($KAl(SO_4)_2 \cdot 12H_2O$), Iron sulfate ($FeSO_4 \cdot 7H_2O$), and Copper sulfate ($CuSO_4 \cdot 5H_2O$). The natural dyes used in the application were madder (*Rubia tinctorum L.*), turmeric (*Curcuma longa*), and walnut shell (*Juglans regia*).

Method

In natural dyeing processes, mordant-free (direct) applications were performed. Mordant applications were also made with Alum ($KAl(SO_4)_2$ $12H_2O$), Iron sulfate ($FeSO_4 \cdot 7H_2O$), and Copper sulfate ($CuSO_4 \cdot 5H_2O$) (Table 1). For all applications, the fabric quantities, mordant materials, and dyestuff amounts were measured separately using a precision scale, and a digital thermometer was used for temperature measurements (Figure 1).

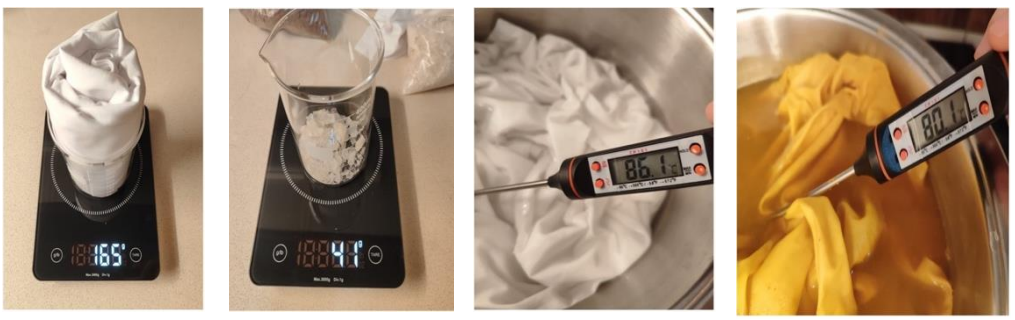


Figure 1. Measurement procedures with precision scales and digital thermometers**.**

Mordant-Free (Direct) Use

Mordant-free samples were subjected to a direct dyeing process without the use of any fixatives and were then used for comparative evaluation. Mordant-free dyeing can be

defined as a technique that involves transferring plant-based dyes directly onto the fiber, depending on time and temperature (Tüm Cebeci, 2024: 200).

Mordanting with Alum ($KAl(SO_4)_2\ 12H_2O$)

Before mordanting, all fabric samples were pre-wetted to ensure uniform absorption of the liquid. In the alum application, 20 times the amount of water was used compared to the fabric, and in the Alum application, 30% of the fabric was added to the water. Mordanting was carried out at approximately 90°C for 1 hour, after which the baths were allowed to cool to room temperature.

Mordanting with Iron Sulfate ($FeSO_4 \cdot 7H_2O$)

The Iron sulfate application was carried out using a different method. Fabrics, previously mordanted and dyed with alum, were immersed in a separately prepared warm water bath with a solution of iron sulfate added at a rate of 20% of the fabric weight. In this method, iron sulfate was used as a secondary mordant, and its darkening effect on color was observed.

Mordanting with Copper Sulfate ($CuSO_4 \cdot 5H_2O$)

In the copper sulfate application, cotton fabrics were first mordanted with Alum, and the dyeing process was completed. Then, the fabrics were placed in a separate warm water bath, where a 20% Copper sulfate solution was added to the fabric.

Table 1: Mordanting Applications

	Fabric Amount	**Mordant Substances**	**Mordant Amount**	**Water Amount**	**Method**	**Temperature**	**Time**
1.	203 gr	Alum $[KAl(SO_4)_2 12H_2O]$	25 %	%1250	Pre-wetting	85-90^{0}C	60 min.
2.	165 gr	Alum $[KAl(SO_4)_2 12H_2O]$	30%	%2000	Pre-wetting	85-90^{0}C	60 min.
3.	191 gr	Alum $[KAl(SO_4)_2 12H_2O]$	30 %	%2000	Pre-wetting	90^{0}C	60 min

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4.	191gr	Alum and Iron sulfate $[KAl(SO_4)_2 12H_2O]$ ve $(FeSO_4 \cdot 7H_2O)$	30% Alum+ 20% Iron sulfate	%2000	Pre-wetting	90^0C	60min. Alum + 20 minutes after dyeing Iron sulphate
5.	150 gr	Alum and Copper sulfate $[KAl(SO_4)_2 12H_2O]$ ve$(CuSO_4 \cdot 5H_2O)$	30% Alum+ 20g Copper sulfate	%2000	Pre-wetting	90^0C	60min. Alum + Copper sulphate for 20 minutes after dyeing

RESEARCH FINDINGS

In this study, natural dyeing processes were carried out experimentally using traditional methods on 100% cotton fabrics using madder (*Rubia tinctorum* L.), turmeric (*Curcuma longa*) and walnut shell (*Juglans regia*) according to the determined recipes.

Fabrics Dyed with Madder (*Rubia tinctorum L.*)

Five separate experimental studies were conducted using different temperature, mordant, and time variables within the scope of dyeing processes using madder (*Rubia tinctorum L.*).

In the first two studies, the fabrics were mordanted with Alum ($KAl(SO_4)_2 \cdot 12H_2O$) before dyeing. Subsequently, dyeing was carried out using madder (*Rubia tinctorum L.*) at a ratio of 50% to the fabric volume. In each study, the dye baths were prepared with 20 times the amount of water as the fabric, and the temperature was maintained at 80°C. The dye was then used after soaking in the water for one day.

Dyeing times were variable, and each group was dyed for 45 and 60 minutes, respectively. This experimental study observed the effects of dyeing time and temperature on color intensity and the fabric's dye uptake capacity. Comparing the color tones between these two studies revealed that increasing the dyeing time had a significant effect on color saturation and depth. It was concluded that the longer the dyeing time, the more intense the color became and the more permanent it penetrated the fibers.

In the third studies, the color with the addition of Alum $[KAl(SO_4)_2 12H_2O]$ and Iron sulfate $(FeSO_4 \cdot 7H_2O)$ became lighter and paler. This indicates that Iron sulfate

($FeSO_4 \cdot 7H_2O$) creates a cold, grayish, and dulling effect on red tones. The findings revealed that the type of mordant and its combination play a decisive role in color quality.

In the fourth studies, the dyeing process was carried out without any mordant. In this treatment, 70% of the fabric was dyed with madder, and the dye bath was prepared with 20 times the amount of water as the fabric. The dyeing process continued for 75 minutes at a constant temperature of 80°C. With this application, the color intensity, vibrancy, and adhesion quality of the dyed product without mordant were evaluated. In the fifth experiment, the same dyeing conditions were maintained; this time, alum [$KAl(SO_4)_2 12H_2O$] and Copper sulfate ($CuSO_4 \cdot 5H_2O$) were used as mordants. The resulting color was observed to become paler and duller despite the use of mordant. This demonstrated the lightening and cooling effect of Copper sulfate ($CuSO_4 \cdot 5H_2O$) on the root dye. According to the test results, in the second experiment, which used only Alum [$KAl(SO_4)_2 12H_2O$], a more vibrant and brighter color was achieved by increasing the dyeing time (Table 2).

Table 2: Experimental studies with madder (*Rubia tinctorum L.*)

Dyestuff	**Usage**	**Amount of fabric**	**Amount**	**Mordant substance**	**Mordanting method**	**Time**	**Temperature**	**Fabric color samples obtained**
Madder	grind	40 g	50%g/1300% ml. the dye was kept in water for 1 day.	Alum	Premordanting	45 min.	80°C	
Madder	grind	40g	50%g/1300% ml. the dye was kept in water for 1 day.	Alum	Premordanting	60 min.	80°C	
Madder	grind	40g	70%g/ 2000% ml. the dye was keptin water for 1 day.	Alum+ Iron sulfate	Premordanting	90 min.	80°C	

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Madder	grind	165g	70%g/2000 %ml.the dye was kept in water for 1 day.	-	Mordant-free	75 min.	80°C	
Madder	grind	165g	70%g/2000 %ml.the dye was kept in water for 1 day.	Alum+ Copper sulfate	Pre-mordanting	75 min.	80°C	

Fabrics Dyed with Turmeric (*Curcuma longa*)

Within the scope of the dyeing studies conducted with turmeric (*Curcuma longa)*, the parameters used in the first, second, and third trials were kept the same; only the mordant material was varied. In all three trials, Turmeric at 22% of the fabric amount was added to a dye bath prepared with 20 times the fabric's water; the dyeing process was carried out at 80 °C for 60 minutes. Under these constant conditions, only Alum [$KAl(SO_4)_2 12H_2O$] was used as mordants in the first trial; Alum [$KAl(SO_4)_2 12H_2O$] and Copper sulfate ($CuSO_4 \cdot 5H_2O$) was used in the second trial; and Alum [$KAl(SO_4)_2 12H_2O$] and Iron sulfate ($FeSO_4 \cdot 7H_2O$) was used as mordants in the third trial. The fabric samples obtained from the experiments showed significant color differences depending on the type of mordant. In the first experiment, using only Alum [$KAl(SO_4)_2 12H_2O$], the fabrics acquired more vibrant, bright, and warm yellow tones. In the second experiment, using both Alum [$KAl(SO_4)_2 12H_2O$] and Copper sulfate ($CuSO_4 \cdot 5H_2O$), the color tone changed to a paler yellow. In the third experiment, adding Iron sulfate ($FeSO_4 \cdot 7H_2O$), the color tone changed to a duller, darker, and greenish yellow. This situation reveals the tone-altering effect of both Copper sulfate ($CuSO_4 \cdot 5H_2O$) and Iron sulfate ($FeSO_4 \cdot 7H_2O$) on the yellow pigment of turmeric and once again confirms the importance of mordant selection on color character. In the fourth and fifth trials with Turmeric, the mordant was kept constant (only Alum [$KAl(SO_4)_2 12H_2O$] was used in both trials). The aim of these studies was to examine the effects of dye amount and dyeing time on color. In the fourth trial, 10% of the fabric amount of Turmeric was added to a dye bath prepared with 20 times the fabric's water. The dyeing process was carried out at 80°C for 30 minutes. In the fifth trial, the Turmeric amount was increased to 20%, and the dyeing time was extended to 60 minutes. All other parameters were kept constant.

When the trial results were compared, it was observed that the increased Turmeric amount and the extended dyeing time had a significant effect on color intensity. In the fourth trial, the color tone was lighter, softer, and less intense, while in the fifth trial, more saturated, warm, and dark yellow tones were obtained. This difference is due to the dye's effect on natural dyeing. Application parameters such as amount and duration have a direct effect on color depth and brightness (Table 3).

Dyestuff	**Usage**	**Amount of fabric**	**Amount**	**Mordant substance**	**Mordanting method**	**Time**	**Temperature**	**Fabric color samples obtained**
Turmeric	grind	203 gr	22%g /2000 %ml.	Alum	Premordanting	60 min.	80^{0}C	
Turmeric	grind	203 gr	22%g /2000% ml.	Alum+ Copper sulfate	Premordanting	60 min.	80^{0}C	
Turmeric	grind	203 gr	22%g /2000% ml.	Alum+ Iron sulfate	Premordanting	60 min.	80^{0}C	

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Tur-meric	grind	40 gr	10%g/ 2000%ml.	Alum	Pre-mor-dan-ting	30 min.	80^{0}C	
Tur-meric	grind	40 gr	20%g/ 2000%ml.	Alum	Pre-mor-dan-ting	60 min.	80^{0}C	

Table 3: Experimental studies with turmeric (*Curcuma longa*)

Fabrics Dyed with Walnut Shells (*Juglans regia*)

In this study, walnut shell (*Juglans regia*) was used as a natural dye, and the effect of mordant types on color was investigated. In the first, second, and third trials, the dyeing parameters were kept constant; only the mordant materials used were varied. In all three trials, walnut shell, at 70% of the fabric volume, was applied in a dye bath prepared with 20 times the amount of water, at 80°C for 45 minutes.

In the first trial, the fabrics were pre-mordanted before dyeing using Alum ($KAl(SO_4)_2{\cdot}12H_2O$). This treatment resulted in a gray color. In the second trial, a combination of Alum ($KAl(SO_4)_2{\cdot}12H_2O$) and Iron sulfate ($FeSO_4{\cdot}7H_2O$) was used as mordants under the same conditions, resulting in a significantly darker color and a more matte appearance. In the third trial, walnut shells, at a ratio of 70% to the fabric, were added to a dye bath prepared with 20 times the amount of water as the fabric. The process was continued at 80°C for 45 minutes. In this trial, Alum ($KAl(SO_4)_2{\cdot}12H_2O$) and Copper sulfate ($CuSO_4{\cdot}5H_2O$) were used as mordants.

In the fourth and fifth trials, the dye ratio was adjusted to 70%, and the dyeing was carried out with 20 times the amount of water as the dye, for 45 minutes, and at 80°C. The main difference between these two trials was the use of mordants. In the fourth trial, no mordant was used at all. In this case, the fabric was dyed a light, pale gray. In the fifth trial, Alum ($KAl(SO_4)_2{\cdot}12H_2O$) and Iron sulfate ($FeSO_4{\cdot}7H_2O$) were used as mordants together. The resulting color from this process is a darker and more saturated gray than the first test. It was observed that the use of a mordant significantly affects color intensity by increasing

the dye's adhesion to the fabric. These two tests clearly demonstrate the difference the mordant makes in color tone in dyeing processes performed under the same conditions.

Table 4: Experimental studies with walnut shell (*Juglans regia*)

Dyestuff	**Usage**	**Amount of fabric**	**Amount**	**Mordant substance**	**Mordanting method**	**Time**	**Temperature**	**Fabric color samples obtained**
Walnut shell	grind	191 gr	70%g/ 2000% ml	Alum	Pre-mordanting	45 min.	80^{0}C	
Walnut shell	grind	191 gr	70%g/ 2000%ml.	30% Alum + 20% Iron sulfate	Pre-mordanting	45 min.	80^{0}C	
Walnut shell	grind	191 gr	70%g/ 2000%ml	Alum+ Copper sulfate	Pre-mordanting	45 min.	80^{0}C	
Walnut shell	grind	40 gr	70%g/ 2000%ml	-	Mordant-free	45 min.	80^{0}C	

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Wal-nut shell	grind	40 gr	70%g/ 2000%ml	Alum+ Iron sulfate	Pre-mor-danting	45 min.	80^{0}C	

Following all these experimental applications, a capsule collection was created. A capsule collection can be defined as a small and limited collection type, prepared in a minimalist style (Renfrew, E. & Renfrew, C., 2009: 33).

Capsule Collection Design "Rooted in Earth"

This capsule collection, titled "Rooted in Earth," was created using 100% cotton fabrics dyed with naturally derived dyes. The fabrics were colored with natural plant-derived dyes like madder (*Rubia tinctorum L.*), turmeric (*Curcuma longa*), and walnut shell (*Juglans regia*), and were made permanent using traditional mordant techniques.

The collection is based on a production approach rooted in nature. In the designs, which emphasize natural tones and simple forms, color transitions, surface movements, and layered structures are transformed into aesthetic details that bear traces of the natural dyeing process.

Each piece is designed with a sustainable fashion approach, free from chemical additives, through a dyeing process using natural materials. The overall language of the collection is simple, balanced, and respectful of nature, while the techniques and forms used combine the traditional and the contemporary.

"Rooted in Earth" is not just a collection created with natural dyes; It is also the reflection of the deep connection established with nature, simplicity and transformation in design (Figure 2).



Figure 2: Storyboard, "Rooted in Earth", (Çalışkan, 2025).

Design 1: Rooted Fringe

In this design, 100% cotton fabrics were colored with madder. Before dyeing, a pre-mordant process was performed using 30% Alum ($KAl(SO_4)_2 \cdot 12H_2O$) and 2000 ml of water at a temperature of 85–90°C for 60 minutes. The madder was then soaked in water for one day and dyed at a temperature of 70–80°C for 75 minutes. Following the drying process, the artistic drawings, technical drawings, pattern applications, and storyboards for the designed dress were created (Figure 3).

The halter-neck dress was created in two layers. Two dresses made from the same pattern were placed on top of each other; the top layer was cut into vertical stripes of equal width to create a dynamic surface. The free movement of these stripes during walking gave the design a rhythmic and fluid effect (Figure 3.1).

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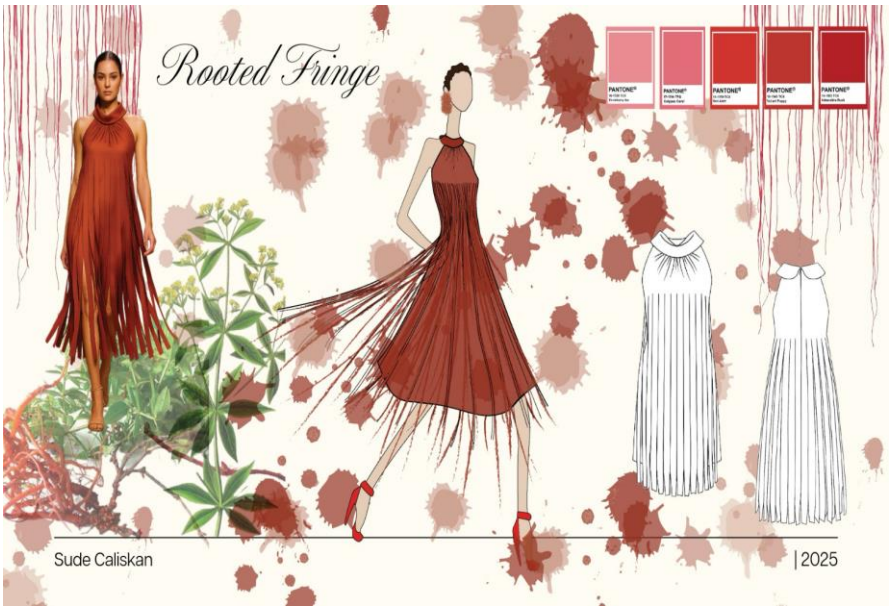


Figure 3: Storyboard, artistic and technical drawing (Çalışkan, 2025).



Figure 3.1: Front and back body view of the application work

Design 2: Morning Fade

In this design, 100% cotton fabrics were dyed with turmeric. Before dyeing, a pre-mordant process was performed using 25% Alum ($KAl(SO_4)_2 \cdot 12H_2O$) and 2000 ml of water at a temperature of 85-90°C for 60 minutes. The dyeing process was carried out with 10 grams of dye at a temperature of 80°C for 30 minutes. First, the entire skirt of the dress was

dyed, then halfway down the upper body. After drying, the dress was then painted with artistic drawings, technical drawings, pattern applications, and a storyboard (Figure 4).

Morning Fade is an elegant and simple dress inspired by the soft light of sunrise, created by dyeing cotton fabric with turmeric. The dress features a soft gradient, starting from the upper body and progressing towards yellow. The crew neck collar, short sleeve ends and flared hem are surrounded by thin white lace strips (Figure 4.1).



Figure 4: Storyboard, artistic and technical drawing (Çalışkan, 2025).



Figure 4.1: Front and back body view of the application work

Design 3: Walnut Form

The 100% cotton main fabric was dyed with natural dye derived from walnut shells. Turmeric was used in the garni fabric. Before dyeing, a pre-mordant process was carried out using 25% Alum ($KAl(SO_4)_2 \cdot 12H_2O$) and 2000 ml of water at a temperature of 85-90°C for 60 minutes. The main fabric was dyed with 70 grams of walnut shells at a temperature of 80°C for 45 minutes. The garni fabric was dyed with turmeric. After all the

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fabrics were dried, the artistic drawings, technical drawings, pattern applications, and storyboard of the designed dress were created (Figure 5).

A contrasting look was created by using turmeric-dyed fabric pieces on the main background dyed with walnut shells. These pieces, starting from the hanger and extending to the sides of the front bodice and the hem, were cut into geometric shapes and arranged in an orderly manner. This layout achieves a balanced and fluid look. The color transitions both emphasize the depth of the natural dyeing and add movement to the dress. The design is completed with simply chosen geometric mother-of-pearl buttons (Figure 5.1).



Figurel 5: Storyboard, artistic and technical drawing (Çalışkan, 2025).



Figure 5.1: Front and back body view of the application work

Conclusion and Recommendations

This study investigated the natural dyeing of 100% cotton fabrics using natural dyeing methods using the natural dyes root dye (*Rubia tinctorum L.*), turmeric (*Curcuma longa*), and walnut shell (*Juglans regia*). Different mordant types, dyeing times, and techniques were applied to evaluate color tone, permanence, and fabric effects.

In addition to the technical aspects of natural dyeing, a capsule collection titled "Rooted in Earth" was created by dyeing 100% cotton fabrics. This collection is a unique design that reflects the aesthetic power of colors derived from nature and the potential of sustainable textile production. Layered surfaces, organic color transitions, and simple forms integrate both the traditional and contemporary aspects of natural dyeing, finding expression in the collection.

In conclusion, this study demonstrates that natural dyes possess both ecological and artistic value, and that integrating naturally sourced colors into the design process is both possible and meaningful. Natural dyeing is not merely a traditional technique; At the same time, as a sustainable design approach, it offers an important alternative for future textile production.

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